CRUISE REPORT
R/V EWING 01-02

MULTICHANNEL SEISMIC REFLECTION STUDY OF MEGAMULLIONS ON THE MID-ATLANTIC RIDGE

BRIAN E. TUCHOLKE AND JOHN A. COLLINS
CO-CHIEF SCIENTISTS

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CHARLESTON, S.C.
TO
SAN JUAN, PUERTO RICO

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BACKGROUND AND SCIENTIFIC OBJECTIVES

Understanding the geological and geophysical structure of ocean crust is a fundamental goal of the earth science community. Primary data on lithology and lithological-structural relations of the sub-volcanic section in the ocean basins have been acquired by ocean drilling and to some extent by submersible studies. However, this record is very incomplete, and ocean drilling to penetrate the entire crust (or even a large fraction thereof) is unlikely to be achieved in the near future. Data on seismic velocity in ocean crustal layers have been correlated with laboratory measurements of velocity in mafic and ultramafic oceanic rocks and with some borehole seismic results in order to infer a layered lithology similar to the Penrose ophiolite model. However, it is uncertain to what degree the idealized Penrose model is representative of normal ocean crust, particularly on spreading ridges where melt supply is limited and intermittent.

The recent discovery of megamullions provides an outstanding new opportunity to study the geological and geophysical character of ocean lithosphere on spreading ridges that have limited magma supply. These features are interpreted to be footwall blocks of long-lived (~1.0-2.5 m.y.) normal (detachment) faults and they appear to expose extensive (~15-35 km) cross sections of the crust and uppermost mantle at the seafloor (Tucholke and others, 1998). This exposure offers relatively unimpeded access for both geological and geophysical sampling to determine the true nature of *in situ* ocean crust.

The present cruise was a multichannel seismic (MCS) investigation of three of the best developed megamullions known on the Mid-Atlantic Ridge (MAR) in the central North Atlantic Ocean. The geometric characteristics of the megamullions (unusually smooth surface, shallow depths) are very favorable for high-resolution seismic determination of seismic velocity and structure, in contrast to MCS study of normal slow-spreading crust which is hampered by side-scattered energy from the extremely irregular topography. By obtaining several seismic lines over each megamullion, our program is attempting to establish lateral coherence or variability of crustal structure in both strike and dip directions. Our goals are 1) to obtain high-resolution velocity structure of the megamullions, 2) to relate this to probable composition, including possible alteration effects such as serpentinization of mantle ultramafics, and 3) where possible to image structural discontinuities, including the relict detachment shear zone dipping through the lithosphere at the young ends (terminations) of the megamullions. To the extent possible within the time available, we also obtained MCS profiles on crust conjugate to the megamullions, in order to investigate how the structure of this "hanging-wall crust" was affected during the period of megamullion formation. Interpretations of our seismic results will be further constrained by modeling density distribution in the megamullions from gravity data obtained during the survey.

The three megamullions studied here have near-bottom survey and sampling programs either planned, proposed, or already conducted. In addition, two of the megamullions (Atlantis and

Kane) have ODP drilling proposals that currently are active. These two megamullions were our primary survey targets, and we expect that our MCS studies will contribute data to help optimize drilling targets and eventually to assist in interpreting drilling results. To the extent that time allowed, we also obtained MCS data over Dante's Domes megamullion to compare and contrast with the results at Atlantis and Kane megamullions.

Previous work at Atlantis megamullion included initial SeaBeam, gravity and magnetics surveys done in 1988 and 1992 (Purdy and others, 1990; Sempéré and others, 1995). The megamullion was first identified as such by Cann et al. (1997), who obtained TOBI sidescan images and dredge samples (basalt , gabbro, and serpentinite) of its surface. OBH/S and near-bottom seismic work (NOBEL) by Collins and Detrick (1998) identified mantle velocities within about 800 meters of the megamullion surface, in general agreement with gravity modeling (Blackman et al., 1998) suggesting that mantle had been exhumed in the young part of the megamullion. Recent DSL-120 and ARGO surveys, plus ALVIN dives, have been conducted over the southern, elevated portion of the megamullion (Blackman et al., unpublished); this work found that the megamullion surface is sediment-covered or crusted with carbonates, and it also found unusual carbonate-silica chimneys formed by low-temperature hydrothermal venting from an apparent peridotite substrate.

The Kane megamullion was first identified by Tucholke et al. (1996; 1998), but very little work has been done there. Regional multibeam, gravity and magnetic surveys were accomplished by Pockalny et al. (1988; 1995) and Gente et al. (1995). Submersible dives (Auzende et al., 1994) and Deep-Tow observations (Karson, 1999) have been made at the northernmost edge of the megamullion (south wall of Kane Fracture Zone), and gabbros and serpentinized peridotites were sampled there. British investigators (C. MacLeod and J. Cann) plan to survey Kane megamullion with TOBI and sample it with the BGS rock drill in April-May 2001.

Dante's Domes megamullion was identified during a 1996 multibeam, magnetics, and gravity survey of the east flank of the Mid-Atlantic Ridge (Tucholke et al., 1996; 1998). In 1998, five submersible dives with Shinkai 6500 made observations and obtained samples along a transect from the breakaway to near the termination (Tucholke et al., in press). Serpentinites were sampled from the area of the gravity high near the center of the megamullion.

OPERATIONAL OBJECTIVES

Our operational plan was to acquire detailed wide-angle and vertical-incidence MCS seismic data over three well developed megamullions on the Mid-Atlantic Ridge, together with sonobuoy profiles at selected locations. The three megamullions are Atlantis megamullion adjacent to the eastern ridge-transform intersection of Atlantis Fracture Zone, Dante's Domes megamullion near 26°40'N, and Kane megamullion on the south side of the Kane F.Z. transform valley. Three primary kinds of seismic lines are of interest: 1) strike lines which parallel isochrons over the domed surfaces of the megamullions, 2) strike lines over crust that is conjugate to the megamullions, and 3) dip lines that parallel plate flow lines, ideally extending from outboard of the megamullions' breakaways to inboard of their terminations and, where appropriate, across the rift valley to conjugate crust.

Primary operational goals for R/V Ewing are summarized as follows:

- Fire a 10-gun array to Ewing's 6-km streamer at 37.5-m shot spacing on each profile.
- Acquire auxiliary geophysical data (gravity, magnetics, multibeam bathymetry, 3.5 kHz echosounding, XBT profiles) along ship track.
- Acquire auxiliary reflection and refraction profiles from expendable sonobuoys.
- Produce near-real-time brute stacks of all MCS data.
- Copy all MCS prestack data to DLT tapes for use ashore.

PRELIMINARY CRUISE ASSESSMENT

Although we experienced a variety of difficulties during the cruise, and some data sets are less than perfect, we are optimistic that the data will contribute strongly to our goal of understanding the crustal structure of megamullions, and we judge that our field work has been a success. Factors responsible for achieving our goals included: 1) adequate planning to accommodate vagaries of instrument performance, and especially inclusion of contingency time to cover unforeseen circumstances, 2) flexibility in survey plans that allowed alternate surveys to be performed when weather made it impossible to work in a programmed area, 3) enough days with sufficiently good weather conditions that we were able to obtain all profiles of primary interest, and 4) the highly professional ship's crew and LDEO technical staff on Ewing, who did everything possible to help us achieve our goals and ensure a safe cruise.

Notable successes included the following:

- Acquisition of strike and dip MCS lines in optimum locations over each of the three megamullions of interest, together with acquisition of strike lines over conjugate crust at both Atlantis megamullion and Kane megamullion.
- Consistent observation of refractions in wide-angle data over the length of the 6-km streamer, wherever we were profiling across a megamullion. We expect that these data will provide excellent insights into the velocity structure and composition of the megamullions.
- Near real-time brute stacks of the MCS data.

Principal operational difficulties included the following:

• We had intermittent difficulties with the MCS streamer, the 3490E tape drives, the Spectra integrated navigation system, and the airgun firing system. Details are given under the Problems and Recommendations section of this report.

• Magnetometer. We had intermittent failure of the magnetometer system and obtained data during about half the cruise.

• 3.5 kHz profiler. The digital EPC recorder burned out two power supplies and had to be replaced by an analog EPC9800. The latter did not automatically mark and annotate half-hour events or reprogam sweep to accommodate seafloor depth changes. During the period when strike lines were being shot at Dante's Domes, the analog profiler also failed to advance paper smoothly, and it produced a choppy and uninterpretable record.

•Weather. We were fortunate to have acceptable to good weather conditions throughout much of the cruise. However, at the time of our initial survey at Atlantis megamullion, strong winds and seas produced very noisy MCS data and endangered the airgun booms and airguns; we were forced to abandon our work there temporarily, to steam south to survey at Kane megamullion, and later return to complete our work at Atlantis megamullion. We lost a total of about 5 days directly to weather and to the extra steaming time entailed when weather forced changes in our survey strategy. We normally towed the hydrophone streamer at 10 meters depth with little noise from surface waves, but there were two major exceptions. The first was our initial survey at Atlantis megamullion, already noted, and the second was during the last half of Line Dante-4, at the end of our survey at Dante's Domes megamullion. At that time winds were picking up to 20 knots and more, and there was a substantial current of up to 2 knots in the direction we were shooting the line. These combined factors brought the streamer to the surface and it was impossible to get it back to depth; thus the latter half of Line Dante-4 is very noisy.

Preliminary scientific results include:

• Each megamullion produced refracted arrivals at channels along the outer portion of the 6-km-long streamer cable. It is clear that high-velocity, subvolcanic rocks are exposed in the megamullions, and we have an excellent data set to evaluate how these velocities are distributed and how they may relate to internal composition of the megamullions.

• Smoothness of the megamullions' surfaces is readily apparent both in MCS profiles and in high-amplitude reflections in 3.5 kHz profiles. The highly diffracting character of normal ocean crust is not observed over the megamullion domes.

• Low-frequency reflections are observed in a number of profiles at ca. 2 seconds two-way travel time sub-seafloor and at other depths. Processing is likely to resolve that these reflections are from Moho and from other features that will help us to interpret the structure and evolution of megamullions.

• MCS strike lines over conjugate crust at Atlantis and Kane megamullions were obtained along relatively shallow, level seafloor. We are optimistic that processing will help to reveal some of the subsurface structure of these conjugates.

SCIENTIFIC AND TECHNICAL PERSONNEL

Dr. Brian E. Tucholke, Co-Chief Scientist
Department of Geology and Geophysics
Clark 241, MS22
Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1541
Tel. (508) 289-2494 Fax (508) 457-2187
Email: btucholke@whoi.edu

Dr. John A. Collins, Co-Chief Scientist
Department of Geology and Geophysics
Clark South 272, MS24
Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1541
Tel. (508) 289-2733 Fax (508) 457-2150
Email: jcollins@whoi.edu

Ms. Kazumi Baba, Shipboard Scientist
Nippon Marine Enterprises, Ltd.
c/o JAMSTEC
2-15 Natsushima-Cho
Yokosuka, Kangawa Pref. 237-0065
JAPAN
Tel. +81-468-65-6803 Fax +81-468-65-6031
Email: baba@nme.co.jp

Mr. Stephen T. Bolmer, Shipboard Scientist
Department of Geology and Geophysics
Clark South 286, MS24
Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1541
Tel. (508) 289-2628 Fax (508) 457-2150
Email: tbolmer@whoi.edu

Dr. Juan Pablo Canales, Shipboard Scientist
Department of Geology and Geophysics
Clark South 285, MS24
Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1541
Tel. (508) 289-2893 Fax(508) 457-2150
Email: jpcanales@whoi.edu

Mr. John DiBernardo, Pneumatic Sound Source Officer
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
Tel. (845) 365-8436 Fax: (845) 359-4069
Email: honey@ldeo.columbia.edu

Mr. Carlos D. Gutierrez, Gunner
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
Tel. (845) 365-8770
Email: carlosgu@ldeo.columbia.edu

Mr. Karl Hagel, Electronics Technician
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
Tel. (845) 365-8828 Fax: (845) 359-6817
Email: hagel@ldeo.columbia.edu

Ms. Robyn Kelly, Shipboard Scientist
MIT/WHOI Joint Program in Oceanography
Department of Geology and Geophysics
Clark 244B MS 22
Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1541
Tel. (508) 289-3422 Fax (508) 457-2187
Email: rkelly@whoi.edu

Mr. Christopher P. Leidhold, Science Officer
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
Tel. (845) 365-8828 Fax: (845) 359-6817
Email: cpl@ldeo.columbia.edu

Mr. Winston M. Seiler, Gunner
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
c/o Office of Marine Affairs, Tel. (845) 365-8367 Fax: (845) 359-6817
Email: winston@ldeo.columbia.edu

Mr. Jeffrey P. Turmelle, Systems Manager
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
Tel. (845) 365-8677 Fax: (845) 359-6817
Email: jefft@ldeo.columbia.edu

Mr. Justin M. Walsh, Gunner
Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964
c/o Office of Marine Affairs, Tel. (845) 365-8367 Fax: (845) 359-6817
Email: cabinboy@ldeo.columbia.edu

SHIP'S PERSONNEL

James E. O'Loughlin, Master

Gilbert C. Thurston, Chief Mate
Jeffrey Sylvia, Second Mate
Ralph J. DiMattia, Third Mate

David L. Philbrick, Bosun
Aubrey A. Benjamin, A/B
Scott E. Peck, A/B
Alexander A. Greig, A/B
Arnold A. Sypongco, O/S
Christopher A. Wheeler, O/S

Stephen M. Pica, Chief Engineer
G. Gartz Gould, First Engineer
Miguel A. Flores, Second Engineer
Daniel P. LoCasto, Third Engineer
John H. Schwartz, Electrician
Michael L. Spruill, Oiler
Guillermo F. Uribe, Oiler
Robert Malloy, Oiler

John S. Smith, Steward
Kelly L. Taylor, Cook
Luke Moqo, Utility

WATCH SCHEDULES

MAIN LAB WATCH

Time (Local)	Watch
1200 - 2000	Brian Tucholke Tom Bolmer
2000 - 0400	John Collins Kazumi Baba
0400 - 1200	Pablo Canales Robyn Kelly

GUN WATCH

Time (Local)	Watch
12 - 4	Winston Seiler
4 - 8	Carlos Gutierrez
8 - 12	Justin Walsh John DiBernardo

BRIDGE WATCH

Time (Local)	Watch
12 - 4	Jeffrey Sylvia Scott Peck Christopher Wheeler
4 - 8	Gilbert Thurston Alexander Greig
8 - 12	Ralph (aka RJ) DiMattia Aubrey Benjamin Arnold Sypongco

SURVEY LAYOUT

Our goal in surveying each of the three megamullions was to obtain strike lines (along isochrons) and dip lines (along plate flowlines) in optimum locations to address the following objectives: 1) to obtain refracted arrivals from the smooth and shallow crust of the megamullions, thereby to derive patterns of velocity structure and interpret apparent composition and compositional variation in the megamullions; 2) to image impedance boundaries in the ocean crust and upper mantle that could provide structural information and allow us to interpret how the megamullions are formed; and 3) to image the crust in locations conjugate to the megamullions and to determine if these "hanging wall" crustal parcels show unusual structure that helps to constrain megamullion formation.

At Atlantis megamullion (Figure 1, top; Figure 2) we acquired MCS data along three major dip lines (MEG-1 to MEG-3). At their west ends, these lines start over crust formed prior to the breakaway of the major detachment fault that is interpreted to have formed the megamullion. They extend ESE across the megamullion, across the rift valley, and onto interpreted "hanging wall" crust conjugate to the megamullion. We interrupted our survey because of bad weather, but when we returned we profiled primarily along strike lines (Figure 1, bottom). Strike lines MEG-4 to MEG-6 were located over smooth and shallow portions of the megamullion surface to optimize acquisition of refracted arrivals. MEG-6 also crossed a portion of apparent basaltic hanging wall on the young edge of the megamullion. On the other side of the rift valley, strike line MEG-8 followed the relatively level axis of a ridge in crust conjugate to the megamullion. Because the weather made the data we collected along dip lines MEG-1 to MEG-3 very noisy, we repeated parts of these lines by acquiring dip lines MEG-9 and MEG-10. These profiles cross shallow and smooth parts of the megamullion surface where we could optimize our chances of recording refracted arrivals, as in profiles MEG-4 to MEG-6.

At Kane megamullion (Figures 3 and 4) we acquired MCS profiles along three dip lines. The two major dip lines (KANE-1 and KANE-4) extended from outboard of the breakaway eastward across the megamullion, across the rift valley, and onto conjugate crust. A shorter dip line (KANE-8) reached from the central part of the megamullion across the termination. We acquired three strike lines (KANE-5 to KANE-7) over the smooth and shallow seafloor of the main megamullion structure. In crust conjugate to the megamullion, we acquired two strike lines (KANE-2 and KANE-3) along a ridge which exhibits a relatively level, double crest.

We had only limited time available to conduct MCS work at Dante's Domes because of time lost to weather earlier in the cruise. Nonetheless, we were able to do two strike lines (DANTE-1 and DANTE-2) that lie along the shallowest parts of the megamullion, and we obtained a long dip line (DANTE-3) that extends from outboard of the breakaway across the megamullion, across the rift valley and onto conjugate crust (Figure 5). A short, quasi-dip line (DANTE-3) also crosses the zone between the megamullion domes and the breakaway.

