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M E M O R A N D U M

DATE: September 20, 1997

TO: Dr. Paul L. Stoffa

FROM: Yosio Nakamura

SUBJECT: Cruise Report, R/V Maurice Ewing Cruise No. 97-05

Four members of UTIG participated in R/V Maurice Ewing Cruise No. 97-05, which took place from July 10 to August 15, 1997 off the coast of Spain/Portugal (Iberia Abyssal Plain/Galicia Bank) in the northeastern Atlantic. It was a part of a cooperative project among Rice University and UTIG from the U.S., GEOMAR of Germany, Universities of Madrid and Barcelona in Spain and University of Aveiro in Portugal. The U.S. participation was supported by the National Science Foundation.

The cruise was to acquire both multichannel seismic (MCS) reflection data using the Ewing's 4-km, 160-channel digital streamer and large-offset seismic data using ocean-bottom seismographs (OBSs) and hydrophones (OBHs) from several profiles across the Galicia Bank, the Galicia Interior Basin, and the transform boundary between the Galicia Bank and the Iberia Abyssal Plain. Eleven OBS/Hs from UTIG and 14 OBHs from GEOMAR were used for the acquisition of large-offset data. Shots from the Ewing's 20-gun array were also recorded by land stations in Spain and Portugal operated by Universities of Barcelona and Madrid.

This report describes mainly the part related to the UTIG OBS operation. Separate reports describing the overall operation and the GEOMAR OBH operation are expected from Rice University and University of Kiel, respectively.

The data acquisition was done in three phases. In each phase, we first deployed OBS/Hs along one or more lines, then deployed the streamer and the air-gun array, shot multiple seismic lines both on and off the lines of OBS/Hs, retrieved the air-gun array and the streamer, and finally retrieved the OBS/Hs.

The first phase, which we called 'Deployment 1,' was mainly over the Galicia Bank, where the so-called S-reflector was found earlier. We dropped 11 UTIG OBSs (red dots in Fig. 1) and 14 GEOMAR OBHs (red triangles) and shot 4 crossing seismic lines (red lines) 1, 4, 5 and 6. Figure 2 shows the ship's track during this phase, where patterned circles indicate locations of UTIG OBSs, open circles indicate locations of GEOMAR OBHs, and squares show the ship's locations at noon and midnight.

The second phase, which we called 'Deployment 2,' was mainly over the Galicia Interior Basin, which lies between the highly extended continental crust of the Galicia Bank Basin and the unextended continental crust of Iberia. We dropped 11 UTIG OBSs (green dots in Fig. 1) and 14 GEOMAR OBHs (green triangles) and shot 12 seismic lines (green lines) 1, 2, 12, 14, 15, 17, 18, 19, 20, 21, 22 and 23. Figure 3 shows the ship's track during this phase (symbols are the same as those in Fig. 2). The length of the streamer was shortened to 1 km for the portions of the lines generally lying east of 10°W to avoid interfering with the ship traffic near the coast.

The third phase, which we called 'Deployment 3,' was in the areas extending from the Galicia Bank to the Iberia Abyssal Plain and also included the area of ODP legs 149 and 173. We dropped 11 UTIG OBSs (purple dots in Fig. 1) and shot 13 seismic lines (purple lines) 9, 10, 11, 13, 14, 15, 24, 25, 26, 27, 28, 29 and 30. Figure 4 shows the ship's track during this phase (symbols are the same as before except that open circles indicate those which were not recovered).

The cruise went relatively smoothly despite occasional bad weather, which caused the delay of the deployment of the air-gun array in the first phase, and nearly constant high wind from north. In all, we made 33 deployments of UTIG OBSs and 28 deployments of GEOMAR OBHs. Unfortunately two UTIG OBSs failed to return during the final phase of the experiment. Of those which were recovered, all but one of the UTIG OBSs and all but four of the GEOMAR OBHs recorded practically full data, although there were minor problems with some of the instruments as described later.

In terms of OBS instrumentation, we had something new in three areas. One was the use of temperature compensated crystal oscillators (TCXOs) on all of our OBS units for the first time to improve the timing accuracy. (We had a TCXO on one unit during the Chicxulub experiment in a successful testing.) They generally worked well, limiting the clock drift to a small fraction of a second in one week of deployment (~1 to 20 ms/day). However, in one case, station 108, the drift was greater than 21 seconds in a week. We need to look at the drift characteristics of these TCXOs at low temperatures more closely.

Another new item was the use of high capacity (1.2 Gbyte) disk drives on most (9) of the instruments, which more than doubled our previous recording capacity. The expanded recording capacity enabled us to record continuously for the entire period of each week-long shooting, thus allowing us a maximum flexibility in scheduling and re-scheduling shooting of several seismic lines even after the OBSs had been deployed. However, since we did not plan to use so many high-capacity disk drives when we planned the experiment, we made a mistake of allowing a set of batteries to be used too long, which resulted in premature loss of CPU power in four of the units deployed in phase 2. Fortunately, since these power losses occurred only shortly before the end of the scheduled recording period, the actual loss of data was minimal.

This experience, however, gave us a chance to observe the practical limit of alkaline batteries. In the past, we almost always limited the use of batteries to about 50% of their expected life. This time, we pushed this limit to as much as 90%, and four cells out of 110 (10 cells x 11 units) failed prematurely. It is clear that we should keep the 50% limit in future experiments.

The third new item was the first sea trial of the newly developed acoustic release system. It intercepts the signal from the regular hydrophone, processes it to detect a release command sent from the ship above, and sends its release command to the existing release circuitry. Since this eliminates the need for an independent transducer and release mechanism, the cost per unit is only about one twentieth of a commercial acoustic release system. A prototype was installed on one of the OBSs and tested in all three phases of the experiment, first at station 120 at a depth of 5111 m, then at station 235 at a shallow depth of 146 m, and finally at station 362 at an intermediate depth of 2164 m. In each of these cases, the system worked perfectly.

On the negative side, the loss of two instruments was clearly not what we expected, and we still do not know why they did not return. Each of the losses we experience in the past decade or so had a clear reason for the loss. We lost one in Alaska in 1989, which was released prematurely due to a programming error and drifted away in a swift current in the Cook Inlet. We lost several on the East Pacific Rise in 1993, which was attributed to a faulty design of special anchor frames, which, we believe, overturned on landing, trapping the instrument underneath. We lost one in a shallow water off Costa Rica in 1995, when it was caught in a fishing net and overturned. This unit was recovered later when another fishing net turned it right side up. This activity was clearly recorded on the unit. We lost one over the Chicxulub impact crater off Yucatan Peninsula last year, when a bad weather prevented R/V Longhorn from getting to the station to retrieve it when it surfaced. The unit was later found by Mexican fishermen. None of these apply to our most recent loss. The program had been well tested and there was little room for an error like the one we experienced in Alaska; the bottom topography was not likely to be rough enough to overturn the instrument as was on the East Pacific Rise; the water depth (>4000m) was too deep for a fishing net; and the weather was perfect.

In addition to the two lost instruments, one other instrument, at station 232, was at least one hour late in returning to the surface. Our ORSTOM colleagues reported similar occurrences with their instruments in the past, but we never had this experience. They attributed this to a soft bottom, which trapped the instrument and caused it to take several hours to release from the bottom. However, we tended to believe that their insistence to use release wires with exposures only at corners was the real cause. [We achieved much more reliable release when we started using release wires with off-corner exposures.] Thus, the delayed release may have entirely different, and yet unknown, cause.

The loss of two OBSs at stations 353 and 355 and the delayed release at station 232 may or may not be related. However, we can speculate a few possible causes for both of them.

While getting the instrument ready for deployment, we sometimes noticed that the fit of the instrument inside the upper ring of the anchor frame was rather tight. Some of the rings, made of a 2" wide steel strip, were found to be deformed slightly from a perfect circle. This may have caused the instrument to be caught in a tight grip until some outside force, such as current, helps it to release from the grip. However, we do no believe that this was a very likely cause because those instruments for which we noted a tight fit on deployment all returned to surface on time.

Another possibility is impaired release-wire connections. Ben observed some release wire connections through the sphere had been corroded. If the corrosion becomes severe, it may impede the flow of release current, thus extending the time it takes to release the unit, and eventually, it may become impossible to release the unit within a reasonable time. It is therefore recommended that we inspect all wire connections through the sphere periodically to make sure all connections are good.

Aside from some problems encountered, the experiment was quite successful overall. We recorded full or nearly full data of high quality on 30 UTIG OBSs, and GEOMAR likewise recorded good data on 24 of their OBHs. In addition, approximately 4,000 km of MCS data were acquired. The mixture of three different kinds of seismic data acquisition kept the scientific party as well as the ship's crew busy but interested, and the 37-day cruise did not seem so long. Every one of the participants worked hard in his/her respective duties to make this cruise a success. Some of us also enjoyed the newly installed science library on board.

Participants

The scientific party included the following participants:

Rice University
- Dale Sawyer - chief scientist
- Colin Zelt - scientist
- ElleMarie Schollenberger - student
- Denise Rodriguez - student
- Michael Gustavson-Unger - student — disembarked on August 4

UTIG
Yosio Nakamura - scientist
Jamie Austin - scientist — embarked on August 4
Ben Yates - engineer
Stephen Clark - student

GEOMAR — all disembarked on August 4
Tim Reston - scientist — currently at University of Aberdeen
Sanyu Ye - scientist
Christian Walther - scientist
Andre Hojka - scientist
Urte Domaschk - student
Marta Perez- student

University of Barcelona
Rafael Bartolone - student

University of Madrid
Mercedes Romero Pascual - student — embarked on August 4

University of Aveiro
Francisco Texeira - student — disembarked on August 4

LDEO
Christopher Leidhold - science officer
Johnny Dibernardo - gun tech
John Byrne - gun tech
Ropate Maiwirwiri - core bosun
Jeff Turmelle - systems manager — disembarked on August 4
Gregory Vsevolozhsky - systems manager
Tom Jackson - electronic technician

Chronology

In the following narrative, all times are in UTC, which happened to be the local time in Azores and one hour behind the local time in Lisbon.

Sunday, July 6 — Y.N., B.Y and S.C arrived at Ponta Delgada, Azores, early evening.

Monday, July 7 — Unloaded spheres and anchor frames from a container, moved OBS chassis and other equipment from the ship's storage to the lab, unpacked them and started setup in the lab.

Tuesday, July 8 — Checked out OBS chassis; GEOMAR personnel came on board; Dale Sawyer, the Chief Scientist, arrived early evening.

Wednesday, July 9 — Completed check out of instruments; worked on plans and recording schedule for the first phase (deployment 1) of the experiment.

Thursday, July 10 — Sailed from Ponta Delgada at 12:00 noon; started and programmed all 11 OBSs for deployment in the first phase; fire drill at 15:20.

Friday, July 11 — Transit to the survey site; stopped at around 15:30 to conduct GEOMAR OBH acoustic release tests, which took about three hours.

Saturday, July 12 — Continued transit to the site; shooting/recording schedule updated; new schedule downloaded to each OBS.

Sunday, July 13 — Deployed 7 GEOMAR OBHs (01:37 - 06:58; see Appendix D for locations), 11 UTIG OBSs (07:35 - 13:55; see Appendix B for details of deployment) and 7 GEOMAR OBHs (14:45 - 19:57); started streamer deployment.

Monday, July 14 — Streamer deployment and balancing continued, completing at around 20:30; air-gun deployment called off because of bad sea condition.

Tuesday, July 15 — Deployed air-gun array starting at around 14:00; started shooting at 15:35 but interrupted from 19:23 to 22:09 due to a computer operator error [see Appendix A for details of shooting].

Wednesday, July 16 - Friday, July 18— Shooting continued.

Saturday, July 19 — Shooting completed at 00:49; retrieved guns and streamer, completing the operation by 06:30; recovered 7 GEOMAR OBHs (10:02 - 22:05).

Sunday, July 20 — Acoustic release signal sent at 01:35 to UTIG OBS at station 120 at 5106 m depth, which surfaced at 03:11; all 11 UTIG OBSs recovered (03:36 - 14:48); recovery of remaining 7 GEOMAR OBHs started at 15:57.

Monday, July 21 — Recovered the last GEOMAR OBH at 00:10, completing the phase 1 (deployment 1) of the experiment; started phase 2 (deployment 2) with deployment of 7 GEOMAR OBHs (09:16 - 19:05); started deployment of UTIG OBSs at 22:08.

Tuesday, July 22 — Continued deployment of UTIG OBSs (till 08:02) and GEOMAR OBHs (starting at 13:03).

Wednesday, July 23 — Completed GEOMAR OBHs at 01:13 and UTIG OBSs at 05:21; deployed streamer and air-gun array and started shooting at 14:41.

Thursday, July 24 — Fire drill at 15:20; stopped shooting at 16:12 and shortened streamer to 1 km length to avoid interfering with ship traffic near the coast; resumed shooting at 21:30.

Friday, July 25 - Saturday, July 26 — Shooting continued; preliminary processing and examination of deployment 1 data started.

Sunday, July 27 — Stopped shooting at 06:51 to extend the streamer to the original 4 km length; resumed shooting at 10:52.

Monday, July 28 - Tuesday, July 29 — Shooting continued.

Wednesday, July 30 — Shooting completed at 20:54; retrieved air guns and streamer.

Thursday, July 31 — Fire drill at 10:20; recovery of the first 7 GEOMAR OBHs (stations 243-249) started at 10:44 and continued for the rest of the day.

Friday, August 1 — Completed recovery of the first group of GEOMAR OBHs at 01:30; recovered two UTIG OBSs (stations 250 and 251) at 08:21 and 10:51; started recovery of remaining 7 GEOMAR OBHs (stations 236-242) at 21:20.

Saturday, August 2 — Completed recovery of GEOMAR OBHs at 10:51; started recovery of remaining 9 UTIG OBSs (stations 227-235) at 14:31.