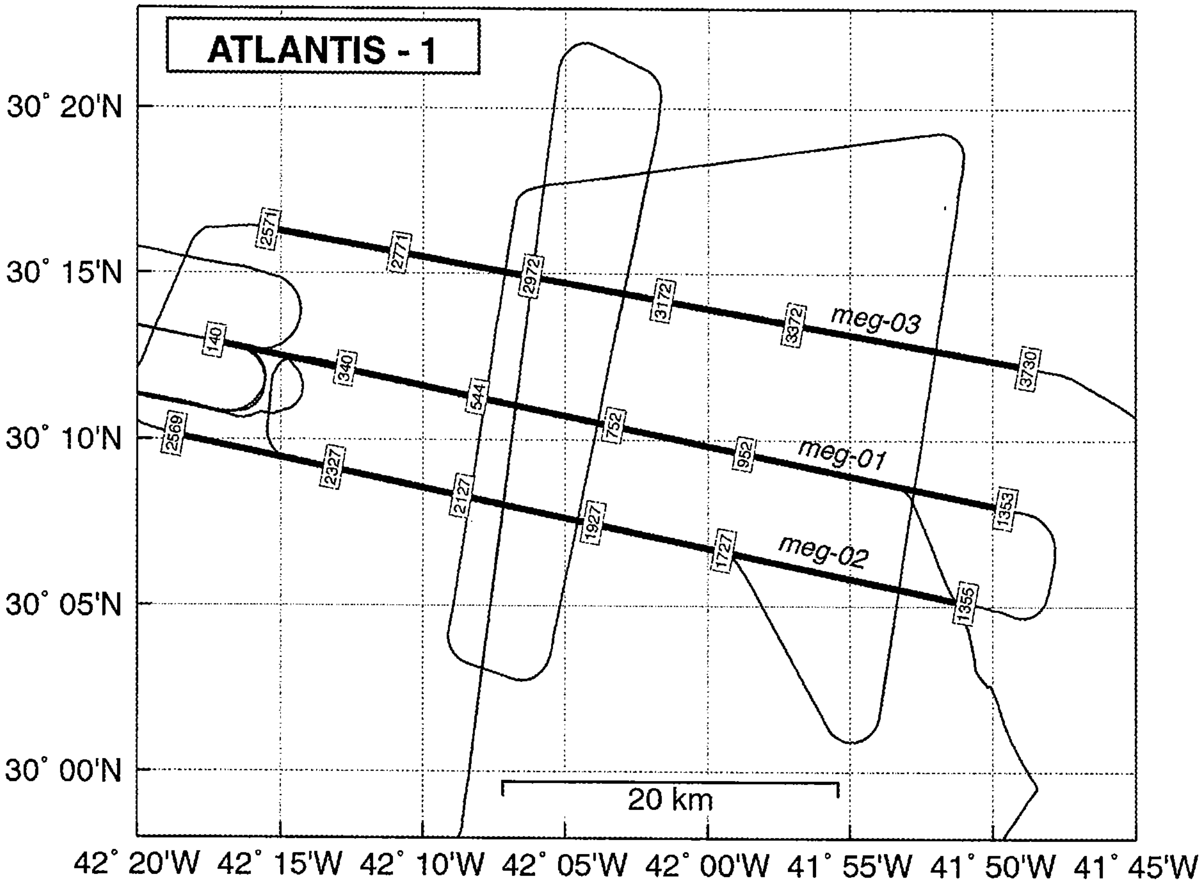
In addition to obtaining MCS data along the lines noted above, we used expendable sonobuoys (SSQ-41B's) to obtain wide-angle reflection and refraction data. These sonobuoys are listed in the table on the next page.

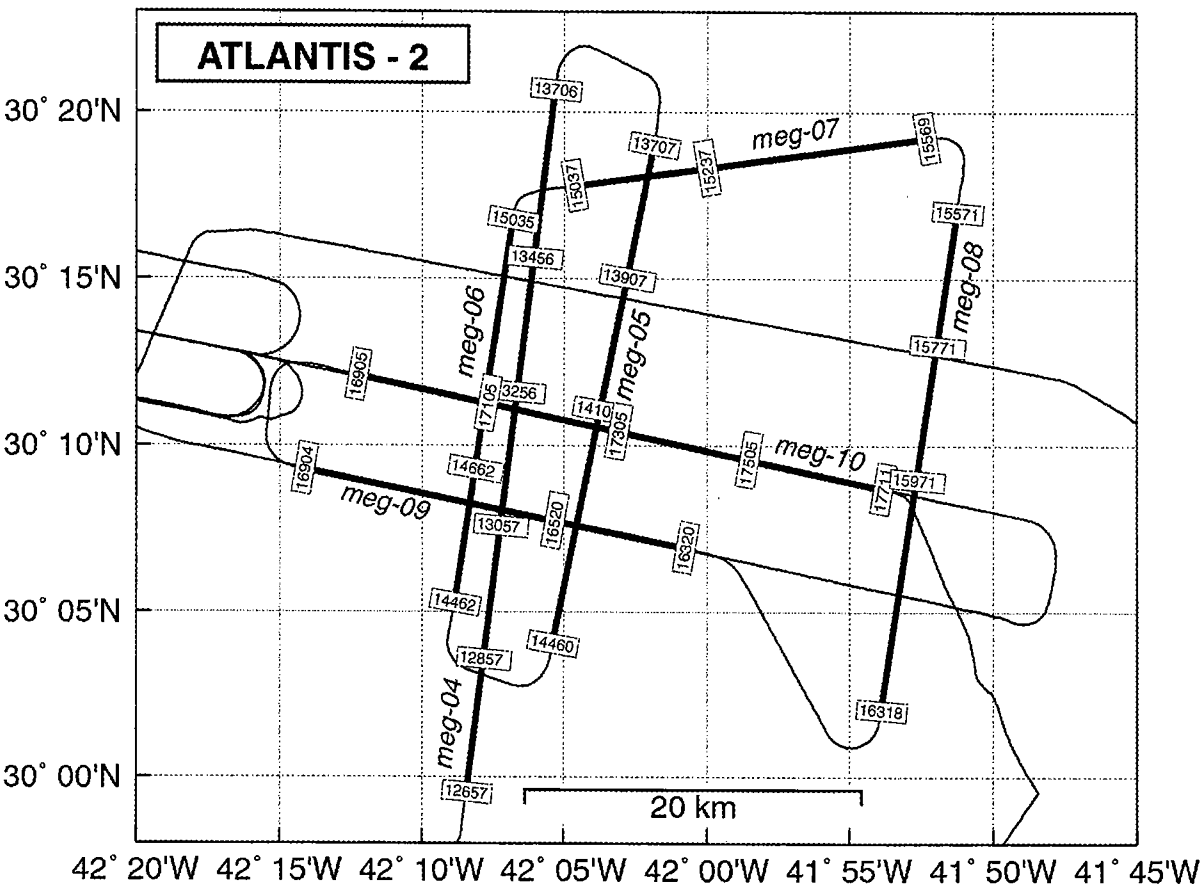
EW-0102 Sonobouys

Sonobouy #	J Day	Time (Z)	Latitude (N)	Longitude (W)	First shot	Last shot	Reel #	MCS Line
01	83	13:05	23° 33.582’	44° 42.546’	6910	7255	151	kane-03
02	83	22:15	23° 29.486’	45° 16.795’	8844	9230	166	kane-04
03	84	06:17	23° 28.580’	45° 23.044’	9890	10109	174	kane-05
04	84	09:11	23° 28.179’	45° 20.344’	10292	10692	177	kane-06
05	84	14:11	23° 30.027’	45° 17.087’	11156	11707	183	kane-07
06	84	20:28	23° 25.800’	45° 18.000’	11951	12263	189	kane-08
07	86	23:08	30° 08.623’ [A]	42° 07.084’ [A]	13060	13230	198	meg-04
08	87	00:21	30° 13.215’	42° 06.398’	13334	13707	199	meg-04
09**	87	04:34	30° 13.653’	42° 03.141’	13975	14148	204	meg-05
10	87	05:10	30° 11.026’	42° 03.757’	14105		205	meg-05
11	87	05:22	30° 10.205’	42° 03.940’	14149	14356	206	meg-05
12*	87	08:49	30° 08.824’	42° 08.221’	14633		210	meg-06
13*	87	09:04	30° 10.031’	42° 08.013’	14693		210	meg-06
14	87	16:07	30° 08.019’ [B]	41° 52.830’ [B]	15989	16318	220	meg-08
15	87	21:02	30° 08.113’	42° 07.480’	16600	16754	226	meg-09
16*	88							meg-10
17**	88	02:08	30° 09.834’	41° 59.963’	17441		232	meg-10
18	89	10:15	26° 36.782’	44° 21.036’	18492	18750	251	dante-01
19	89	15:57	26° 38.235’	44° 22.085’	19499	19809	258	dante-02
20	90	01:08	26° 35.360’	44° 20.170’	21114	21419	270	dante-04

* No reception. ** Bad data. [A] Position at 23:20 Z. [B] Position at 16:15 Z.

Figure 1


ATLANTIS - 1
30° 20'N
30° 15'N
30° 10'N
30° 05'N
30° 00'N
42° 20'W
42° 15'W
42° 10'W
42° 05'W
42° 00'W
41° 55'W
41° 50'W
41° 45'W
meg-03
meg-01
meg-02
2571
2771
2972
3172
3372
3730
140
340
544
752
952
1353
2569
2327
2127
1927
1727
1355
20 km


ATLANTIS - 2
30° 20'N
30° 15'N
30° 10'N
30° 05'N
30° 00'N
42° 20'W
42° 15'W
42° 10'W
42° 05'W
42° 00'W
41° 55'W
41° 50'W
41° 45'W
meg-07
meg-08
meg-06
meg-05
meg-10
meg-09
meg-04
13706
13707
15237
15569
15037
15035
15571
13456
13907
15771
16905
17105
3256
1410
17305
17505
17711
15971
16904
14662
13057
16520
16320
14462
14460
12857
16318
12657
20 km

EW-0102 shots Atlantis Fracture Zone Area

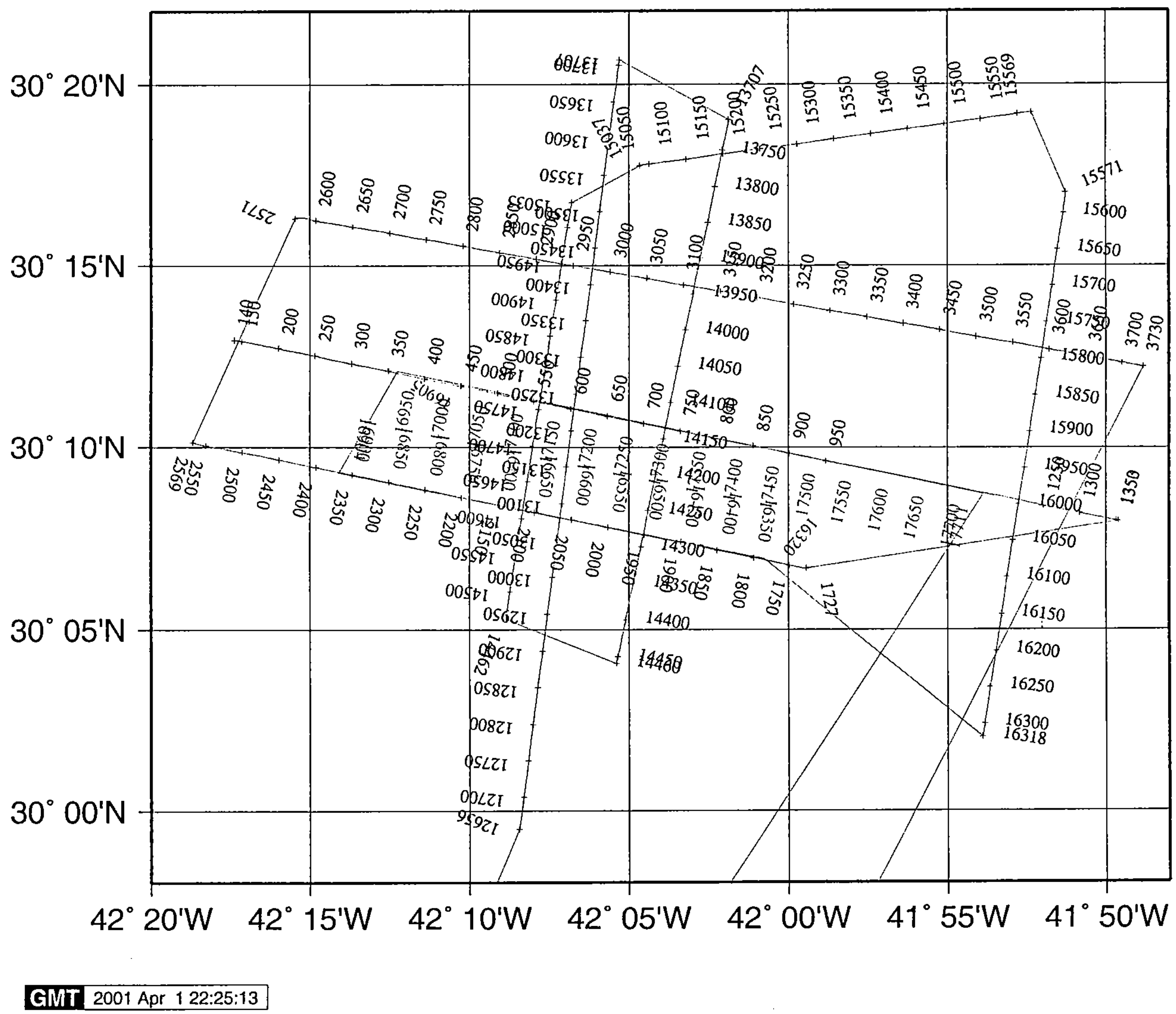


Figure 2

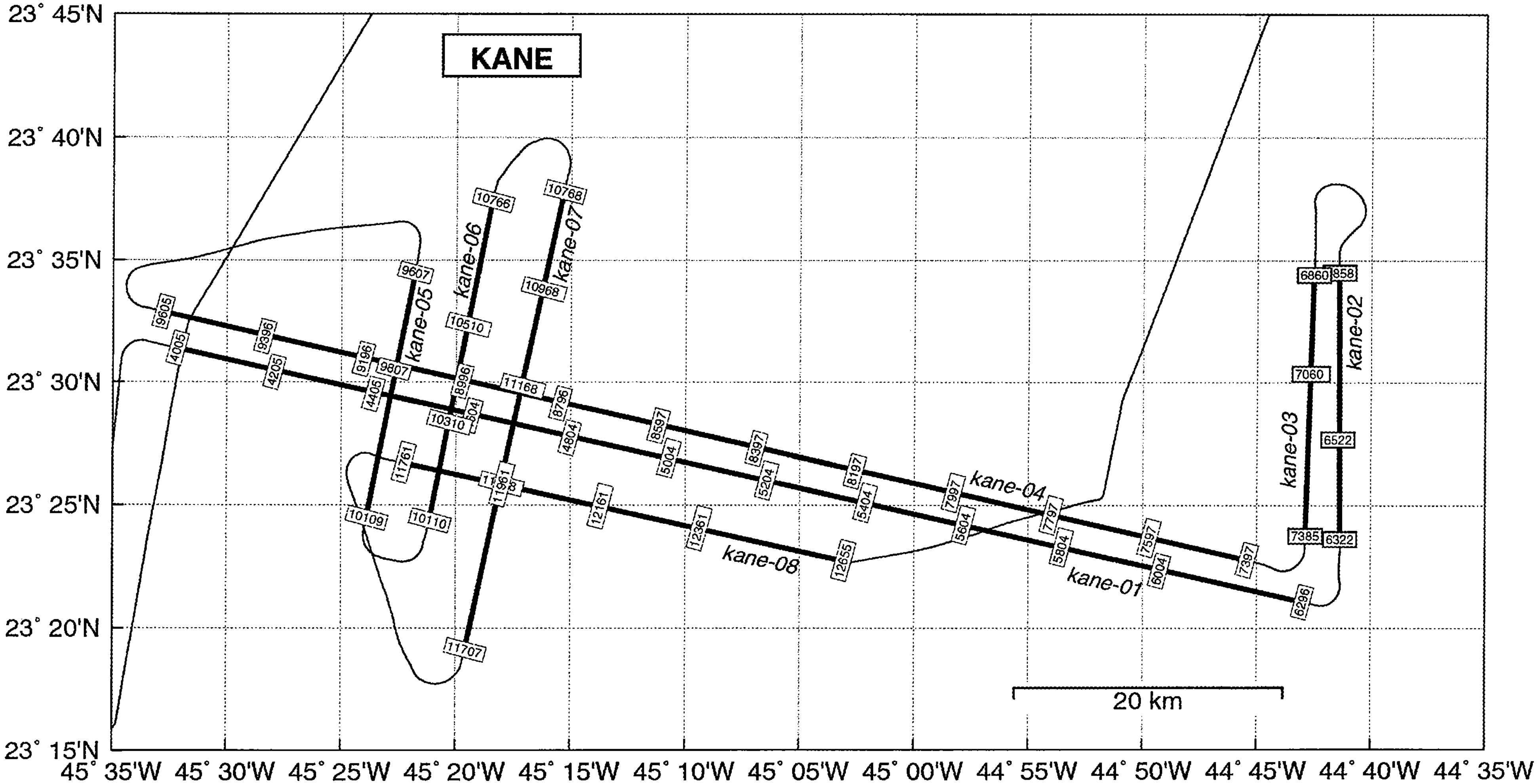

KANE
kane-01
kane-02
kane-03
kane-04
kane-05
kane-06
kane-07
kane-08
20 km
23° 45'N
23° 40'N
23° 35'N
23° 30'N
23° 25'N
23° 20'N
23° 15'N
45° 35'W
45° 30'W
45° 25'W
45° 20'W
45° 15'W
45° 10'W
45° 05'W
45° 00'W
44° 55'W
44° 50'W
44° 45'W
44° 40'W
44° 35'W