Sunday, August 3 — UTIG OBS at station 232 failed to surface at expected time and abandoned after a 45-minute wait; completed recovery of the rest of UTIG OBSs at 04:32; started preliminary processing of data from newly recovered OBSs; returned to station 232 and found and recovered the dilatory OBS at 19:33.

Monday, August 4 — Arrived at Lisbon at 09:45 (10:45 local) for a port call to disembark GEOMAR personnel and equipment; Jamie Austin came on board; sailed out of Lisbon at 17:00 (18:00 local).

Tuesday, August 5 — Deployed 11 UTIG OBSs at stations 352-362 (06:23 - 20:59); continued preliminary processing of OBS data from deployment 2; deployed streamer.

Wednesday, August 6 — Deployed air-gun array and started shooting at 02:54; continued with processing of OBS data from deployment 2.

Thursday, August 7 - Tuesday, August 12 — Shooting continued; processing of data from deployment 2 also continued.

Wednesday, August 13 — Shooting completed at 06:44; retrieved air guns; retrieval of streamer delayed a few hours due to hydraulic problem but accomplished in time for the first OBS recovery; OBSs at stations 362-360 recovered starting at 18:18.

Thursday, August 14 — Recovery of OBSs continued for remaining stations; OBSs at stations 355 and 353 did not surface at expected times; returned to the stations after dark but failed to find any sign of the instruments.

Friday, August 15 — Returned to Lisbon at around 13:00 (14:00 local); this being a Portuguese national holiday, we were unable to make any contact with the shipping agent.

Sunday, August 17 — J.A. and S.C left Lisbon.

Monday, August 18 — Arrangement with a local shipping agent to air-freight equipment back to Austin completed.

Tuesday, August 19 — Y.N and B.Y. left Lisbon and returned to Austin.

Station performance

Details of the performance of individual OBS stations are as follows:

Station 106:	no problem
Station 107:	no problem
Station 108:	large clock drift (>21 s in 7 days); H_1 signal ringy and H_2 signal weak — instrument tilted?
Station 109:	H_1 ringy and H_2 very weak — instrument tilted?
Station 110:	no problem
Station 111:	no problem
Station 120:	no problem
Station 121:	no problem
Station 122:	no problem
Station 125:	H_2 weak — instrument tilted?
Station 126:	numerous disk write errors
Station 227:	no problem
Station 228:	CPU battery failed 8 hours short of full recording
Station 229:	CPU battery failed 3 hours short of full recording
Station 230:	CPU battery failed 19 hours short of full recording
Station 231:	no problem
Station 232:	released at least an hour late; many disk write errors
Station 233:	no problem
Station 234:	no problem
Station 235:	CPU battery failed 15 hours short of full recording; a few disk write errors
Station 250:	no problem
Station 251:	no problem
Station 352:	no problem
Station 253:	not recovered
Station 254:	no problem
Station 255:	not recovered
Station 256:	no problem
Station 257:	no problem
Station 258:	no problem
Station 259:	no problem
Station 260:	no problem

Station 261: no problem
Station 262: no problem

Technical Details

Pertinent recording parameters of the UTIG OBS/Hs used in the experiment are as follows:

Active sensor channels: 1 through 4 or 1 and 4, where
Channel 1 vertical geophone, Mark Products L-15B, 4.5 Hz
Channel 2 horizontal geophone 1, Mark Products L-15B, 4.5 Hz
Channel 3 horizontal geophone 2, Mark Products L-15B, 4.5 Hz
Channel 4 hydrophone, Ocean & Atmospheric Science E-2PD

Nominal sensitivity of sensors (unit digitizing level):
Geophones: 2.5 nm/s
Hydrophones: 1.0 mPa

Anti-alias filters: 30 Hz Butterworth high-pass, 24 dB/oct roll off

Sampling interval: 5.000 ms

Recording mode: continuous with short inter-record gaps

Parameters related to the sound source and navigation are as follows:

Mean air-gun depth: 8.5 m

Total air-gun volume: 8,400 cu in. (138 ℓ)

Source setback from navigation reference: 88.7 m

Bathymetry reference: 17.1 m forward of navigation reference

Other pertinent information needed by the users of the data appear in the Appendix.

Data Files

Raw and partially processed data files brought back to Austin are the following:

Data Files	Media	Tape/Disk Label
Raw OBS data, complete		
Station 106	DAT tape	IB01
Station 107	DAT tape	IB02
Station 108	DAT tape	IB03
Station 109	DAT tape	IB04
Stations 110 & 111	DAT tape	IB05
Station 120	DAT tape	IB06
Station 121	DAT tape	IB07
Station 122	DAT tape	IB08
Station 125	DAT tape	IB09
Station 126	DAT tape	IB10
Station 227	DAT tape	IB17
Station 228	DAT tape	IB18
Station 229	DAT tape	IB19
Station 230	DAT tape	IB20
Station 231	DAT tape	IB21
Station 232	DAT tape	IB22

Data Files	Media	Tape/Disk Label
Station 233	DAT tape	IB23
Station 234	DAT tape	IB24

Stations 235, 250 & 251	DAT tape	IB15
Station 352	DAT tape	IB33
Station 354	DAT tape	IB32
Stations 356 & 358	DAT tape	IB31
Stations 357, 359 & 361	DAT tape	IB30
Station s360 & 362	DAT tape	IB29
Raw OBS data, trimmed to only those while shooting		
Stations 106, 107 & 108	DAT tape	IB11
Stations 110 & 111	DAT tape	IB12
Stations 120, 121 & 122	DAT tape	IB13
Stations 125 & 126*	DAT tape	IB14
Stations 227 & 228	DAT tape	IB25
Stations 229 & 230	DAT tape	IB26
Stations 231 & 232*	DAT tape	IB27
Stations 233 & 234	DAT tape	IB28
Stations 235, 250 & 251	DAT tape	IB16
Raw OBS data, trimmed to Line 9 only		
Stations 352, 354, 356, 357, 358, 359, 360, 361* & 362	DAT tape	IB34
Raw SEG-Y data		
Station 108*	DAT tape	IB14
OBS/Mac dialog capture files (include all start-up, diagnostic, pre-deployment and post-recovery information)	Floppy	Iberia #1
also on	DAT tape	IB35
Shot tables (recording schedules)	Floppy	Iberia #1
also on	DAT tape	IB35
Shot times		
from Ewing (ts.n** files)	DAT tape	IB35
as recorded with UTIG GPS	Floppy	Iberia #1 & #2
Navigation data from Ewing (hb.n** files)	DAT tape	IB35
OBS header lists	DAT tape	IB35
Bathymetric correction tables from Ewing	DAT tape	IB35
Program written during cruise	Floppy	Iberia #1
also on	DAT tape	IB35
Tape directories	DAT tape	IB35

*Certain corrections applied; see Appendix E

Post-Cruise Data Processing Plan

A basic processing plan for the UTIG OBS data given in Appendix F was discussed and agreed on before leaving the ship. It was also agreed that Stephen Clark would work on Line 9 OBS data for his M.S. thesis and Colin Zelt of Rice University would visit UTIG to do the initial processing of the rest of the OBS data with us after we would have completed the calibration of the TCXOs.

Appendices

Appendix A — Summary of seismic lines. Information on each line are, from left to right: shot time in year, Julian day, hours, minutes and seconds (to ms) in UTC, shot number, latitude and longitude in degrees and minutes, line designation by Ewing (in ts.n** format), and annotation in the last column. Since where one line ends and the next line starts is not always clear, the line divisions given here are often arbitrary. Only in those cases where the line boundaries are clear from a change in line designation or a gap in shot times, they are indicated by BOL (beginning of line) or EOL (end of line). 'On line' and 'start turn' are indicated at those places outside of which the ship's heading diverged more than 10° from the line orientation. The number following each line number is the nominal shot interval in seconds. Randomization of the shots causes the actual shot intervals to vary up to ±0.5 s from the nominal value.

Appendix B — Deployment, recovery and data summary for UTIG OBSs. The deployment and recovery times are given in UTC, which was the same as the local time in Azores and one hour behind the local time in Portugal. The deployment and recovery coordinates have been recomputed from the ship's navigation data. The water depths are from the center beam of the Hydrosweep, and are not corrected for the variation in sound speed, which is assumed to be 1500 m/s. They are, however, corrected for the depth of the transducer at 5.5 m.

Appendix C — Key clock calibration data. Clock calibration at about one hour before deployment, the final pre-deployment calibration and the first post-recovery calibration (missing if the CPU was dead on recovery) are given for each station. They are as recorded in capture files: in each line, the left hand is an OBS time string, starting with a character T followed by OBS identification number (the last two digits of station number), the OBS time in year, month, hours, minutes seconds and deciseconds, and the right hand is the corresponding GPS clock time in Julian day, hours, minutes, and seconds to ns. All times are in UTC.

Appendix D — GEOMAR OBH deployment locations. These locations have been taken from watch stander's logs.

Appendix E — Corrections applied to some raw OBS data.

Appendix F — Post-cruise OBS data processing plan.

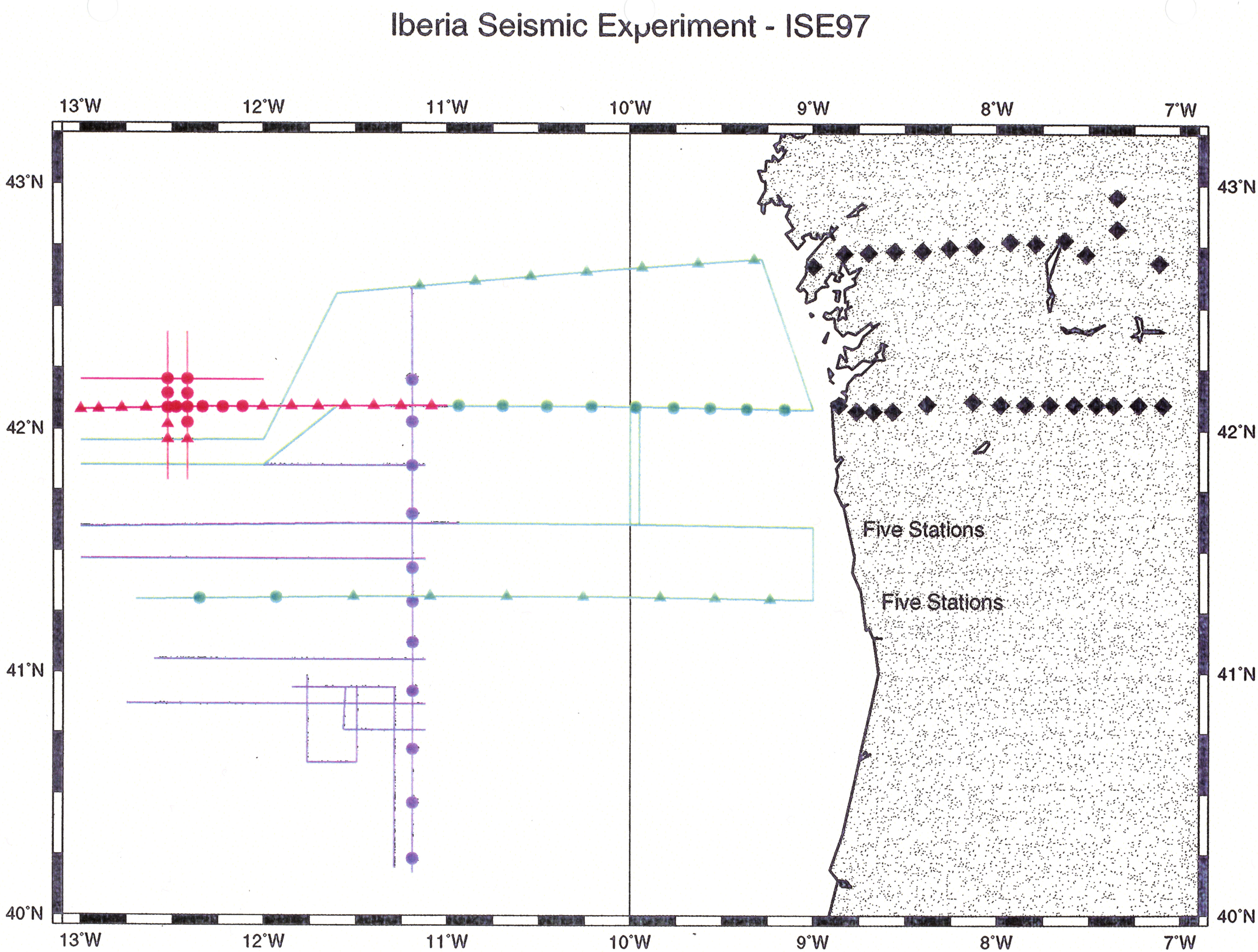

Iberia Seismic Experiment - ISE97
13°W
12°W
11°W
10°W
9°W
8°W
7°W
43°N
42°N
41°N
40°N
Five Stations
Five Stations