Figure 3

EW-0102 shots KANE Fracture Zone Area

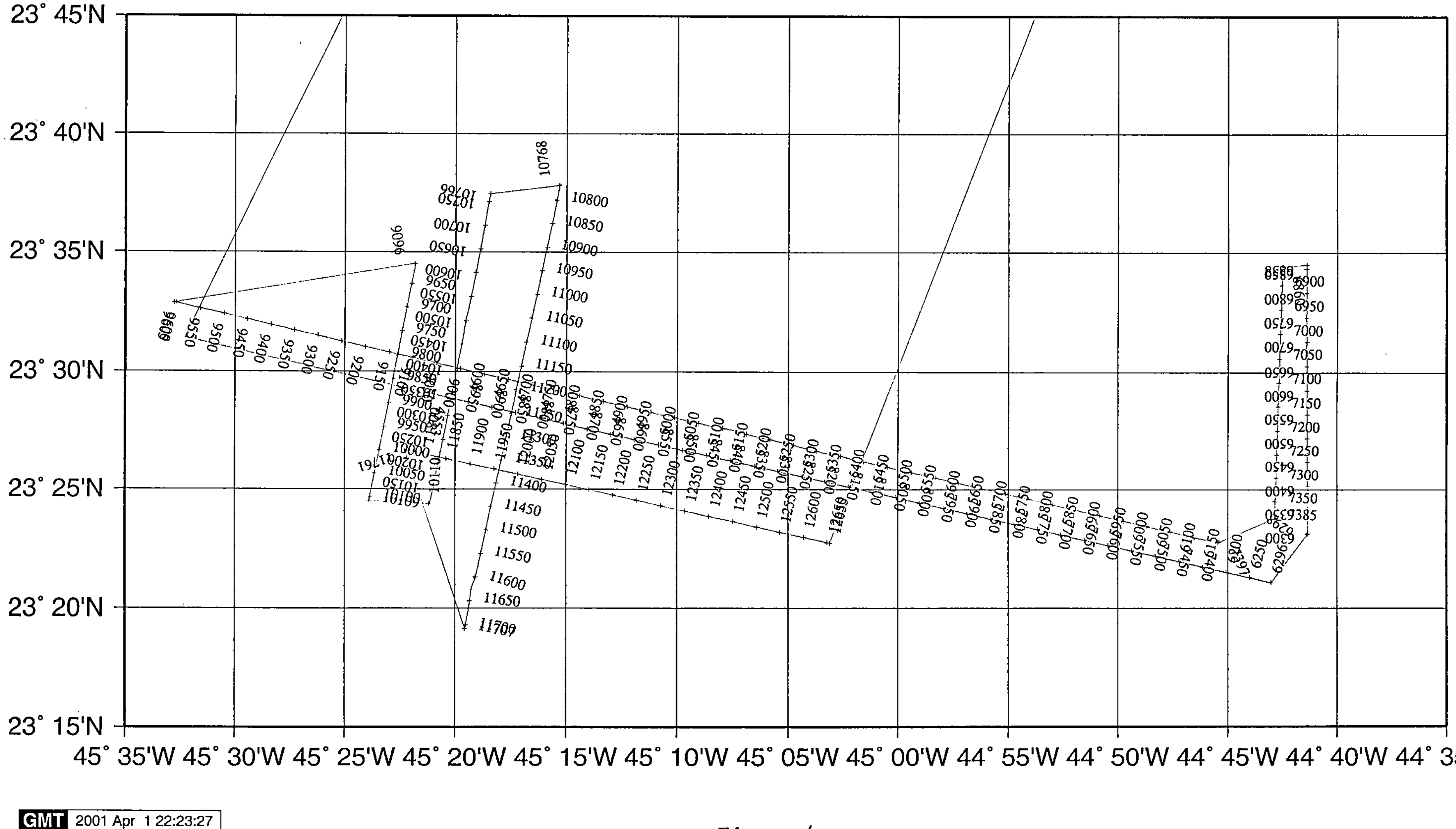


Figure 4

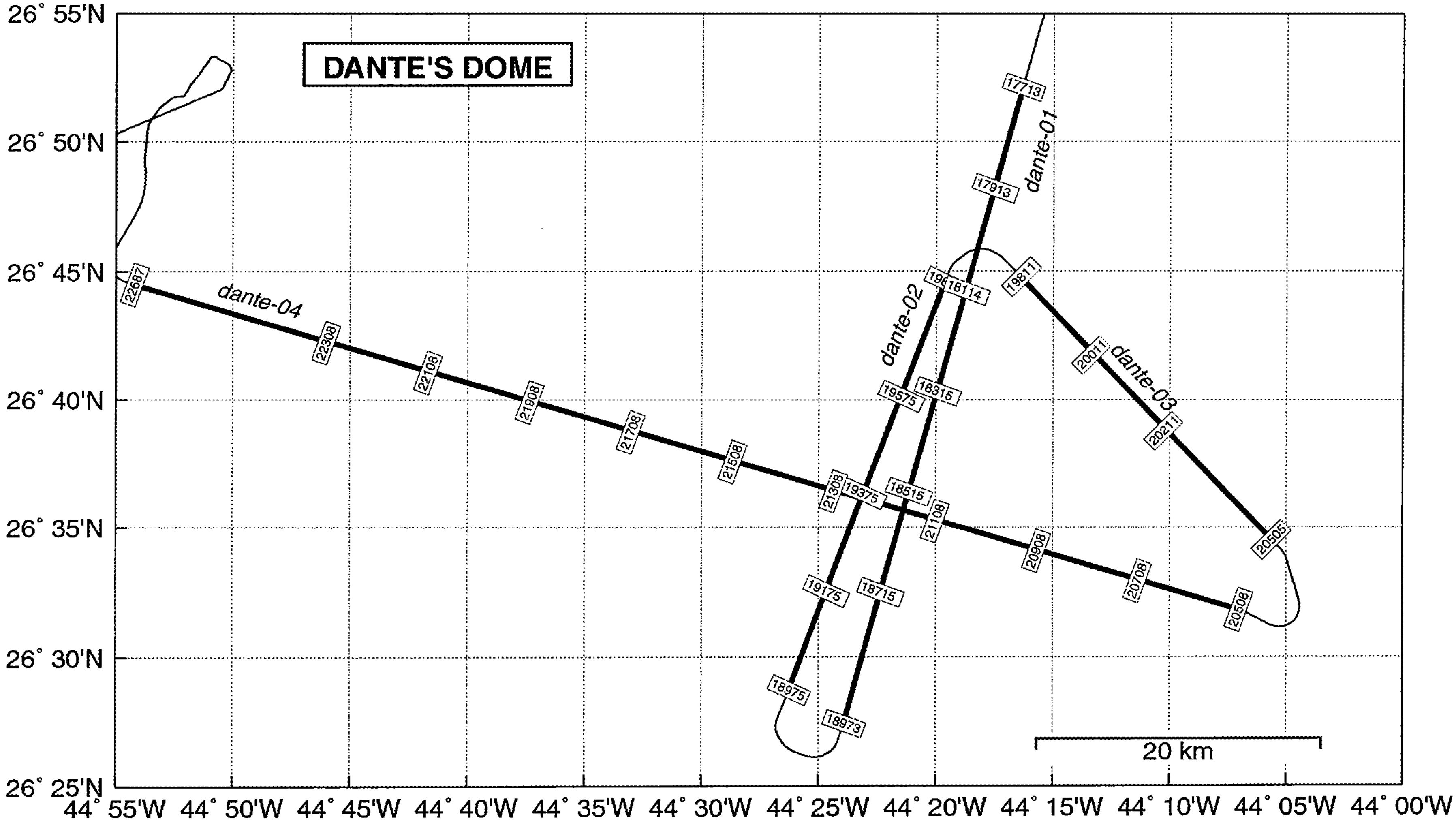

DANTE'S DOME
dante-01
dante-02
dante-03
dante-04
17713
17913
18114
18315
18515
18715
18973
18975
19175
19375
19575
19811
20011
20211
20505
20508
20708
20908
21108
21308
21508
21708
21908
22108
22308
22687
20 km
26° 55'N
26° 50'N
26° 45'N
26° 40'N
26° 35'N
26° 30'N
26° 25'N
44° 55'W
44° 50'W
44° 45'W
44° 40'W
44° 35'W
44° 30'W
44° 25'W
44° 20'W
44° 15'W
44° 10'W
44° 05'W
44° 00'W

Figure 5

WAYPOINTS

The waypoints listed below define the locations of the MCS lines we acquired. Typically, we began to shoot a line beginning 50 shotpoints (1.875 km) before the beginning waypoint of the line, and we stopped shooting the line 80 shotpoints (3 km, i.e., half the streamer length) beyond the end waypoint of the line. Thus the first full common midpoint (CMP) of a line is typically 1.875 km before the first waypoint, and the last full CMP is at the end waypoint. On the starting line of a survey, we began shooting more than 50 shotpoints before the first waypoint, provided the ship and streamer were on-course to follow directly onto the line.

Atlantis Megamullion First Survey

Line MEG-1	WP 1	30°12.80'N	42°16.50'W
	WP 2	30°08.30'N	41°51.50'W
Line MEG-2	WP 3	30°05.30'N	41°52.00'W
	WP 4	30°09.80'N	42°16.80'W
Line MEG-3	WP 5	30°16.20'N	42°14.40'W
	WP 6	30°12.50'N	41°50.70'W

Atlantis Megamullion Second Survey

Line MEG-4	WP 12	30°06.50'N	42°07.40'W
	WP A1	30°19.00'N	42°05.55'W
Line MEG-5	WP 14	30°18.10'N	42°02.10'W
	WP 13	30°05.70'N	42°05.00'W
Line MEG-6	WP 16	30°06.20'N	42°08.70'W
	WP A2	30°15.10'N	42°07.10'W
Line MEG-7	WP A3	30°17.90'N	42°03.60'W
	WP A4	30°19.00'N	41°54.25'W
Line MEG-8	WP 7	30°16.10'N	41°51.40'W
	WP 8	30°03.70'N	41°53.60'W
Line MEG-9	WP A5	30°07.10'N	42°01.80'W
	WP A6	30°08.95'N	42°12.20'W
Line MEG-10	WP A7	30°11.90'N	42°11.20'W
	WP A8	30°09.05'N	41°55.75'W

Kane Megamullion Survey

Line KANE-1	WP K1	23°31.20'N	45°31.30'W
	WP K2	23°21.45'N	44°44.80'W
Line KANE-2	WP K3	23°24.05'N	44°41.35'W
	WP K4	23°32.80'N	44°41.40'W
Line KANE-3	WP K5	23°33.50'N	44°42.55'W
	WP K6	23°25.45'N	44°42.80'W
Line KANE-4	WP K7	23°22.95'N	44°46.40'W
	WP K8	23°32.50'N	45°31.00'W
Line KANE-5	WP K9	23°33.60'N	45°22.00'W
	WP K10	23°26.15'N	45°23.55'W
Line KANE-6	WP K11	23°25.30'N	45°20.95'W
	WP K12	23°35.80'N	45°18.75'W
Line KANE-7	WP K13	23°36.90'N	45°15.50'W
	WP K14	23°20.80'N	45°19.20'W
Line KANE-8	WP 15	23°26.50'N	45°21.30'W
	WP 16	23°23.10'N	45°04.90'W

Dante's Domes Survey

Line DANTE-1	WP D28	26°43.40'N	44°19.00'W
	WP D1	26°29.10'N	44°23.40'W
Line DANTE-2	WP D2	26°29.60'N	44°25.90'W
	WP D3	26°43.00'N	44°20.30'W
Line DANTE-3	WP D4	26°44.10'N	44°15.70'W
	WP D5	26°35.75'N	44°06.90'W
Line DANTE-4	WP D6	26°32.10'N	44°08.00'W
	WP D7	26°44.00'N	44°52.40'W

CRUISE NARRATIVE

10 March 2001. We departed the dock in Charleston, South Carolina about 1700L (local time). In addition to our scientific party, we were carrying two technicians who were testing the Spectra navigation and control system newly installed on Ewing, plus Joe Stennett and John Diebold from LDEO. This testing took place just outside the estuary entrance until about 2200L, when we offloaded the technicians plus Diebold and Stennett onto the pilot boat and got underway for the Mid-Atlantic Ridge.

11 March. This was an uneventful day, steaming toward our first survey site which will be at Atlantis megamullion near 30 degrees N, 42 degrees W. We had a fire and boat drill at 1020 hours.

12 March. We continued steaming to our first site. We had a science meeting at 1400L to review the purpose of our scientific program and to discuss the survey layout that we plan to use.

13-14 March. We continued steaming. Winds picked up to 20-25 knots with 8 - 10 foot seas, but we still made about 11 knots over the ground.

15 March. Winds were down somewhat, and we began in mid-morning to deploy the MCS streamer. It had been removed from the reel in Charleston, piled in containers, then loosely remounted on the reel, and it needed to be deployed and then retrieved under tension. In addition, sections needed to be changed out and ballasting was required in places.

16 March. We had the streamer back on the reel by late morning after more than 24 hours of work, and we continued steaming to our first survey area at Atlantis megamullion.

17 March. We continued steaming to Atlantis megamullion. We had a meeting at 1300L so that Chris Leidhold and Jeff Turmelle could provide us with technical orientation on MCS operations and watchkeeping procedures.

18 March. The wind began to come up strongly today, with gusts to 35 knots and swells of 10-14 feet. We arrived at our first survey site on Atlantis megamullion, and beginning about 1800L, we deployed the 6 km MCS streamer, finishing about 0030L on 19 March.

19 March. During streamer deployment, the winds and seas continued to increase. When we finished deploying the streamer, the captain decided not to deploy the gun booms and guns because of concerns about damaging them. He set up a steaming circuit for the ship to follow, bringing us back to our starting waypoint every 8 hours. We continued to do this throughout the day. Winds were 25-30 knots and waves and swell were 10-15 feet. The winds and seas were caused by a huge low that was centered in and covered almost the entire North Atlantic.

20 March. The captain decided that we could attempt MCS work, although the winds and seas had not changed much from yesterday. The booms and airguns were deployed beginning about 1000L, and at 1210L we fired our first shot on Line MEG-1, a dip line running from NW to SE across Atlantis megamullion. Winds were generally from the NW, so our dip lines running NW - SE were not too rough in terms of ship and gun-boom motion. The real problems were encountered while turning between lines when the ship was in the trough and the gun booms were inundated in the swells. Unfortunately, the MCS data we acquired in this weather are very noisy because of winds and waves.

21 March. Line MEG-3, the third of three major dip lines crossing the megamullion and the rift valley to conjugate crust, was finished about 0815L, and the captain decided to retrieve the airguns and gun booms. The weather was just too rough to proceed. Some of the guns were tangled, and some needed repair. Tucholke, Collins, and Canales discussed options on how to proceed. Winds were running 25-30 knots with gusts to 40 knots, and seas were 12-15 feet with some swells to 20-25 feet. The forecast showed that the huge North Atlantic low was basically stationary and that it was likely to continue affecting our survey area with high winds and large swells for another several days. We decided that our best option was to pull the streamer and steam south to do the Kane megamullion survey. By the time we finished there, we hoped that the weather would allow us to return and complete our survey at Atlantis megamullion. We began recovering the streamer at 1530L, and by about 1950L the streamer and tail buoy were aboard and we were underway for Kane megamullion.

22 March. We spent the day steaming to Kane megamullion.

23 March. We arrived at Kane megamullion about 1000L and began deploying the MCS streamer. Winds were only ca. 10 knots and swells were generally less than 10 feet. We spent a significant amount of time changing out bad sections of streamer (5 sections, for a total of 15 sections up to this time), adding oil to flat sections, and taping and lead ballasting. By about 1845L we crossed waypoint K1 and began shooting the first of the Kane MCS lines, a long dip line that crosses the megamullion, the rift valley, and reaches onto conjugate crust.

24 March. We continued MCS survey of Kane megamullion and its conjugate crust. At 1413L we had a streamer power failure and lost about 25 shots. At about 2015L the Syntron system crashed and we lost about 70 shots.