Fig. 1

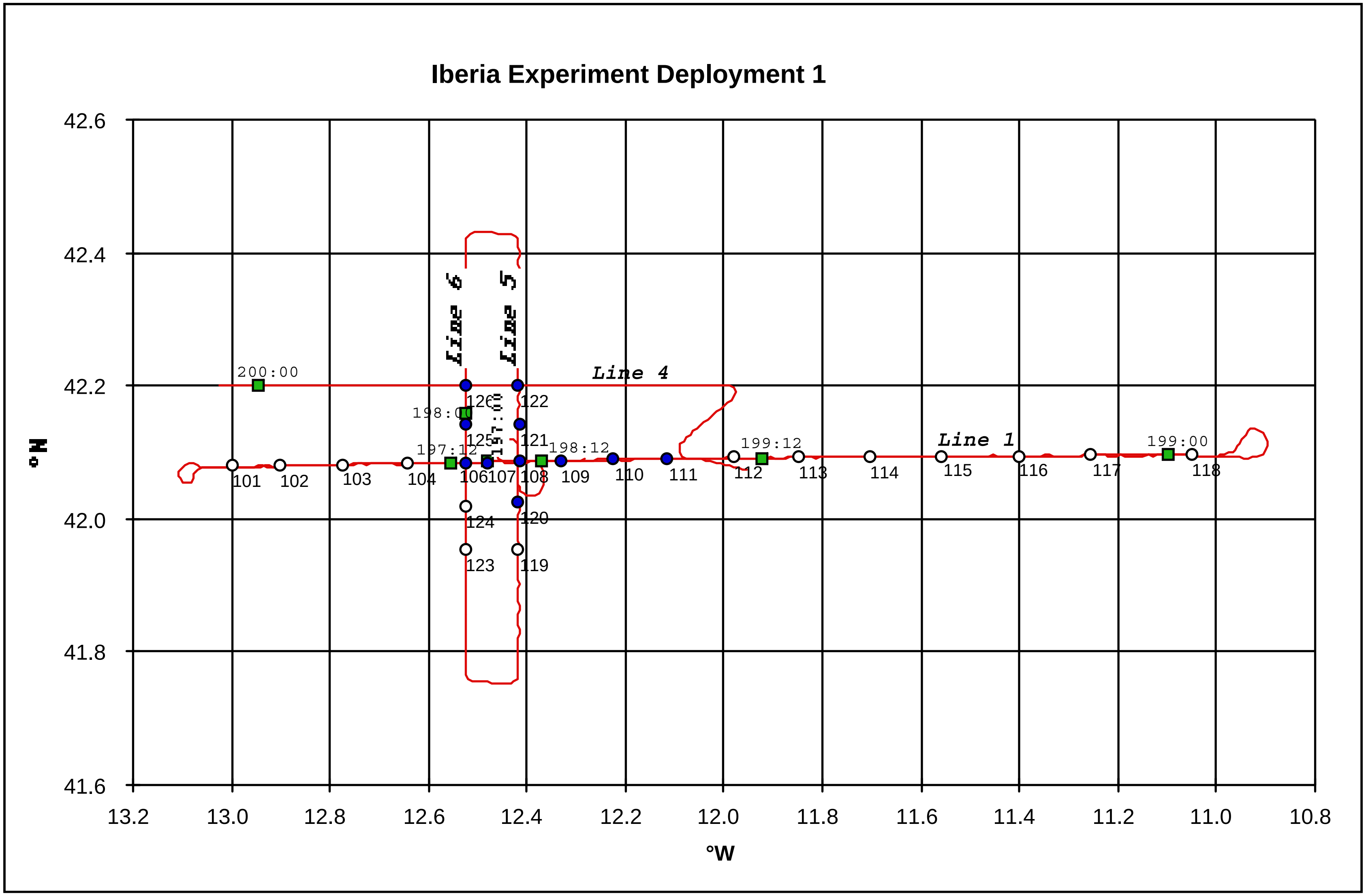
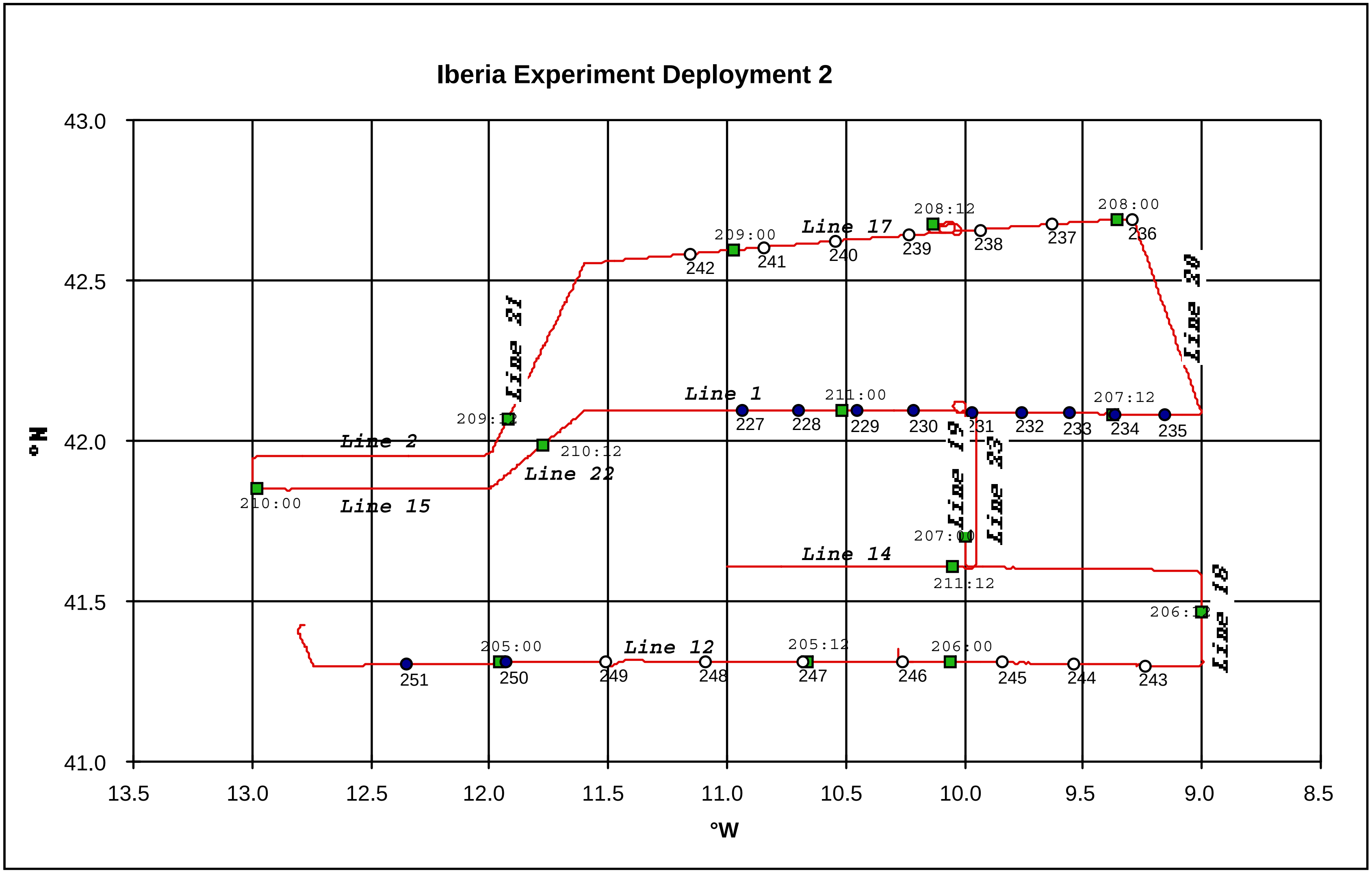

Iberia Experiment Deployment 1
Line 1
Line 4
Line 5
Line 6
200:00
198:00
197:12
197:00
198:12
199:12
199:00
101
102
103
104
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
42.6
42.4
42.2
42.0
41.8
41.6
13.2
13.0
12.8
12.6
12.4
12.2
12.0
11.8
11.6
11.4
11.2
11.0
10.8
°N
°W

Fig. 2



Iberia Experiment Deployment 2
°N
°W
43.0
42.5
42.0
41.5
41.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
Line 1
Line 2
Line 12
Line 14
Line 15
Line 17
Line 18
Line 19
Line 20
Line 21
Line 22
Line 23
205:00
205:12
206:00
206:12
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208:00
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209:12
210:00
210:12
211:00
211:12

Fig. 3

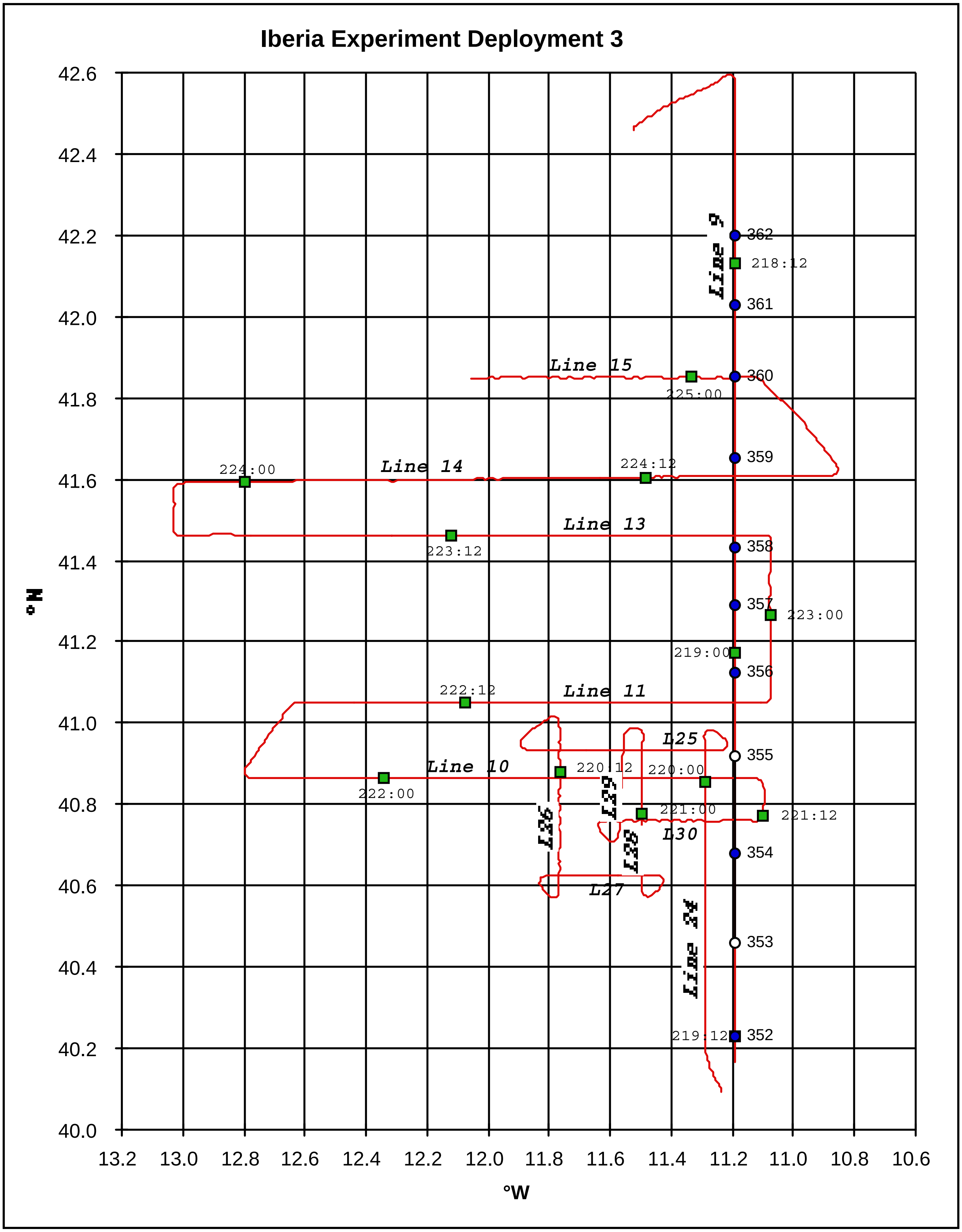
Iberia Experiment Deployment 3
42.6
42.4
42.2
42.0
41.8
41.6
41.4
41.2
41.0
40.8
40.6
40.4
40.2
40.0
°N
13.2
13.0
12.8
12.6
12.4
12.2
12.0
11.8
11.6
11.4
11.2
11.0
10.8
10.6
°W
Line 9
Line 15
Line 14
Line 13
Line 11
Line 10
L25
L30
L27
L36
L39
L38
Line 34
362
361
360
359
358
357
356
355
354
353
352
218:12
225:00
224:00
224:12
223:12
223:00
219:00
222:12
222:00
220:12
220:00
221:00
221:12
219:12