25 March. MCS survey of Kane megamullion continued. The streamer has been towing very well, typically within 1-2 meters of nominal 10-meter depth set for the birds. At 2030L, we ended Line Kane-8 and began to haul in the airguns and streamer. Altogether, we acquired two long dip lines (Kane-1 and Kane-4) that cross from the megamullion to conjugate crust, one shorter dip line crossing the megamullion and termination only (Kane-8), three strike lines on the megamullion (Kane-5 to Kane-7), and two strike lines on the crust conjugate to the megamullion (Kane-3 and Kane-4).

26 March. The streamer and tailbuoy were aboard by about 0100L. We got underway to return to Atlantis megamullion and spent the remainder of the day steaming.

27 March. About 1300L we arrived 30 miles south of our waypoint to continue the Atlantis megamullion survey, and we began deploying the MCS streamer. Winds and seas were light. At 1820L we were on line and commenced shooting Line MEG-4, the first of four strike lines (along isochrons) that we planned. The 3.5 kHz digital profiler failed yesterday, and was replaced by an analog profiler near the end of the day today. The magnetometer has been down and we recorded no magnetometer data today.

28 March. We continued our MCS survey over Atlantis megamullion. At about 1500L, the magnetometer was repaired and we began recording data again.

29 March. At 0022L we completed Line MEG-10, the last line of the Atlantis megamullion survey. We acquired four strike lines as planned (3 on the megamullion [MEG-4 to MEG-6] and one on its conjugate crust [MEG-8]) and we repeated portions of two dip lines over the megamullion to get a good set of "quiet data" where the previous dip lines had been very noisy because of strong wind and waves. We pulled the airguns and streamer, and at 0500L we were underway to Dante's Domes for our final MCS survey.

30-31 March. At about 0030L on 30 March we started deploying the streamer for survey of Dante's Domes, and we started shooting the first line at 0346L. We shot two strike lines (Dante-1 and Dante-2) approximately N-S over the megamullion domes, then shot Line Dante-3 southeastward to a position where we could then shoot a long dip line (Dante-4) from east of the breakaway westward across the megamullion and the rift valley. We completed Line Dante-4 at 0441L on 31 March and began retrieving airguns, gun booms, and streamer at that time. The streamer tail buoy was on board at 0958L and we immediately turned and got underway for San Juan, Puerto Rico.

The magnetometer stopped working during the turn from Line Dante-1 to Dante-2, and no further magnetic data were recorded during the survey. The 3.5 kHz profiler was periodically hanging up while trying to advance paper, and it provided no useful record until it was repaired about 1600L. Problems with the MCS tape drives and SCSI connections appeared during Line Dante-1, and short segments of MCS data were lost while repairs were made and the system was rebooted. During the latter half of Line Dante-4, there was considerable difficulty with the streamer not operating at the proper depth but coming to the surface, and much of this record is very noisy.

1-5 April. We steamed to San Juan, Puerto Rico, arriving to pick up the pilot outside San Juan Harbor at 0800L on 5 April.

WINDS AND SEAS

DATE	AVERAGE WIND DIRECTION	AVERAGE BEAUFORT FORCE	CORRESPONDING AVERAGE WIND SPEED (KNOTS)	AVERAGE SEAS (FEET)
MAR. 10	NE	3	10	4
11	SSE	4	13	6
12	SSW	4	13	6
13	S	5	19	6-8
14	SW	7	30	8-10
15	S	4	13	6
16	SW	2	5	4
17	WSW	5	19	6-8
18	WSW	6	24	6-8
19	WSW	6-7	24-30	10-12
20	WSW	6-7	24-30	10-12
21	NW-W	6-7	24-30	12-15
22	SW	4	13	6-8
23	E	4	13	4-6
24	E-S	5	19	8
25	E	4	13	4
26	E-S	6	24	6-8
27	E-S	4	13	4-6
28	SE	4	13	4
29	SSE	5	19	6
30	SW	4	13	4
31	NE	5	19	6
APR. 1	SSE	4	13	6
2	SE	4	13	4-6
3	SE	2	5	2
4	E	2	5	2
5	ARRIVAL	IN	SAN JUAN	P.R.

TIME, DATE, AND LOG KEEPING

All science records and logs kept on Ewing Cruise 01-02 were recorded in GMT (Zulu), which was **three hours ahead** of local, ship time during the MCS surveys. Date annotation was in either Calendar Day or Julian Day. The table below gives calendar days and corresponding Julian days.

CD	JD	CD	JD	CD	JD
10 Mar. (Sa)	69	19 Mar. (Mo)	78	28 Mar. (We)	87
11 Mar. (Su)	70	20 Mar. (Tu)	79	29 Mar. (Th)	88
12 Mar. (Mo)	71	21 Mar. (We)	80	30 Mar. (Fr)	89
13 Mar. (Tu)	72	22 Mar. (Th)	81	31 Mar. (Sa)	90
14 Mar. (We)	73	23 Mar. (Fr)	82	01 Apr. (Su)	91
15 Mar. (Th)	74	24 Mar. (Sa)	83	02 Apr. (Mo)	92
16 Mar. (Fr)	75	25 Mar. (Su)	84	03 Apr. (Tu)	93
17 Mar. (Sa)	76	26 Mar. (Mo)	85	04 Apr. (We)	94
18 Mar. (Su)	77	27 Mar. (Tu)	86	05 Apr. (Th)	95

Several hard-copy cruise logs were maintained in the Main Lab. A Science Watchstander Log (standard LDEO log sheets) was typically annotated every half hour and at every event with position, course, speed, etc. An R/V Maurice Ewing Seismic Recording Log was maintained once the seismic program commenced. A Scientific Lab Logbook also was maintained, containing miscellaneous detailed notes on events and observations during the cruise. Copies of all logs are in the possession of the Co-Chief Scientists, and copies will be archived at Woods Hole Oceanographic Institution.

DATA ACQUISITION: SYSTEMS, PROCESSING AND PERFORMANCE

Positioning of Sensors

The sonars and other sensing instruments used on Ewing are not located directly under the Tasmon GPS antenna. The displacement of each of the sensors with respect to the GPS antenna is as follows (see also Appendix IV):

-Magnetometer	about 230m aft
-3.5 kHz	32 m forward
-Hydrosweep	50.6 m forward
-Gravimeter	31 m forward
-Airgun array center	39.6 m + 13.8 m = 53.4 m aft
-Near-trace center, MCS streamer	221.25 m +13.8 m = 235.05 m aft

Ewing Data-Logging System

The main logging system is built around a Sun Ultra Enterprise 3000 server running the Solaris 8 operating system. From this computer, RS-232C serial lines go to the serial port of each of the instruments logged (e.g., GPS receiver, gravimeter). Each type of instrument has its own separate and slightly specialized logging program. In general, each data-record output by an instrument through its serial port is captured, time-stamped with the CPU's current time, and appended to the current daily file for the instrument. The GPS clock is also logged and the CPU clock is updated to UTC time each 30 minutes. The CPU time-tags are used for data from the Furuno speed log, BGM-3 gravimeter, magnetometer, and Hydrosweep bathymetry. The GPS data records are also time tagged with the CPU time but the time of position comes from the times established by the receiver for the position. When a logging process receives a new record from an instrument, it also passes it to another process that in turn "broadcasts" the data on the real-time network. This allows other computers on the real-time network to receive the new data and do such things as draw real-time plots. The Sun computer logs all data directly.

The sections below list the instruments and steps in the data logging and reduction sequence for instruments used during Ewing Cruise 01-02. Asterisks (*) indicate data logged on the Ewing data-logging system.

Time*

Instrument: Datum StarTime 9390-1000
Logging: 30 minute intervals.

Speed and Heading*

Instrument: Furuno CI-30 2-axis doppler speed log.
Logging: 3 second intervals.
Checking: Visual check of plot of data.
Smoothing: Mean value of all good values within the same minute.

GPS Satellite Fixes*

Primary navigation was from Tasmon P-Code and Trimble NT200D Global Positioning System (GPS) receivers. Good GPS navigation was obtained 24 hours per day.

Instruments: Tasmon P-Code and Trimble NT200D Global Positioning System receivers.
Note: Data set "gp1" is from the Tasmon P-Code receiver, and the data set "gp2" is from the Trimble receiver.
Logging: 10 second intervals
Checking:
-minimum number of sats: 4
-dilution of precision (DOP) maximum: north-4.0, east = 4.0
-compare GPS speed and course with Furuno smooth speed and heading
-reject fixes producing Eotvos correction errors in gravity
Interpolation: Interpolated positions at 00, 30 seconds of each minute.

Navigation*

A "1-minute navigation" was produced from the shipboard GPS and Furuno sources. The smoothed speed and heading data are used to fill the gaps between the processed GPS position by computing 1-minute dead-reckoned position corrected for set and drift. The dead-reckoned positions are produced at 00 seconds of each minute.

Note: Final navigation used the P-Code gp1 data set.

Center-Beam Bathymetry*

Instrument: Atlas Hydrosweep DS
Logging: Every ping.
Sound velocity: Center beam depths were recalculated using the traveltimes and a sound velocity of 1500 meter per second.
Checking: Visual check of plot of data.
Final data: Interpolated depth value (meters) at 00 seconds of each minute.

Magnetics*

The magnetic field was recorded using a Varian 75 magnetometer with a bottle towed nominally 230 meters behind the Tasmon GPS antenna on the ship. Digital recording was provided by the LDEO data logging system.

Instrument: Varian V75 magnetometer.
Logging: 6 second intervals.
Checking: Visual check of plot of data. Data were reduced by filtering with a median filter, and spikes were removed with a standard deviation filter.
Reference field: International Geomagnetic Reference Field 2000 (IGRF 2000) model of the main field at 2000.0 and a predictive model of the secular variation for adjusting to dates between 2000.0 and 2005.0
Final data: Median values at 00 seconds of each minute calculated from the values +- 30 seconds of this time.

Gravity*

<u>Gravimeter</u>

The gravity field was recorded on a BGM-3 gravimeter. Performance was excellent and trouble-free, except that the gyro had to be replaced in mid-cruise.

Instrument: Bell Aerospace BGM-3 marine gravity meter.
Logging: 1 second counts.
Filtering: An observed gravity value in mGal is calculated by filtering the 1-second counts with a 360-second Gaussian filter, scaling the result, and adding a bias. A value in mGal is calculated for 00 seconds of each time.
Merge with navigation: Calculate Eotvos correction and Free Air Anomaly. The velocities (from the navigation) that are used in the Eotvos correction are smoothed with a 5-point running average for all days.
Checking: Visual check of plot of data to determine satisfactory Eotvos corrections; delete spikes of data at turns.
DC shift: 7.30 mGal.
Final data provided by LDEO: Free Air Anomaly value at 00 seconds of each minute. 1980 theoretical gravity formula.

The first gravity tie of the ship gravimeter was made on 9 March 2001 by Systems Manager Jeff Turmelle at a dock tie-point in Charleston, SC. A second gravity tie will be carried out by Turmelle in San Juan, Puerto Rico at the end of the cruise. It is expected that the total drift of the BGM-3 gravimeter will be ca. 0.5 mGal for the 27-day period between gravity ties (0.02 mGal/day).

The gravity base stations in San Juan, Puerto Rico and Charleston, SC are not corrected for the 13.6 mGal "Potsdam Error". We therefore use the 1980 international formula in calculating the free-air anomaly, because this formula has a built-in correction for the Potsdam error.

<u>Free-Air Anomaly</u>

The raw gravity data were reduced to free-air anomaly (FAA) by Jeff Turmelle using the LDEO software "m_grv3.c". This Eotvos reduction process corrects for artificial gravity effects due to changes in ship course and speed:

$$eotvos\_corr=7.5038*vel\_east*\cos(lat) + 0.004154*vel^2$$

where vel is ship speed in knots and vel_east is eastward velocity. These velocities were derived from a smoothed GPS and Furuno navigation using software developed by Bill Robinson.

The FAA was also corrected for a regional field based on a 1980 theoretical gravity formula:

$$gtheo=978032.7*[1.0+0.0053024*\sin^2(lat) - 0.0000058*\sin^2(2*lat)]$$

We note that the "m_grv3.c" software also contains an option for the 1967 formula:

$$gtheo=978031.846*[1.0+0.005278895*\sin^2(lat) - 0.000023462*\sin^2(2*lat)]$$

and the 1930 formula:

$$gtheo=978049.0*[1.0+0.0052884*\sin^2(lat) - 0.0000059*\sin^2(2*lat)]$$

It appears that earlier LDEO cruises have used the 1967 and 1930 formula in calculating free-air anomalies. Since the 1980 formula differs by a constant from the 1930 formula, it is important to check the formula used in a specific LDEO survey when merging it with our current study.

Hydrosweep

Description

Hydrosweep is a 15-kHz multi-narrow-beam echosounding system that maps a seafloor swath nominally equal to twice water depth. For each insonification of the bottom, the system measures the round-trip travel times of 59 beams (29 port, 29 stbd, and 1 at nadir), each of approximately 1.5 degrees angular width athwartships, and estimates the depths. The system also logs echo amplitude and duration. An average sound velocity for the water column is used to convert the two-way travel times to estimates of depth and distance across track. The real-time processing estimates a depth, and cross-track distances do not take into account raypath bending due to variations in sound speed.

Performance

The Hydrosweep during Ewing 01-02 performed rather poorly, providing data with ca. 15-18% dropouts.

Bathymetry Processing

With the exception of center beam data, no Hydrosweep processing was done during this cruise. The center beam data were median filtered and merged with navigation using GMT's sample 1d.

Time Corrections

The time associated with each ping is set by the Hydrosweep processor, which is fed the correct UTC time from the Lamont data logging system. The host computer that performs this function receives time updates and corrections via a GPS-based clock. No further corrections to the Hydrosweep ping time are anticipated.

Beam-Amplitude Data

In addition to the travel-time data generated for the determination of bathymetry, the Hydrosweep DS system produces an eight-bit amplitude value per beam, along with the echo length. At present, there is no standard, established procedure for processing Hydrosweep amplitude data.

MCS System

The MCS system consisted of 6 kilometers of active sections with 40 active digital modules, 480 channels, and 12.5 meter groups. It used a Syntrak recording system, GCS gun firing system, Spectra navigation control, and Digiscan bird control. For this project we used 10 Bolt airguns, deployed as shown in Appendix IV.

3.5-kHz Profiler

Echosounding with hull-mounted EDO 3.5-kHz transducers (12-bottle array), an EDO 550 transceiver, and a 10 kW booster was conducted continuously throughout the cruise. During much of the cruise, profiles of digital data were recorded on an EPC9800 Thermal Plotter using an ungated 1-sec sweep, and they were automatically annotated on the half hour. For a period during the middle of the cruise, we had only an analog EPC9800 recorder available. During this time, the recorder (always at 1 second sweep) was intermittently re-programmed to follow changing seafloor depth and hand annotations were made on the records; however, the hand annotations were not made consistently. The hardcopy profiles were recorded on a plasticized medium, in roll form, and then accordion folded and stored in large envelopes for easy access. The original records were taken to Woods Hole Oceanographic Institution for analysis and archiving.

PROBLEMS AND RECOMMENDATIONS - EWING CRUISE 01-02

MCS SYNTRON System

In general the SYNTRON system worked well. Chris Leidhold (Science Officer) did have to reboot the system twice during shooting because of the SCSI bus hanging due to failures in the 3490E tape drives. On each occasion, ~0.5 hours of valuable data was lost. The 3490E tape drives continue to be an intermittent problem, either hanging up or unloading before the tape is full.

3490E Tape Pre-tensioner

This system failed constantly. Typically, it took a lot of work by Chris Leidhold or Karl Hagel to get the tensioner working again. The tensioner needs to be repaired or replaced.

Spectra Integrated Navigation System

This was the first MCS experiment which made use of the Spectra Integrated Navigation System. Operational testing of this system prior to MCS operations was limited to ~3 hours just outside the harbor at Charleston, S.C. Of course, this test did not involve deployment of the streamer or any shooting. Not surprisingly with a package of this complexity, we experienced some teething problems with the Spectra system during the early part of our cruise. In our opinion, it would have been more appropriate if the LDEO Marine Office had scheduled a short 1 or 2 day test cruise to debug the new system rather than to do this debugging during an actual experiment. However, it is clear to us that this is a very powerful package that will benefit the MCS community in the long run. LDEO is to be commended for upgrading to this state-of-the-art system.

Throughout the cruise, the Spectra system was never successfully integrated with the ship's steering system, with the result that all MCS lines were steered with old InStar system. This problem needs to be corrected.

The hardware box (labeled RTNu) that provided inputs such as Hydrosweep center-beam depth, gun depths, tail buoy position, etc. to the Spectra system hung periodically with the result that these data were not logged by Spectra and hence were not available to be written to the SEG-D header. (These data are recorded elsewhere but will have to be loaded into the shot headers later rather than in real time.) The fix to this problem involved powering off/powering on the RTNu box. A new board is promised at the end of the cruise.

With the use of the Spectra system, the science watchstanders have more control over data acquisition but also more responsibilities. There are more windows to watch, and more ways that the user can mess up. LDEO should write up a complete watchstanders' manual and have it available for all MCS cruises.

Airguns and Firing Systems

The airguns worked very well throughout the cruise. By towing two spare guns we were able to maintain a 10-gun array throughout the duration of the experiment despite the occasional leaky airhose, lost float, etc.