Fig. 4

Appendix A Summary of Seismic Lines

Approach 60 s
```
97+196:15:35:00.655 00002 N 42 04.3744 W 011 57.2343 iberiaA
97+196:15:55:00.579 00022 N 42 04.8172 W 011 59.4407 iberiaA
```
Line 1 60 s
```
97+196:15:56:00.148 00100 N 42 04.8362 W 011 59.5499 iberiaB BOL
97+196:16:27:00.396 00131 N 42 05.4208 W 012 02.8532 iberiaB on line heading west
97+196:19:23:00.379 00307 N 42 05.2700 W 012 20.7664 iberiaB stop shooting
97+196:22:09:00.237 01310 N 42 05.3825 W 012 16.9604 iberiaB resume shooting
97+196:22:15:00.600 01316 N 42 05.2297 W 012 17.5642 iberiaB on line heading west
97+197:05:38:00.606 01759 N 42 04.6072 W 013 03.6008 iberiaB start turn north
97+197:05:53:00.289 01774 N 42 05.0229 W 013 04.9764 iberiaB northern extreme
97+197:06:00:00.195 01781 N 42 04.8852 W 013 05.6860 iberiaB EOL
```
Turn 20 s
```
97+197:06:12:20.131 01782 N 42 04.1521 W 013 06.4401 iberiaB resume shooting
97+197:06:13:00.248 01784 N 42 04.1039 W 013 06.4469 iberiaB western extreme
97+197:06:14:20.532 01788 N 42 03.9982 W 013 06.4441 iberiaB stop shooting
```
Line 1 20 s
```
97+197:06:17:23.132 00099 N 42 03.7681 W 013 06.3907 iberiaC BOL
97+197:06:32:03.234 00143 N 42 03.1964 W 013 05.4859 iberiaC southern extreme
97+197:07:07:03.253 00248 N 42 04.5738 W 013 03.3156 iberiaC on line heading east
97+197:13:37:03.273 01418 N 42 05.1422 W 012 23.3400 iberiaC start turn south
97+197:13:57:03.580 01478 N 42 04.1627 W 012 21.9927 iberiaC eastern extreme
97+197:14:29:03.356 01574 N 42 02.0347 W 012 23.3472 iberiaC southern extreme
97+197:14:55:03.459 01652 N 42 03.1785 W 012 25.0410 iberiaC EOL
```
Line 5 40 s
```
97+197:14:57:00.146 00100 N 42 03.3252 W 012 25.0471 iberiad BOL
97+197:14:58:20.278 00102 N 42 03.4234 W 012 25.0480 iberiad on line heading north
97+197:19:31:40.531 00512 N 42 24.9874 W 012 25.0583 iberiad start turn west
97+197:19:45:00.583 00532 N 42 25.7149 W 012 25.9695 iberiad end turn heading west
97+197:19:53:40.230 00545 N 42 25.7322 W 012 26.9522 iberiad stop shooting
```
Line 6 40 s
```
97+197:19:55:42.153 00100 N 42 25.7340 W 012 27.1708 iberiae resume shooting
97+197:20:27:42.309 00148 N 42 25.8067 W 012 30.5998 iberiae start turn south
97+197:20:43:02.301 00171 N 42 25.0195 W 012 31.6004 iberiae on line heading south
97+198:04:42:22.212 00890 N 41 46.4972 W 012 31.4950 iberiae start turn east
97+198:05:03:02.558 00921 N 41 45.3088 W 012 30.4339 iberiae end turn heading east
```
Line 5 40 s
```
97+198:05:45:42.383 00985 N 41 45.1858 W 012 25.9786 iberiae start turn north
97+198:05:59:02.540 01005 N 41 45.8760 W 012 25.0443 iberiae on line heading north
97+198:10:09:42.560 01381 N 42 05.5782 W 012 25.0665 iberiae EOL
```
Turn 20 s
```
97+198:10:12:00.152 00100 N 42 05.7641 W 012 25.0675 iberiaf resume shooting
97+198:10:20:00.446 00124 N 42 06.3967 W 012 25.0454 iberiaf start rurn west
97+198:10:24:00.249 00136 N 42 06.7001 W 012 25.1568 iberiaf stop shooting
```
Line 1 20 s
```
97+198:10:26:00.153 00100 N 42 06.8389 W 012 25.2700 iberiag BOL
97+198:10:37:00.537 00133 N 42 07.2490 W 012 26.2940 iberiag northern extreme
97+198:10:58:00.348 00196 N 42 06.0677 W 012 27.6722 iberiag western extreme
97+198:11:18:00.438 00256 N 42 04.9818 W 012 26.3818 iberiag on line heading east
97+199:01:21:40.208 02787 N 42 06.0607 W 010 57.9257 iberiag EOL
```
Line 1 60 s
```
97+199:01:25:00.144 00100 N 42 06.2274 W 010 57.7516 iberiah BOL
97+199:02:03:00.606 00138 N 42 08.1586 W 010 55.5231 iberiah northern extreme
97+199:02:27:00.249 00162 N 42 06.8740 W 010 53.7605 iberiah eastern extreme
97+199:02:58:00.542 00193 N 42 05.4993 W 010 56.4556 iberiah on line heading west
97+199:13:22:00.255 00817 N 42 05.4461 W 012 04.3747 iberiah start turn north
97+199:13:36:00.230 00830 N 42 06.1013 W 012 05.4670 iberiah EOL
```
Interline segment 60 s
```
97+199:13:42:28.149 00831 N 42 06.5939 W 012 05.4263 iberiah turning northeast
97+199:13:45:28.464 00834 N 42 06.7793 W 012 05.2853 iberiah stop shooting
```
Interline segment 20 s
```
97+199:13:53:20.645 00101 N 42 07.2176 W 012 04.7030 iberiai resume shooting
97+199:15:01:20.489 00305 N 42 10.7691 W 011 58.9270 iberiai start turn north
```
Line 4 20 s
```
97+199:15:10:00.656 00331 N 42 11.4330 W 011 58.6127 iberiai eastern extreme
97+199:15:22:00.253 00367 N 42 12.1333 W 011 59.4903 iberiai on line heading west
97+200:00:48:20.387 02066 N 42 12.0282 W 013 01.9267 iberiai EOL
```