At the start of the experiment, the GCS90 airgun firing system failed to display all of the airgun blast phones. The concern here was whether or not all of the guns were firing synchronously. Between shooting lines, Chris Leidhold swapped boards with no effect. However, during the transit to our second site, Chris took the system apart, removed a lot of dust from the VME bus, put it together again, and it worked perfectly thereafter.

Throughout most of the experiment, occasionally we missed shots, i.e. the airguns did not fire. This problem seemed to happen more frequently if the ship's speed over the ground was >= 4.8 knots. This was a puzzle because the shot interval was ~15 s, and the system should not have a problem firing at this rate. Chris noticed an extra character in the output of the GCS90 firing system. Prior to the last day of shooting, Chris reloaded the GCS90 software and the "missed shot" problem went away, so this problem presumably is fixed.

ACKNOWLEDGMENTS

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APPENDIX I. Tape Copy Script

Tape Copy Script

```
#               EW0102 SIOSEIS tape copy/reformat script

#run on "grampus" in directory:
/export/home/ew0102/realtime/reformat

#   Go to trace 481 to include the sonobouy


sioseis << eof
procs segdin output end
segdin
   secs 10
   ffilen 99999   # take all shots (this is the preset!)
   ftr 1 ltr 481  # skip the auxiliary channels - 161-172 and 161-
180
   fcset 1 lcset 1
   offline yes  # eject after the rewind after EOT
   newfile yes  # start a new SEG-Y file on every SEG-D tape
   iunit 11 end
end

output
   ontrcs 481
   rewind 0   # leave the tape alone!
   ounit 21 end
end
end
eof
```

APPENDIX II. Brute Stack Script

Brute Stack Script

```
#! /bin/csh

#                EW0102 SIOSEIS "realtime" stack script

#run on "grampus" in directory:    /export/home/ew0102/realtime/brute_stack


if( $#argv < 1 ) then
    echo ""
    echo " ******************************************************"
    echo " *                                                    *"
    echo " *  Not enough parameters\!  You need a LINE number\!  *"
    echo " *        Usage: brutestack line-number               *"
    echo " *                                                    *"
    echo " ******************************************************"
    echo ""
    exit 1
endif
set LINENO = $1

sioseis << eof

procs segdin prout geom header diskob gather nmo mute diskod stack diskoe filter
agc plot end

segdin
! take all shots
   ffilen 99999
!   ftr 1 ltr 480 trinc 2 fcset 1 lcset 1
   ftr 241 ltr 480 fcset 1 lcset 1
!   stime 1 secs 5.0    Used for line 1 ew0102
   stime 1 secs 7.0
   offline yes  # eject after the rewind after EOT
   iunit 11 end
end

prout
 fno 0 lno 99999 ftr 479 ltr 479 noinc 10 end
end

geom
  type 2 # increment the shot loaction based on the shot number
  fs 1 ls 999999  # all shot have the same parameters (preset)
!  gxp 480 -196.6   # RESET the closest group only.
  gxp 480 -181.65   # RESET the closest group only.
  ggx -12.5         # Used to extrapolate gxp!
 dfls 37.5 dbrps 6.25 smear 6.25
!  dfls 37.5 dbrps 12.5 smear 12.5
  rpadd 1000 end
end

header
```

```
   fno 0 lno 9999999 ftr 1 ltr 9999
   r50 r54 / 750.  # convert water depth to water time
   end
end

diskob
! write every 50th shot to a "circular" file
    fno 1 lno 999999 noinc 50 rewind 1
    opath /export/home/ew0102/realtime/shots/latest.shot end
end


gather
!   maxtrs 90 maxrps 500 end
   maxtrs 50 maxrps 250 end
end

nmo
! real time nmo, replace interpolation by RP to WB depth in Meters.
! If water depth changes by > 500 m, use previous value. Water-depth
! velocity functions derived from ESP5, interpolation by iso-velocity layering
 vtrkwb 500 stretc 0.50
 fno 1000 lno 1000
 vtp 1500 1.333
     1557 1.414
     1607 1.443
     1789 1.492
     2346 1.645
     2638 1.746
     2900 1.846
     2971 1.872
     3150 1.983
     3141 2.102
     3264 2.362
     4228 3.742
     4343 3.892
     4898 4.393 end
 fno 1500 lno 1500
 vtp 1500 2.0
     1539 2.081
     1574 2.110
     1705 2.159
     2137 2.312
     2379 2.413
     2603 2.513
     2665 2.539
     2827 2.650
     2834 2.769
     2967 3.029
     3939 4.409
     4053 4.559
     4596 5.060 end
 fno 2000 lno 2000
 vtp 1500 2.667
     1529 2.748
     1557 2.777
     1659 2.826
```

```
    2012 2.979
    2218 3.080
    2414 3.180
    2468 3.206
    2614 3.317
    2629 3.436
    2761 3.696
    3711 5.076
    3823 5.226
    4351 5.727 end
fno 2500 lno 2500
vtp 1500 3.333
    1524 3.414
    1546 3.443
    1629 3.492
    1928 3.645
    2108 3.746
    2282 3.846
    2330 3.872
    2463 3.983
    2481 4.102
    2608 4.362
    3526 5.742
    3636 5.892
    4146 6.393 end
fno 3000 lno 3000
vtp 1500 4.0
    1520 4.080
    1538 4.110
    1609 4.159
    1868 4.312
    2028 4.413
    2184 4.513
    2228 4.539
    2350 4.650
    2368 4.769
    2489 5.029
    3373 6.409
    3479 6.559
    3972 7.060 end
fno 3500 lno 3500
vtp 1500 4.667
    1517 4.748
    1533 4.777
    1595 4.826
    1823 4.979
    1967 5.080
    2108 5.180
    2148 5.206
    2260 5.317
    2279 5.436
    2395 5.696
    3243 7.076
    3346 7.226
    3822 7.727 end
fno 4000 lno 4000
vtp 1500 5.333
```

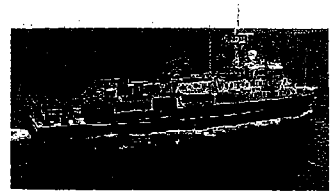
```
     1515 5.414
     1529 5.443
     1583 5.492
     1788 5.645
     1919 5.746
     2048 5.846
     2085 5.872
     2189 5.983
     2208 6.102
     2317 6.362
     3131 7.742
     3231 7.892
     3692 8.393 end
 fno 4500 lno 4500
 vtp 1500 6.0
     1513 6.081
     1526 6.110
     1574 6.159
     1760 6.312
     1879 6.413
     1999 6.513
     2033 6.539
     2130 6.650
     2148 6.769
     2252 7.029
     3034 8.409
     3131 8.559
     3577 9.060 end
 fno 5000 lno 5000
 vtp 1500 6.667
     1512 6.748
     1523 6.777
     1567 6.826
     1737 6.979
     1847 7.080
     1958 7.180
     1990 7.206
     2080 7.317
     2098 7.436
     2197 7.696
     2948 9.076
     3042 9.226
     3474 9.727 end
end

mute
   fno 1 lno 999999
   addwb yes xtp 200 -.1 1500 -.1 3000 1 6200 2 end
end

diskod
    fno 1 lno 999999 noinc 50 rewind 1
    opath /export/home/ew0102/realtime/shots/latest.mute end
end

diskoe   # Write out disk file
  opath  /export/home/ew0102/realtime/stacks/stack.$LINENO end
```

```
end

filter
    pass 5 40 ftype 0 dbdrop 48 end
end

!diskoa   # Write out disk file
!  opath MEGAMULLION.$LINENO end
!end

!diskoc
!    set 3 6 opath /export/home/ew0102/realtime/cmps/cmps.$LINENO end
!end

agc
   winlen .5 center .1 end
end

plot
  scalar 1.e-07
!  tlines 0.5 1 nibs 7224 ann gmtint anninc 30
  tlines 0.5 1 nibs 7224 ann gmt anninc 10
!  tlines 0.5 1 nibs 7224 ann sh&tr anninc 30
  def 0.01 trpin 80 wiggle 0
  stime 1 nsecs 7 vscale 2.5
!  stime 1 nsecs 5 vscale 3.75  used for line 1
!  stime 2 nsecs 4 vscale 5
  opath siopltfil.$LINENO
!   srpath sunfil end
end

end
end
eof
```

APPENDIX III. LDEO Data Aquisition and Reduction Report

Lamont- Doherty Earth Observatory
Office of Marine Affairs
61 Route 9W
Palisades, NY 10969

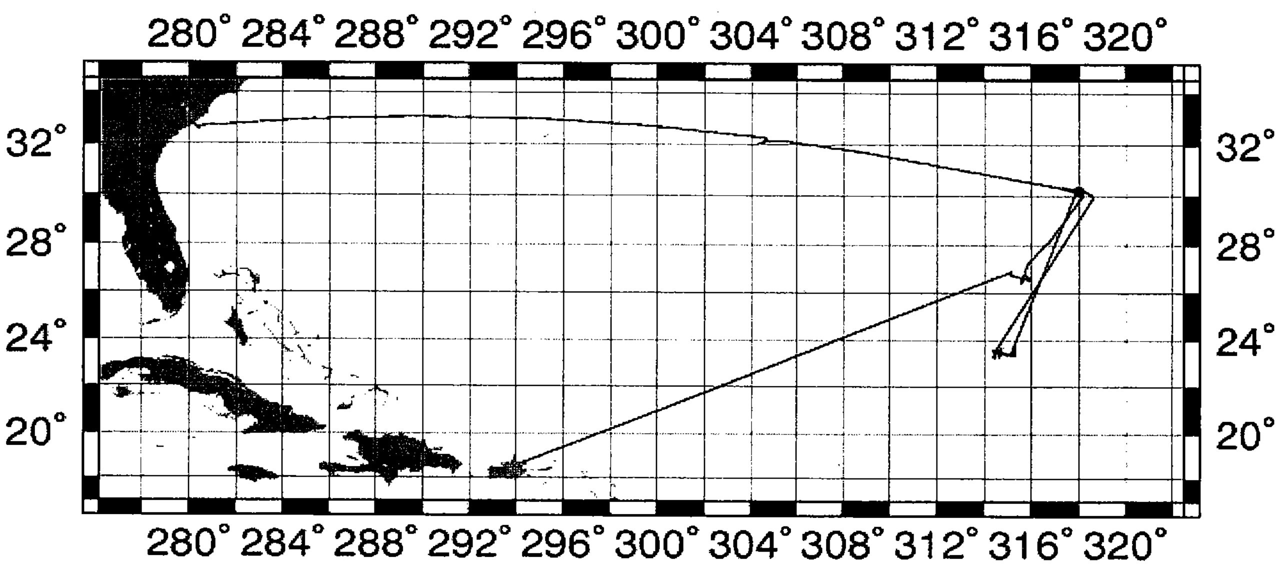
Prepared By:Jeffrey Turmelle
jefft@ldeo.columbia.edu
845 365-8677



R/V Maurice Ewing Data Reduction Summary

EW-0102 Charleston, SC – San Juan, Puerto Rico

Date	Julian Date	Time	Port
March 10, 2001	69	22:00:00	Charleston, SC
April 5, 2001	95	12:03:00	San Juan, Puerto Rico



Project Summary

Mid–Atlantic Ridge Megamullions MCS

Background and Scientific Objectives

Understanding the geological and geophysical structure of ocean crust is a fundamental goal of the earth science community. Primary data on lithology and lithological–structural relations of the sub–volcanic section in the ocean basins have been acquired by ocean drilling and to some extent by submersible studies. However, this record is very incomple, and ocean drilling to penetrate the entire crust (or even a large fraction thereof) is unlikely to be achieved in the near future. Data on seismic velocity in ocean crustal layers have been correlated with laboratory measurements of velocity in mafic and ultramafic oceanic rocks and with some borehol seismic results in order to infer a layered lithology similar to the Penrose ophiolite model. However, it is uncertain to what degree the idealized Penrose model is representative of normal ocean crust.

The recent discovery of megamullions provides an outstanding new opportunity to study the geological and geophysical character of ocean lithosphere on spreading ridges that have limited magma supply. These features are interpreted to be footwall blocks of long–lived (~1 - 2.5 my) normal faults and the appear to expose extensive (~15 - 35 km) cross sections of the crust and uppermost mantle at the seafloor (*Tucholke et al.*, 1998b.). This exposure offers relatively unimpeded access for both geological and geophysical sampling to determine the true nature of in–situ ocean crust.

The present cruise was a multi–channel seismic (MCS) investigation of three of the best-developed megamullions known on the Mid–Atlantic Ridge (MAR) in the central North Atlantic ocean. The geometric characteristics of the megamullions (unusually smooth surface, shallow depths) are very favorable for high–resolution seismic determination of seismic velocity and structure, in contrast to MCS study of normal, slow–spreading crust whicih is hampered by multiple reflections from the extremely irregular topography. By obtaining several seismic lines over each megamullion, our program attempts to establis lateral coherence or variablility of crustal structure in both strike and dip directions. Our goals are 1) to obtain high–resolution velocity structure of the megamullions, 2) to relate this to probable composition, including possible alteration effects such as serpentization of mantle ultramafics and 3) where possible to image structural discontinuities including the relict detachment shear zone dipping through the lithosphere at the young end (termination) of the megamullion. To the extent possible within the time allowed, we also obtained MCS profiles on crust conjugate to the megamullions, so as to investigate how the structure of this 'hanging–wall crust' was affected during the period of megamullion formation. Interpretations of our seismic results will be further constrained by modelling density distribution in the megamullion s from gravity data obtained during the survey. The three megamullions studied here have near–bottom survey and sampling programs either planned, proposed or already conducted.

Our MCS studies and the sampling studies are complementary and will benefit one another in interpretation of results.

Cruise Members

Science Party

Brian Tucholke	Chief Scientist	btucholke@whoi.edu
John Collins		jcollins@whoi.edu
Tom Bolmer		tbolmer@whoi.edu
Juan Pablo Canales		jpcanales@whoi.edu
Robin Kelly		rkelly@whoi.edu

Ship's Science

Chris Leidhold	Science Officer	sci@ewing.ldeo.columbia.edu
John Dibernardo	PSSO	gunners@ewing.ldeo.columbia.edu
Carlos Gutierrez	PSSO	gunners@ewing.ldeo.columbia.edu
Karl Hagel	ET	hagel@ldeo.columbia.edu
Winston Seiler	Gunner	winston@ldeo.columbia.edu
Jeff Turmelle	Data Reduction	jefft@ldeo.columbia.edu
Justin Walsh	Gunner	cabinboy@ldeo.columbia.edu

Ship Crew

James O'Loughlin	Captain	captain@ewing.ldeo.columbia.edu
Steven Pica	Chief Engineer	engine@ewing.ldeo.columbia.edu
Gilbert Thurston	1st Mate	
Jeffrey Sylvia	2nd Mate	
RJ DiMattia	3rd Mate	
Gartz Gould	1st A/Engineer	
Miguel Flores	2nd A/Engineer	
Daniel LoCasto	3rd A/Engineer	
John Smith	Steward	
David Philbrick	Bosun	
Aubrey, Benjamin	A/B	
Grieg, Alexander	A/B	
Malloy, Robert	Oiler	
Moqo, Luke	Messman	
Peck, Scott	A/B	
Schwartz, Jack	Electrician	
Spruill, Michael	Oiler	
Sypongco, Arnold	O/S	
Taylor, Kelly	Cook	
Uribe, Fernando	Oiler	
Wheeler, Christopher	O/S	

All data in this report is logged using GMT time and Julian days in order to avoid confusion with local time changes.

Spectra

Spectra logs data to files in UKOOA[1] P1/90 format and P2/94 Format. The file formats are included in separate PDF documents on the tape. The contents of these files contain all the parameters used during shooting each of the lines, as well as the positions of all the sensors. I have included perl scripts for extracting shot times and positions from the P1 and P2 files on the tape.

This cruise was the first cruise running the Spectra navigation and seismic shooting system. There were some problems related to this:

1. Tailbuoy configuration was initially incorrect due to several configuration problems:
   Manual compass configuration was set to a depth bird instead of a compass bird.
   No magnetic declination was input for the compass data.
   Tailbuoy range did not take into account the Vessel Reference Offset.
   This was fixed by the time the MEG-1 line was shot.
2. P2 data was not logged for all the shots on the first few lines due to a configuration error in the Spectra logging configuration:
   Since the *approach shots* do not count as the *actual shot start,* it is necessary to start logging **approach shots** <u>before</u> the **actual shot point.**
3. Problems combining the Spectra output shot header and various Ewing input logs caused some data (*line 1*) for shots to be unrecoverably lost (see #2).
4. Shot times are not accounted for in the millisecond range in the P2 files.
5. An RTNu (spectra box) hung causing Hydrosweep data to be lost in the Seg-D headers for much of Day 083.

Positioning of Sensors

The Spectra system defines a reference point which is used as a reference to all points which need an offset (range and bearing to TB, for example). This reference point has been defined as the center of the ship's mast, at sealevel.

Any documentation included herein that refers to the vessel reference or reference or master will be referring to this reference point.

However, daily navigation files that are not related to spectra (ie. n., hb.n, mg.n, files) are referenced to the Tasmon P-Code GPS filtered positions.

Offset information can be found under the **Ship Diagrams** section of this document.

Data Reduction

Since spectra positions its shots precisely based on a Kalman filtering algorithm, we will assume that it has the correct shot location. However, as a fallback measure, I have also processed the shots using our normal navigation filtering.

Therefore you will find the following shotlog files:

1 *United Kingdom Offshore Operators Association*

- nb0.r Contains shot times and positions based on Spectra positioning.
- nb2.r Contains shot times and positions based on Spectra navigation
- ts.n Contains shot times and positions based on Ewing navigation
- shots.p1 Contains shot times and positions based on Spectra P1 files
- shots.p2 Contains shot times and positions based on Spectra P2 files

Please see the File Formats section for more information on these files.

Hydrosweep

Hydrosweep acquisition was extremely bad during this cruise with 18% average dropouts. No processing was done on the Hydrosweep bathymetry

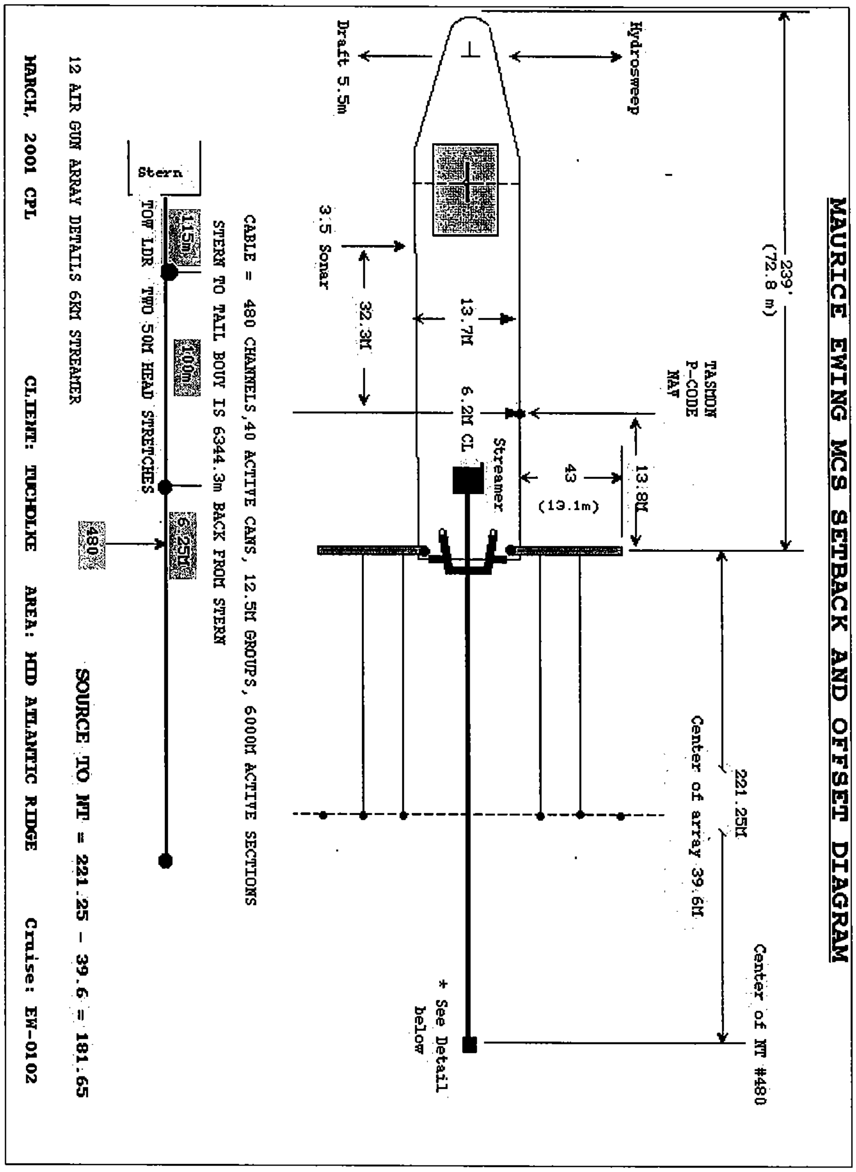
Gravity

One of the gyros failed on Julian Day 088 at 0200Z, and was promptly replaced by Chris by 0800Z on the same day

Seismic Acquisition

There were 2 failures of the Syntron system this cruise. Both related to tape drive failures. Streamer configuration files are included on the tape in Excel 97 format.

Ship Offset Diagram



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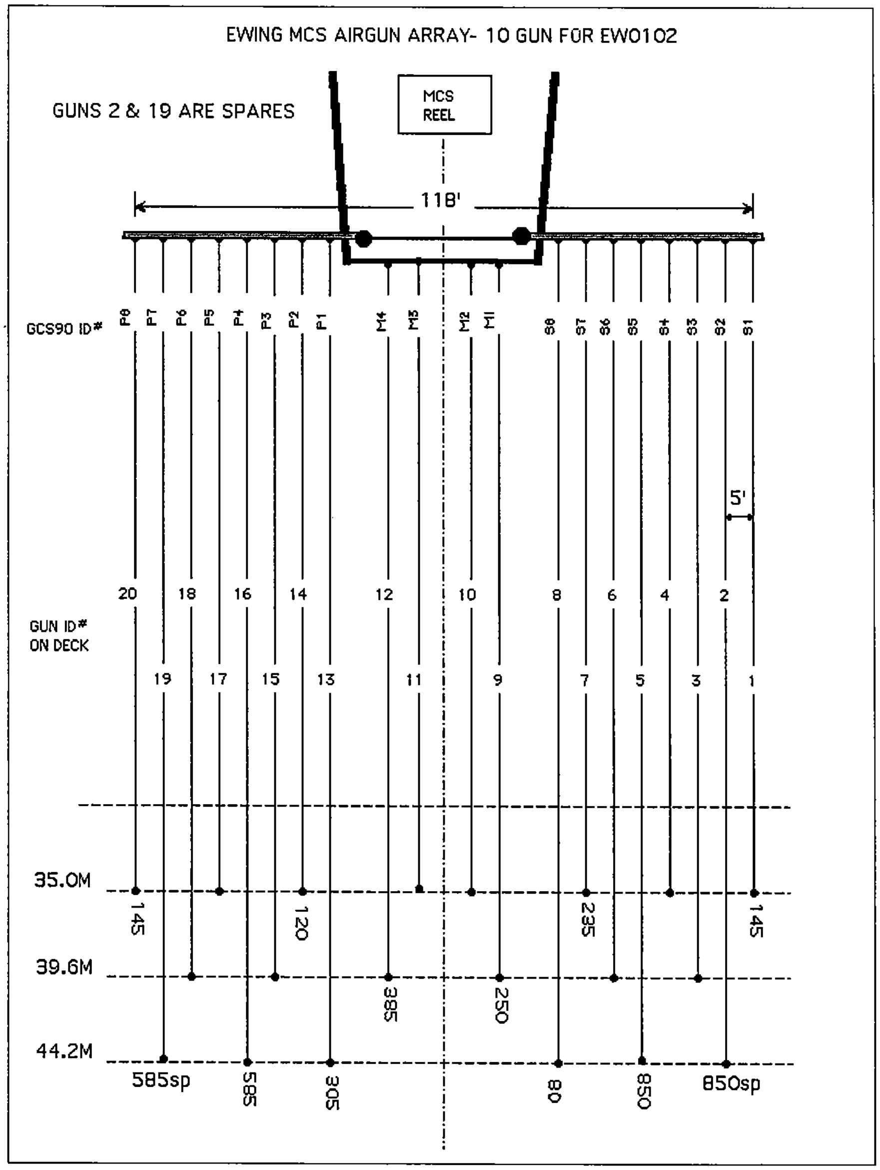
Guns Diagram



Data Logging

The R/V Maurice Ewing data logging system is run on a Sparc Ultra Enterprise Server. Attached are 48 serial ports via 3 16-port Digi International SCSI Terminal Servers. Generally, all data logged by the Ewing Data Acquisition System (DAS) is time stamped with the CPU time of the server, and broadcast to the Ewing network using UDP packet broadcasts. The CPU time of the server is synchronized once every half hour to a Datum UTC gps time clock.

GPS times are also time-tagged with cpu time, although the time of the GPS position is from the GPS fix itself.

The following tables describe the data instruments which performed logging during this cruise. The tables associated with the instruments describe logging periods and data losses for that instrument.

Time Reference

Datum StarTime 9390-1000

logging interval: 30 minutes
file id: tr2

Used as the CPU synchronization clock. This clock is polled once every half hour to synchronize the CPU clock of the data logger to UTC time. The logger (octopus) is responsible for updating the times of the other CPUs.

This clock was running and synchronizing the system the entire cruise.

Interruption s greater than 30 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+069:19:53:30.128		Logging officially started
2001+095:16:30		Logging officially ends

Spectra

Spectra uses its own Trimble gps receiver for synchronizing its hardware to UTC time. This is the time the shot points are referenced to; not the CPU time.

Spectra P2 files were logged, although due to some configuration problems, not all shots at the beginning of the lines were logged.

GPS Receivers

GPS data is usually logged at 10 second intervals. The NMEA strings GPGGA and GPVTG are logged for position, speed, and heading fixes. This data was logged constantly throughout the cruise.

The Tasmon GPS was the primary GPS for this cruise.

Trimble Tasmon P/Y Code Receiver

logging interval: 10 seconds
file id: gp1

The Tasmon is the primary GPS receiver for the Ewing Logging system and the primary GPS for Spectra fixes. The accuracy is around 15 meters. There were no interruptions during this cruise.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+069:19:54:54.360		Logging officially started
2001+095:16:30:00		Logging officially ends

Trimble NT200D

logging interval: 10 seconds
file id: gp2

The Trimble is the secondary receiver for GPS data. Data is logged at 10 second intervals and is also used as an input to Spectra, although it is weighed at a lower value than the Tasmon receiver.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+069:19:55:03.310		Logging officially started
2001+070:00:39:46.010	2001+070:00:56:43.650	Data interruption
2001+070:22:13:48.067	2001+071:20:33:15.798	Data interruption
2001+073:02:06:47.968	2001+073:02:21:26.131	Data interruption
2001+095:16:30:		Logging Ends

Tailbuoy Garmin GP8

logging interval: 10 seconds
file id: tb1

The tailbuoy receiver was not working for the first 3 MEG lines. After this the tailbuoy worked during all lines with the exception of minor blackouts during turns and during the streamer failure on line KANE-7. Also note that often, the tailbuoy was being logged while it was on deck for testing purposes.

Interruptions greater than 30 minutes are displayed in the following table

Log Date	Log Date	Comment
2001+070:00:00:15.362	2001+070:12:53:21.811	Tailbuoy logging starts
2001+070:16:44:11.018	2001+071:18:21:45.334	
2001+071:19:31:22.632	2001+071:20:13:07.786	
2001+071:22:23:55.743	2001+071:22:37:35.688	
2001+071:23:40:29.962	2001+071:23:49:08.511	
2001+072:00:46:56.377	2001+072:12:53:25.941	
2001+072:13:38:43.579	2001+074:15:08:21.597	
2001+074:15:55:05.932	2001+074:16:05:18.766	
2001+074:19:15:55.166	2001+074:19:27:54.002	
2001+075:00:54:30.554	2001+075:02:38:32.641	
2001+075:08:08:38.979	2001+075:12:22:10.260	
2001+075:13:52:44.824	2001+076:12:36:45.708	
2001+076:19:22:58.309	2001+077:21:32:48.410	
2001+077:22:04:14.033	2001+078:19:47:49.875	
2001+078:20:50:25.341	2001+080:22:15:23.761	
2001+080:22:49:43.931	2001+082:16:43:14.794	
2001+082:19:00:08.925	2001+086:11:37:41.578	
2001+086:12:22:29.325	2001+086:13:00:28.535	
2001+086:14:53:48.197	2001+089:05:29:43.639	
2001+089:06:30:40.732	2001+089:09:50:45.903	
2001+089:12:37:40.947	2001+090:16:23:30.722	Tailbuoy logging officially ends

Speed and Heading

Furuno CI-30 Dual Axis Speed Log
Sperry MK-27 Gyro

logging interval: 6 seconds
file id: fu

The Furuno and Gyro are combined to output speed, heading and course information to a raw Furuno file, as well as an NMEA VDVHW signal used as an input to various systems including steering and Spectra.

Interruptions greater than 30 minutes are displayed in the following table

Log Date	Log Date	Comment
2001+069:19:56:07.600		Official start date
2001+095::16:30:00		Official end date

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Gravity

Bell Aerospace BGM-3 Marine Gravity Meter System

logging interval: 1 second
file id: vc. (raw), vt. (processed)
drift per day: 0.035

The BGM consists of a forced feedback accelerometer mounted on a gyro stabilized platform. The gravity meter outputs raw counts approximately once per second which are logged and processed to provide real-time gravity displays during the course of the cruise as well as adjusted gravity data at the end of the cruise.

The BGM lost a gyro on day 088 of the cruise and was fixed 4 hours later by Chris.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	Log Date	Comment
2001+069:19:57:10.772		Official start date
2001+088:02:09:50.970	2001+088:06:39:33.717	Lost BGM output
2001+095:16:30		Official end time

Bathymetry

Krupp Atlas Hydrosweep-DS

logging interval: variable based on water depth
file id: hb (centerbeam), hs (swath)

The hydrosweep full swath data is continuously logged for every cruise, and centerbeam data is extracted and processed separately. The centerbeam operates at a logging frequency dependent on the water depth.

The full swath data is not routinely processed, but can be processed with the MB-System software which can be downloaded for free. For instructions, use the website: http://www.ldeo.columbia.edu/MB-System.

MBSystem, version 4.6.10 is necessary to process data after Jan 1, 2000.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+069:22:23:05.000		Official start logging
2001+073:02:06:36.000	2001+073:02:18:55.000	HS Interruption
2001+078:03:12:58.000	2001+078:03:35:56.000	HS Interruption
2001+088:23:24:22.000	2001+089:00:42:16.000	HS Interruption
2001+095:16:30		Official end logging

Weather Station

RM Young Precision Meteorological Instruments, 26700 series

logging interval: 1 minute
file id: wx

The weather station is used to log wind speed, direction, air temperature, and barometric pressure. We log this information at 1-minute intervals.

Log Date	LogDate	Comment
2001+069:19:57:45.736		Official start logging
2001+073:02:07:00.189	2001+073:02:17:17.327	Interruption
2001+074:20:45:00.763	2001+074:20:57:55.603	Interruption
2001+095:16:		Official end logging

Magnetics

Varian Magnetometer

logging interval: 12 seconds
file id: mg

The following table shows the times the magnetometer was logging

Start Log Date	End LogDate	Comment
2001+077:02:39:25.537	2001+077:20:24:23.970	Logging interval 1
2001+079:14:30:05.838	2001+080:11:52:11.516	Logging interval 2
2001+082:21:07:16.963	2001+084:23:43:28.668	Logging interval 3
2001+086:20:12:25.017	2001+087:16:12:08.402	Logging interval 4
2001+087:17:20:20.147	2001+088:03:46:41.557	Logging interval 5
2001+089:06:43:10.716	2001+089:19:35:28.228	Logging interval 6
2001+089:21:14:18.575	2001+090:08:04:29.841	Logging interval 7

Seismic Lines

The Spectra system was used for the first time as the system to fire the guns and log the shot times. Since we are still in the process of integrating the Spectra system into the Ewing system, this resulted in some compromises in shot logging.

The following items were of concern during this cruise:

- The P2 and P1 formats do not store the shot time in millisecond range
- SIOSEIS cannot handle the Spectra output header for SEG-D

Due to these facts, I created a system where we would use data from the Spectra header, data from the Digicourse cable output, data from the gun depths, and real-time data from the Ewing logging system to compose a Ewing standard SEG-D header readable by SIOSEIS to place on the 3490 tape for each shot.

Due to several bugs in my software, some shot data was lost during the first few lines. Due to configuration errors in Spectra, the P2 file format wasn't being logged for up to 60 of the first shots in a line. The Spectra default logging was for 20 shots before the start of line. Since Spectra doesn't count the approach length as the start of line, any approach length greater than 20 shots (50 shots was standard for this cruise) was not logged until we realized this.

Also, tailbuoy information could be incorrect in the Spectra files, as we did not have the tailbuoy correctly configured for the first half of the cruise. The tailbuoy data in the processed files tb1.c, is the raw data and will be correct.

There are several files for each line reflecting the line status:

File	Description
ts.n	Shot time is merged with Ewing navigation to determine shot location
nb2.r	Navigation is from Spectra, and includes tailbuoy, tailbuoy range and bearing
shotlog.p1	Shots are from the p1 file. (should be identical to nb2.r), includes source position
shotlog.p2	Shots are from the p2 file (should be identical to tss.n), includes source position

Shot Files Table

Line Name	Times ()	Ewing(ts.n, nb2.r)		Spectra (shots.p1, shotlog.p2)		
		Shots	Missing	P1 Shots	P2 Shots	Missing
MEGA-1	079:15:20:57 079:20:47:43	140-1353	100-139, 260-262, 383-386, 507-509, 627-634, 978-1139, 1150-1163, 1170, 1175-1181, 1192-1200, 1203, 1218-1219	170-1353	172-1353	
MEGA-2	080:00:00:05 080:03:48:41	1727-2569	2412-2430	1393-2569	1395-2569	
MEGA-3	080:05:55:34 080:11:08:34	2571-3730	2783	2610-3730	2612-3730	
MEG-4	086:21:20:38 087:02:00:45	12656-13707		12786-13707	12788-13707	
MEG-5	087:03:21:28 087:06:46:40	13707-14460	13891	13707-14460	13709-14460	
MEG-6	087:08:02:34 087:10:33:43	14462-15035		14461-15035	14463-15035	
MEG-7	087:11:05:36 087:13:31:23	15037-15569		15036-15569	15038-15569	
MEG-8	087:14:12:36 087:17:35:29	15571-16318		15570-16318	15572-16318	
MEG-9	087:19:45:27 087:22:19:23	16320-16904		16319-16904	16321-16904	
MEG-10	087:23:43:11 088:03:20:46	16905-17711		16905-17711	16907-17711	
KANE-1	082:21:32:55 083:07:43:42	4000-6296	6090	4039-6296	4041-6296	
KANE-2	083:08:28:43 083:10:55:28	6298-6858	6336?	6337-6858	6339-6858	
KANE-3	083:12:48:52 083:15:11:00	6860-7385		6859-7385	6861-7385	

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Line Name	Times ()	Ewing(ts.n, nb2.r)		Spectra (shots.p1, shotlog.p2)		
		Shots	Missing	P1 Shots	P2 Shots	Missing
KANE-4	083:15:54:47 084:01:34:29	7397-9605	8745	7396-9605	7398-9605	9058-9062 9064-9070 9072-9073 9075-9079
KANE-5	084:05:04:02 084:07:15:01	9606-10109		9606-10109	9608-10109	
KANE-6	084:08:20:45 084:11:11:55	10110-10766		10110-10766	10112-10766	
KANE-7	084:12:28:03 084:16:34:01	10768-11707		10767-11707	10769-11707	
KANE-8	084:19:39:34 084:23:36:19	11761-12655		11761-12655	11763-12655	
DANTE-1	089:06:47:05 089:12:23:30	17713-18973	17953, 18187	17749-18973	17751-18973	
DANTE-2	089:13:35:15 089:17:19:40	18975-19809		18974-19809	18976-19809	
DANTE-3	089:18:10:50 089:21:14:10	19811-20505		19810-20506	19812-20506	
DANTE-4	089:22:29:41 090:07:41:33	20508-22687		20507-22687	20509-22687	

Charleston, SC

EW0102 Charleston, SC

Pier/Ship **Latitude** **Longitude**

32 51.119N	079 56.8611W

Pier N, Old Charleston Navy Base, near the second "shack" in the middle of the doc

Reference **Latitude** **Longitude**

32 47.80 N	079 57.80W

Citadel University, Bond Hall in front of the Registrar's Office between the mechanic room and the elevator.

	EW0007	230	09.03.01	3.44	0.02	3.44
	Id	**Julian**	**Date**	**Mistie**	**Drift/Day**	**Prev Mistie**
Pre Cruise	EW0007	230	12.08.00	3.44	0.02	3.44
Post Cruise	EW0102	230	09.03.01	7.30	0.018	3.44
Total Days			209.00	3.86		

Time	Entry	Value	
20:40	CDeck Level BELOW Pier	1.30	
20:40	Pier 1 L&R Value	3165.11	L&R
21:20	Reference L&R Value	3154.22	L&R
21:50	Pier 2 L&R Value	3165.11	L&R
###	Reference Gravity	979550.05	mGals
22:55	Gravity Meter Value (BGM Reading)	979571.00	mGals
	Potsdam Corrected	0	1 if corrected

Gravity meter is 5.5 meters below CDeck

Difference in meters between Gravity Meter and Pier: 6.80 meters

Height Cor = Pier Height* FAA Constant

6.80	0.31			2.11 mGals/min

Difference in mGals between Pier and Gravity Meter

Pier (avg) -	Reference *1.06 L&R/mGal			Delta L&R
3165.11	3154.22	1.06		11.54 mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam]				Pier Gravity
979550.05	11.54	0.00		979561.59 mgals

Gravity in mGals at Meter

Pier Gravity+	Height Correction			Gravity@meter
979561.59	2.11			979563.70 mGals

Current Mistie

BGM Reading	Calculated Gravity			Current Mistie
979571.00	979563.70			7.30 mGals

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EW0103 San Juan, Puerto Rico

Pier/Ship	Latitude	Longitude
	18 27.84N	66 06.36W

Pier 8

Reference	Latitude	Longitude
	18 27.8N	66 05.5W

Cruise Ship terminal

	Id	Julian	Date	Mistie	Drift/Day	Prev Mistie
Pre Cruise	EW0102	230	09. Mar 01	7.30	0.02	3.44
Post Cruise	EW0103	68	05. Apr 01	8.25	0.035	7.30
Total Days			27.00	0.95		

Time	Entry	Value	
1400	CDeck Level BELOW Pier	0.00	
1410	Pier 1 L&R Value	2332.11	L&R
1430	Reference L&R Value	2334.21	L&R
	Pier 2 L&R Value	2332.11	L&R
	Reference Gravity	978680.69	mGals
	Gravity Meter Value (BGM Reading	978688.42	mGals
	Potsdam Corrected	0	1 if corrected

Gravity meter is 5.5 meters below CDeck

Difference in meters between Gravity Meter and Pier: 5.50 meters

Height Cor = Pier Height* FAA Constant

Pier Height*	FAA Constant			
5.50	0.31			1.71 mGals/min

Difference in mGals between Pier and Gravity Meter

Pier (avg) -	Reference	*1.06 L&R/mGal		Delta L&R
2332.11	2334.21	1.06		-2.23 mGals

Gravity in mGals at Pierside

Reference +	Delta mGals	[+ Potsdam]		Pier Gravity
978680.69	-2.23	0.00		978678.46 mgals

Gravity in mGals at Meter

Pier Gravity+	Height Correction			Gravity@meter
978678.46	1.71			978680.17 mGals

Current Mistie

BGM Reading	Calculated Gravity			Current Mistie
978688.42	978680.17			8.25 mGals

For all formats, a – in the time field means an invalid value for some reason.

Streamer Compass/Bird Data — cb.r

This data is not processed, but can still be found in the "processed" data directory.

```
Shot Time               Line     Shot    Latitude      Longitude
2000+079:00:08:40.085 strike1 000296  N 15 49.6217 W 060 19.8019

2nd GPS Position                        Tailbuoy Position
Latitude     Longitude                  Latitude     Longitude
N 15 49.6189 W 060 19.8101    N 15 47.1234 W 060 20.1901

Furuno  Streamer
Gyro    Compasses & Heading
344.1      C01 2.3 C02 1.7  ...
```

Gun Depths — dg

Gun depths in tenths of meters. There will always be 20 gundepths even if only one gun was configured and shooting.

```
                         Gun Depths
Shot Time                1   2   3   4   5   6   7   8   9  ...  20
2001+089:06:47:05.909 189 068 005 005 096 005 060 054 005 ... 6
```

Raw Furuno Log — fu.s

This data has been smoothed and output 1 fix per minute.

```
CPU Time Stamp          Track Speed Hdg   Gyro
2000+166:00:01:53.091 -      4.4   140.5 148.3
```

Hydrosweep Centerbeam — hb.n

Hydrosweep data merged with navigation

```
                                   Centerbeam
CPU Time Stamp          Latitude  Longitude          Depth
2000+074:09:55:00.000 N 13 6.6206    W 59 39.3908    134.9
```

Merged Data — m

```
                                                          GPS
CPU Time Stamp          Latitude      Longitude           Used  Set  Drift Depth
2000+200:12:25:00.000 N 45 54.1583 W 42 47.1770       gp1   0.0  0.0

Magnetic                           Gravity
Total Intensity    Anomaly         FAA  GRV          EOTVOS   Drift   Shift
49464.7            55.5            22.2 980735.0     -8.4     -0.1     2.8

Temperature Salinity Conductivity
0.0          0.0       0.0
```

The gravity drift and shift are values that have been added to the raw gravity to make up for drift in the meter that has been lost in accordance with a gravity check at each port stop.

Temperature,Salinity and Conductivity will only be valid while logging a Thermosalinograph, which is not usually the case.

Magnetics Data mg.n

- A minus sign in the time stamp is flagged as a spike point, probably noise...
- Anomaly is based on the International Geomagnetic Reference Field revision 2000

CPU Time Stamp	Latitude	Longitude	Raw Value	Anomaly
200+077:00:23:00.000	N 16 11.2918	W 59 47.8258	36752.2	-166.8

Navigation File n

CPU Time Stamp	Latitude	Longitude	Used	Set	Drift
2000+074:00:03:00.000	N 13 6.2214	W 59 37.9399	gp1	0.0	0.0

Navigation Block nb0

Navigation is a compendium of Ewing logged data at shot time. The shot position here is the shot position from the Spectra system.

Shot Time	Shot #	CPU Time	Shot Position
2001+088:00:00:00.606	016967	2001+088:00:00:03.031	N 30 11.8324 W 042 10.8162

Water Depth	Sea Temp	Wind Spd	Wind Dir	Tailbuoy Latitude	Tailbuoy Longitude	Tailbuoy Range	Tailbuoy Bearg	Line Name	Speed	Heading
2565.1	20.7	16.4	164	N 30 12.0427	W 042 14.7319	6296.3	93.5	MEG-10	4.2	101.1

Tailbuoy Navigation tb1.c

Raw tailbuoy fixes

CPU Time Stamp	Latitude	Longitude	GPS Precision
2001+088:00:00:02.000	N 30 12.0424	W 042 14.7309	SA

GPS Precision is either SA, DIFF or PCODE

Ewing Processed Shot Times ts.n

Shot times and positions based on the Ewing navigation data processing

CPU Time Stamp	Shot #	Latitude	Longitude	Line Name
2000+079:00:08:01.507	000295	N 15 49.5703	W 060 19.7843	strike1

Shot Data Status ts.n.status

The ts.nxxx.status file describes the line information for that day, giving some basic statistics about the line: start, end times; missing shots; start and end shots.

```
LINE    strike1: 98+079:00:00:15.568 : 000283 .. 002286
         MISSING: 347, 410, 1727
LINE    dip2: 98+079:23:05:22.899 : 000002 .. 000151
```

This example says that on Julian Day 079 of 1998, two lines (strike1 and dip2) were run: the end of strike 1 (shots 000283 to 002286) and the start of dip2 (shots 000002 to 000151).

Line strike1 had some missing shots in the data file (probably missing on the SEG-d header as well).

Spectra Shot Times **nb2.r**

The shot times and positions based on the Spectra positioning; with raw tailbuoy range and bearing.

CPU Time Stamp	Shot #	Latitude	Longitude	Line Name
2001+084:00:00:05.924	009245	N 23 31.2410	W 045 25.0894	

Latitude	Longitude	Tailbuoy Range	Tailbuoy Bearing	Line Name
N 23 30.4540	W 045 21.4338	6389.8	283.2	KANE-4

Raw Gravity Counts **vc.r**

sample BGM-3 gravity count record (without time tag):

```
pp:dddddd ss
|    |    |___________ status: 00 = No DNV error; 01 = Platform DNV
|    |                         02 = Sensor DNV;    03 = Both DNV's
|    |________________ count typically 025000 or 250000
|_____________________ counting interval, 01 or 10
                       The input of data can be at 1 or 10 seconds.
```

Gravity Data **vt.n**

* A minus sign in the time stamp is flagged as a spike point
* m_grv3 calculates the Eotvos correction as:
  eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
* The theoretical gravity value is based upon different models for the earth's shape.
  - 1930 = 1930 International Gravity Formula
  - 1967 = 1967 Geodetic Reference System Formula
  - 1980 = 1980 Gravity Formula
* The FAA is computed as:
  faa = corrected_grv - theoretical_grv
* Velocity smoothing is performed w/ a 5 point window

CPU Time Stamp	Latitude	Longitude	Model	FAA	RAW
2000+148:00:10:00.000	N 09 34.7255	W 085 38.5826	1980	9.48	978264.16

Eotvos Smooth	Drift Total	DC Shift	Raw Velocity North	Raw Velocity East	Smooth Velocity North	Smooth Velocity East
-74.78	0.06	4.16	1.875	-10.373	1.927	\10.166

Datum Time **ts2.r**

CPU Time	Datum Time	Time Reference
2001+069:00:15:29.727	069 00 15 29.378	datum

Raw GPS **gp(12).d, tb1.d**

Raw GPS is in NMEA Format.

Meteorological Data **wx**

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CPU Time Stamp	True Spd	True Dir
2001+045:00:00:00.967	7.8	22

Bird1: Speed Inst	60sA	60mA	60sM	Direction Inst	60sA	60mA	Bird 2 Speed Inst	60sA	60mA	60sM	Direction Inst	60sA	60mA
7.8	6.6	8.5	16.8	277	291	5	0.0	0.0	0.0	0.0	0	0	0

Temperature Inst	60mA	60mm	60mM	Humidity Inst	60mm	60mM	Barometer
15.0	14.2	14.3	15.1	92	90	93	1027.5

Inst: Current

60sA: 60 second average

60mA: 60 minute average

60sM: 60 second maximum

60mm: 60 minute minimum

60mM: 60 minute maximum

Shot Times from Spectra P1 Files — shots.p1

These files were created with the script: *extract_shots_from_p1* ***-a 1***

Epoch Time	Shot#	Source Lat/Lon		TB Lat	TB Lon
985788741.000	015570	30.283881	-41.854536	30.320144	-41.886642

Vessel Ref Lat/Lon		Antenna GPS Lat/Lon		Water Depth
30.283478	-41.854117	30.283531	-41.854078	2894.2

- Source is the Center of the Guns
- TB is the Tailbuoy, according to Spectra
- Vessel Ref is the location of the center of the Mast
- Antenna GPS is the location of Antenna 1 (-a 1 flag); in this case is the Tasmon GPS
- Water Depth is the HS Centerbeam depth

Shot Times from Spectra P2 Files — shots.p2

These files were created with the script: *extract_shots_from_p2 -o "V1 G1"*

Epoch Time	Shot#	Vessel Ref Lat/Lon		Source Lat/Lon	
985716772.4	00015572	30.282803	-41.866136	30.283207	\41.866540

- Vessel Ref is the location of the center of the Mast
- Source is the Center of the Guns

Scripts

I have included some scripts for extracting information out of the P1 and P2 formatted files. In order to use these scripts you will also need to install the Ewing Perl libraries I have included in the scripts directory, or at least include that directory in your PERL5LIB environment. It is not my intention to describe how to use perl in this document though.

extract_shots_from_p1 [-a antenna] [-h] filename

Given an input P1 File, create a shotpoint file with the times, and the positions of the given antenna [1 = tasmon, 2 = Trimble] and optionally the header records at the beginning of the file.

The output will be:

```
epochtime shotnumber sourcePos tbPos vesselPos antennaPos depth
```

- **epochtime** is the # of seconds since Jan 1, 1970
- **shotnumber** is the shot number
- **sourcePos** is the center position of the sound source [lat lon]
- **tbPos** is the position of the tailbuoy [lat lon]
- **vesselPos** is the position of the vessel reference (center of mast) [lat lon]
- **antennaPos** is the position of the specified antenna [lat lon]
  1 = tasmon, 2 = trimble
- **depth** is the water depth in meters

extract_shots_from_p2 [-s shotnumber] [-o "output values"]

-s define if you only want the statistics for a single shot

-o "*outputs*" defines the outputs you want from the P2 file.

This routine will output by default the shotpoint, the line name and the shot time. Optionally, you can output position (Lat Lon) info for a number of items:

Outputs can be one or more of the following:

- V1 Vessel 1 Reference
- V1G1 Tasmon GPS Receiver
- V1G2 Trimble GPS Receiver
- V1E1 Hydrosweep Transducer
- TB1 Tailbuoy 1
- S1 Streamer 1
- V1SC Streamer Compasses
- G1 Gun Array 1

All the formats output a Lat Lon pair in decimal degrees. (*West and South being negative*)

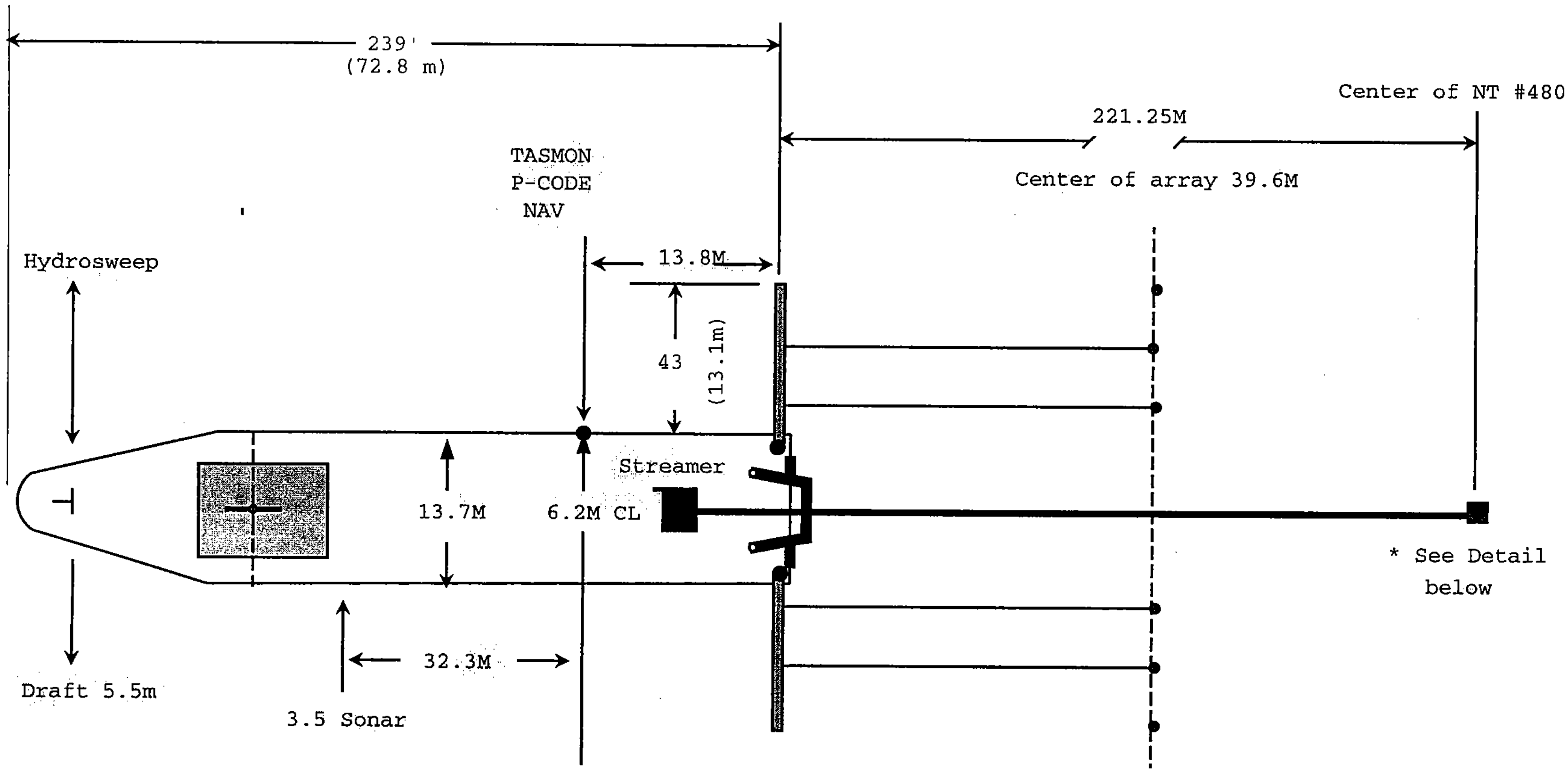
Output will be: `epochtime  shotnumber  [output lat/lon pairs]`

Tape Contents

EW0102/	
EW0102.pdf	this document
ew0102.cdf	NetCDF database file of this cruise
ew0102.cdf_nav	NetCDF database file of this cruise' navigation
docs/	File Formats, Spectra manuals
processed/	Processed datafiles merged with navigation
shotlogs/	processed Shot Files
trackplots/	daily cruise track plots (*postscript*)
raw/	Raw data directly from logger
reduction/	Reduced data files
clean/	daily processing directory, includes daily postscript plots of the data.
fixes/	fixes for the RTNu HS loss of d088
scripts/	Perl scripts and their friends
spectra/	P1/90 and P2/94 files from MCS lines
streamer/	Excel spreadsheets of streamer configuration

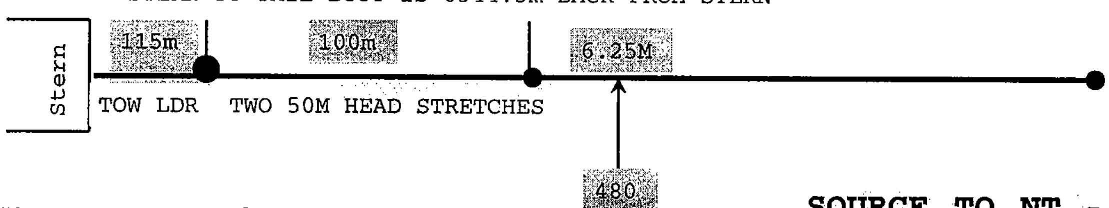
APPENDIX IV. Sensor and Airgun Configurations

MAURICE EWING MCS SETBACK AND OFFSET DIAGRAM



CABLE = 480 CHANNELS,40 ACTIVE CANS, 12.5M GROUPS, 6000M ACTIVE SECTIONS

STERN TO TAIL BOUY IS 6344.3m BACK FROM STERN



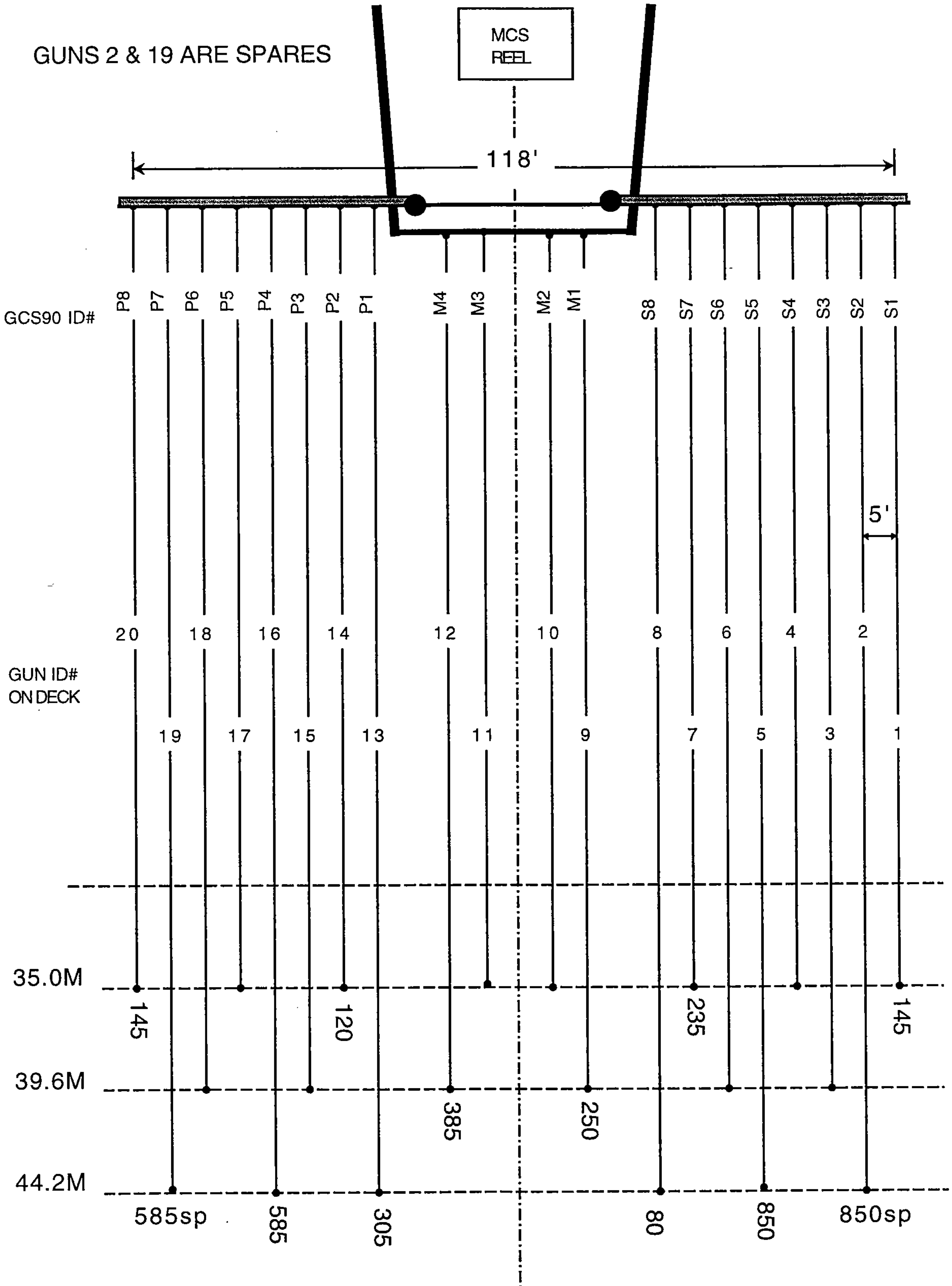
12 AIR GUN ARRAY DETAILS 6KM STREAMER

SOURCE TO NT = 221.25 - 39.6 = 181.65

MARCH, 2001 CPL **CLIENT: TUCHOLKE** **AREA: MID ATLANTIC RIDGE** **Cruise: EW-0102**

EWING MCS AIRGUN ARRAY- 10 GUN FOR EW0102

GUNS 2 & 19 ARE SPARES



APPENDIX V. Ewing 01-02 Tape List

EW0102 Tape List
4/4/01

Line #	Shot Numbers Start	End	Reel #	DLT #	Acutal Frist Shot	Comments Shot Numbers
MEG–1	100	241	100	1		
MEG–1	242	382	101	1		
MEG–1	383	520	102	1		
MEG–1	521	664	103	1		
MEG–1	665	805	104	1		
MEG–1	806	899	105	1		
MEG–1	900	1040	106	1		
MEG–1	1041	1181	107	1		
MEG–1	1182	1322	108	1		
MEG–1	1323	1353	109	1		
MEG–2	1355	1495	110	2		
MEG–2	1496	1636	111	2		
MEG–2	1637	1777	112	2		
MEG–2	1778	1918	113	2		
MEG–2	1919	2059	114	2		
MEG–2	2060	2200	115	2		
MEG–2	2201	2341	116	2		
MEG–2	2342	2482	117	2		
MEG–2	2483	2569	118	2		
MEG–3	2569	2710	119	2		
MEG–3	2711	2851	120	2		
MEG–3	2852	2992	121	2		
MEG–3	2993	3133	122	2		
MEG–3	3344	3274	123	2		
MEG–3	3275	3415	124	2		
MEG–3	3416	3556	125	2		
MEG–3	3557	3697	126	2		
MEG–3	3698	3730	127	2		
MEG–1 –> 3	100	3730		3		
KANE–1	4005	4144	129	4		
KANE–1	4145	4285	130	4		
KANE–1	4286	4426	131	4		
KANE–1	4427	4567	132	4		
KANE–1	4568	4708	133	4		
KANE–1	4709	4849	134	4		
KANE–1	4850	4990	135	4		

EW0102 Tape List
4/4/01

Line #	Shot Numbers Start	End	Reel #	DLT #	Acutal Frist Shot	Comments Shot Numbers
KANE-1	4991	5131	136	4		
KANE-1	5132	5272	137	4		
KANE-1	5273	5413	138	4		
KANE-1	5414	5554	139	4		
KANE-1	5555	5695	140	4		
KANE-1	5696	5830	141	4		
KANE-1	5832	5972	142	4		
KANE-1	5973	6113	143	4		
KANE-1	6114	6254	144	4		
KANE-1	6255	6296	145	4		
			146			
KANE-2	6322	6462	147	4		
KANE-2	6465	6603	148	4		
KANE-2	6604	6744	149	4		
KANE-2	6745	6858	150	4		
KANE-3	6859	6999	151	4		
KANE-3	7000	7140	152	4		
KANE-3	7141	7277	153	4		
KANE-3	7179	7385	154	4		
KANE-4	7386	7536	155	4		
KANE-4	7537	7668	156	4		
KANE-4	7670	7702	157	4		
KANE-4	7715	7855	158	4		
KANE-4	7856	7996	159	4		
KANE-4	7997	8137	160	4		
KANE-4	8138	8278	161	4		
KANE-4	8279	8419	162	4		
KANE-4	8420	8560	163	4		
KANE-4	8561	8701	164	4		
KANE-4	8702	8842	165	4		
KANE-4	8843	8983	166	4		
KANE-4	8984	9067	167A	4		
KANE-4	9074	9074	167B	4		
KANE-4	9146	9286	168	4		
KANE-4	9287	9427	169	4		
KANE-4	9428	9568	170	4		

EW0102 Tape List
4/4/01

Line #	Shot Numbers Start	End	Reel #	DLT #	Acutal Frist Shot	Comments Shot Numbers
KANE-4	9569	9605	171	4		
KANE-5	9607	9746	172	5		
KANE-5	9747	9887	173	5		
KANE-5	9888	10028	174	5		
KANE-5	10029	10109	175	5		
KANE-6	10110	10250	176	5		
KANE-6	10251	10391	177	5		
KANE-6	10392	10532	178	5		
KANE-6	10533	10673	179	5		
KANE-6	10674	10766	180	5		
KANE-7	10767	10907	181	5	10778	First shot out of order
KANE-7	10908	11048	182	5		
KANE-7	11050	11189	183	5		
KANE-7	11190	11330	184	5		
KANE-7	11331	11471	185	5		
KANE-7	11472	11612	186	5		
KANE-7	11613	11707	187	5		
KANE-7	11761	11901	188	5		
KANE-7	11902	12042	189	5		
KANE-7	12043	12183	190	5		
KANE-7	12184	12324	191	5		
KANE-7	12325	12465	192	5		
KANE-7	12466	12606	193	5		
KANE-7	12607	12655	194	5		
MEG-4	12657	12796	195	6		
MEG-4	12797	12937	196	6		
MEG-4	12938	13078	197	6		
MEG-4	13079	13219	198	6		
MEG-4	13220	13360	199	6		
MEG-4	13361	13501	200	6		
MEG-4	13502	13642	201	6		
MEG-4	13643	13707	202	6		
MEG-5	13707	13847	203	6		
MEG-5	13848	13988	204	6		
MEG-5	13989	14129	205	6		
MEG-5	14130	14270	206	6		

EW0102 Tape List
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Line #	Shot Numbers Start	End	Reel #	DLT #	Acutal Frist Shot	Comments Shot Numbers
MEG–5	14271	14411	207	6		
MEG–5	14412	14460	208	6		
MEG–6	14461	14601	209	6	14405	First shot out of order
MEG–6	14602	14742	210	6		
MEG–6	14743	14883	211	6		
MEG–6	14884	15024	212	6		
MEG–6	15025	15035	213	6		
MEG–7	15036	15176	214	6	14978	First shot out of order
MEG–7	15177	15317	215	6		
MEG–7	15318	15458	216	6		
MEG–7	15459	15969	217	6		
MEG–8	15570	5710	218	6	15510	First shot out of order
MEG–8	15711	15851	219	6		
MEG–8	15852	15992	220	6		
MEG–8	15993	16133	221	6		
MEG–8	16134	16274	222	6		
MEG–8	16275	16318	223	6		
MEG–9	16319	16459	224	6	16256	First shot out of order
MEG–9	16460	16600	225	6		
MEG–9	16601	6741	226	6		
MEG–9	16742	16882	227	6		
MEG–9	16883	16904	228	6		
MEG–10	16905	17045	229	6		
MEG–10	17046	17186	230	6		
MEG–10	17187	17327	231	6		
MEG–10	17328	17468	232	6		
MEG–10	17469	17609	233	6		
MEG–10	17610	17711	234	6		
DANTE–1	17712	17728	235	7	17643	First shot out of order
DANTE–1	17730	17870	236	7		
DANTE–1	17879	18019	239	7		
DANTE–1	18028	18168	244	7		
DANTE–1	18169	18180	245	7		
DANTE–1	18214	18354	247	7		
DANTE–1	18363	18373	250	7		
DANTE–1	18432	18572	251	7		

EW0102 Tape List
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Line #	Shot Numbers Start	End	Reel #	DLT #	Acutal Frist Shot	Comments Shot Numbers
DANTE-1	8573	18713	252	7		
DANTE-1	18714	18854	253	7		
DANTE-1	18855	18973	254	7		
DANTE-2	18974	19114	255	7	18900	First shot out of order
DANTE-2	19115	19255	256	7		
DANTE-2	19256	19396	257	7		
DANTE-2	19397	19537	258	7		
DANTE-2	19538	19678	259	7		
DANTE-2	19679	19809	260	7		
DANTE-3	19810	19950	261	7	19733	First shot out of order
DANTE-3	19951	20091	262	7		
DANTE-3	20092	20232	263	7		
DANTE-3	20134	20373	264	7		
DANTE-3	20374	20506	265	7		
DANTE-4	20507	20647	266	7	20427	First shot out of order
DANTE-4	20648	20788	267	7		
DANTE-4	20789	20929	268	7		
DANTE-4	20930	21070	269	7		
DANTE-4	21071	21211	270	7		
DANTE-4	21212	21352	271	7		
DANTE-4	21353	21493	272	7		
DANTE-4	21494	21634	273	7		
DANTE-4	21635	21775	274	7		
DANTE-4	21776	21916	275	7		
DANTE-4	21917	22057	276	7		
DANTE-4	22058	22198	277	7		
DANTE-4	22199	22339	278	7		
DANTE-4	22340	22480	279	7		
DANTE-4	22481	22621	280	7		
DANTE-4	22622	22687	281	7		