LineSummary.d2
Approach 40 s
```
97+204:14:41:20.262 00102 N 41 25.5048 W 012 46.6217 iberiaj turing west to south
97+204:14:54:00.581 00121 N 41 25.2705 W 012 48.0181 iberiaj stop shooting
97+204:14:55:00.149 00100 N 41 25.2123 W 012 48.0923 iberiak resume shooting
97+204:15:04:20.459 00114 N 41 24.5343 W 012 48.4015 iberiak western extreme
97+204:16:34:20.246 00249 N 41 18.2432 W 012 44.7507 iberiak start turn east
```
Line 12 40 s
```
97+204:16:45:40.287 00266 N 41 17.8049 W 012 43.7844 iberiak on line heading east
97+205:16:11:40.550 02375 N 41 18.6768 W 010 12.6238 iberiak end 4km streamer
97+205:21:29:40.658 00101 N 41 20.9602 W 010 16.7300 iberial start 1km streamer
97+205:21:49:00.217 00130 N 41 19.4760 W 010 16.8991 iberial western extreme
97+205:22:05:40.208 00155 N 41 18.5946 W 010 15.9937 iberial on line heading east
97+206:09:55:40.639 01220 N 41 18.1814 W 009 00.1100 iberial EOL
```
Line 18 20 s
```
97+206:10:08:20.652 00101 N 41 19.0940 W 008 59.8185 iberiam BOL heading north
97+206:13:28:20.246 00701 N 41 34.8874 W 009 00.0129 iberiam start turn west
97+206:13:33:00.537 00715 N 41 35.1907 W 009 00.2734 iberiam mid point of turn
```
Line 14 20 s
```
97+206:13:56:00.502 00784 N 41 35.6801 W 009 02.6180 iberiam on line heading west
97+206:22:36:00.418 02344 N 41 36.3946 W 009 58.3467 iberiam start turn north
97+206:22:51:00.501 02389 N 41 36.9237 W 009 59.6689 iberiam mid point of turn
```
Line 19 20 s
```
97+206:23:04:00.497 02428 N 41 37.8921 W 010 00.0293 iberiam on line heading north
97+207:05:08:00.609 03520 N 42 07.0521 W 010 00.0753 iberiam EOL
```
Line 1 40 s
```
97+207:05:11:00.166 00100 N 42 07.2309 W 010 00.2877 iberian turning west
97+207:05:19:00.355 00112 N 42 07.4589 W 010 01.1120 iberian northern extreme
97+207:05:41:00.381 00145 N 42 06.3708 W 010 02.8500 iberian western extreme
97+207:06:00:20.564 00174 N 42 05.4386 W 010 01.6856 iberian on line heading east
97+207:15:21:00.352 01015 N 42 04.7313 W 009 01.0762 iberian start turn north
97+207:15:33:40.512 01034 N 42 05.3934 W 009 00.1434 iberian EOL
```
Line 20 20 s
```
97+207:15:35:00.152 00100 N 42 05.4897 W 009 00.1354 iberiao BOL
97+207:15:36:00.450 00103 N 42 05.5615 W 009 00.1468 iberiao on line heading 340°
97+207:23:18:00.445 01489 N 42 40.9948 W 009 17.2078 iberiao start turn west
97+207:23:23:40.509 01506 N 42 41.2967 W 009 17.6727 iberiao EOL
```
Line 17 40 s
```
97+207:23:26:00.157 00100 N 42 41.3781 W 009 17.9161 iberiap BOL
97+207:23:34:00.376 00112 N 42 41.5235 W 009 18.7925 iberiap on line heading 265°
97+208:06:50:40.563 00767 N 42 38.8848 W 010 06.6550 iberiap end 1km streamer
97+208:10:51:40.654 00101 N 42 38.8933 W 010 04.2096 iberiaq start 4km streamer
97+208:11:53:40.319 00194 N 42 40.0950 W 010 08.8047 iberiaq stop shooting
97+208:12:17:00.237 00229 N 42 40.4939 W 010 06.3801 iberiaq resume shooting
97+208:12:43:40.252 00269 N 42 40.8975 W 010 03.7623 iberiaq stop shooting
97+208:13:05:40.253 00302 N 42 39.6204 W 010 02.4694 iberiaq resume shooting
97+208:13:32:20.621 00342 N 42 38.9574 W 010 04.7627 iberiaq stop shooting
97+208:13:39:40.370 00353 N 42 38.9906 W 010 05.5405 iberiaq resume shooting
97+208:13:53:40.336 00374 N 42 39.4519 W 010 06.5343 iberiaq stop shooting
97+208:13:55:00.148 00100 N 42 39.5208 W 010 06.5617 iberiar resume shooting
97+208:15:47:00.264 00268 N 42 39.0112 W 010 04.4071 iberiar on line heading 265°
97+209:05:13:00.411 01477 N 42 33.1044 W 011 35.6909 iberiar start turn south
97+209:05:25:40.534 01496 N 42 32.3310 W 011 36.6398 iberiar EOL
```
Line 21 20 s
```
97+209:05:27:00.152 00100 N 42 32.2270 W 011 36.7024 iberias BOL heading 206°
97+209:13:27:00.576 01540 N 41 57.9669 W 011 59.4966 iberias start turn west
97+209:13:39:40.628 01578 N 41 57.3809 W 012 00.6521 iberias EOL
```
Line 2 20 s
```
97+209:13:41:00.152 00100 N 41 57.3333 W 012 00.7895 iberiat BOL
97+209:13:44:00.422 00109 N 41 57.2501 W 012 01.1026 iberiat on line heading west
97+209:22:35:00.426 01702 N 41 57.0010 W 012 58.9311 iberiat start turn south
97+209:22:50:00.280 01747 N 41 56.2414 W 013 00.0629 iberiat end turn heading south
```
Line 15 20 s
```
97+209:23:50:20.239 01928 N 41 51.3596 W 012 59.5906 iberiat start turn east
97+209:23:58:00.555 01951 N 41 51.1004 W 012 58.9615 iberiat on line heading east
97+210:09:11:00.196 03610 N 41 51.0263 W 012 00.3388 iberiat start turn north
97+210:09:13:00.535 03616 N 41 51.0626 W 012 00.1289 iberiat mid point of turn
```
Line 22 20 s
```
97+210:09:15:00.355 03622 N 41 51.1286 W 011 59.9392 iberiat on line heading 50°
97+210:13:53:00.369 04456 N 42 05.4094 W 011 36.3667 iberiat start turn east
97+210:14:04:40.302 04491 N 42 05.6050 W 011 35.1130 iberiat EOL
```
Line 1 60 s
```
97+210:14:07:00.146 00100 N 42 05.6069 W 011 34.8578 iberiau BOL heading east
97+210:19:48:00.188 00441 N 42 05.6871 W 010 58.1626 iberiau end 60s shooting
```
Line 1 40 s
```
97+210:19:49:02.152 00442 N 42 05.6893 W 010 58.0531 iberiau start 40s shooting
97+211:05:02:22.476 01272 N 42 05.3670 W 009 58.2237 iberiau start turn south
97+211:05:05:02.528 01276 N 42 05.3081 W 009 57.9360 iberiau EOL
```
Line 23 20 s
```
97+211:05:06:25.147 00100 N 42 05.2581 W 009 57.7893 iberiav BOL
97+211:05:17:45.603 00134 N 42 04.4579 W 009 57.0258 iberiav on line heading south
97+211:10:56:05.171 01149 N 41 37.0275 W 009 57.0507 iberiav start turn west
```
Line 14 20 s
```
97+211:11:13:45.492 01202 N 41 36.1214 W 009 58.2796 iberiav on line heading west
97+211:20:47:05.171 02922 N 41 36.5533 W 010 59.5585 iberiav start turn south
97+211:20:53:45.606 02942 N 41 36.3378 W 011 00.2176 iberiav EOL
```

```
LineSummary.d3
```

Approach 20 s

```
97+218:02:54:20.650 00101 N 42 27.5523 W 011 31.5209 isea    heading northeast
97+218:06:23:00.308 00727 N 42 35.7104 W 011 12.5986 isea    northern extreme
97+218:06:38:00.450 00772 N 42 34.9865 W 011 11.5101 isea    on line heading south
97+218:06:55:40.327 00825 N 42 33.5761 W 011 11.5487 isea    end 20s shooting
```

Line 9 60 s

```
97+218:06:56:00.225 00826 N 42 33.5488 W 011 11.5492 isea    start 60s shooting
97+219:12:46:00.181 02616 N 40 09.8884 W 011 11.5168 isea    EOL
```

Line 24 20 s

```
97+219:14:31:20.644 00101 N 40 05.8032 W 011 14.1231 iseb    BOL heading 330°
97+219:15:51:00.352 00340 N 40 11.3636 W 011 17.3419 iseb    on line heading north
97+220:01:23:40.610 02058 N 40 58.2484 W 011 17.5153 iseb    EOL
```

Line 25 20 s

```
97+220:01:25:00.153 00100 N 40 58.3542 W 011 17.4853 isec    BOL turning east
97+220:01:40:00.377 00145 N 40 59.0616 W 011 16.2052 isec    northern extreme
97+220:02:19:00.378 00262 N 40 56.9937 W 011 13.1163 isec    eastern extreme
97+220:02:35:00.522 00310 N 40 56.0843 W 011 14.0232 isec    on line heading west
97+220:08:33:00.639 01384 N 40 56.1160 W 011 52.7308 isec    start turn north
97+220:08:49:00.302 01432 N 40 57.0381 W 011 53.7578 isec    western extreme
```

Line 26 20 s

```
97+220:10:10:00.253 01675 N 41 01.0901 W 011 47.3044 isec    northern extreme
97+220:10:27:40.285 01728 N 41 00.1662 W 011 46.0358 isec    on line heading south
97+220:15:40:00.506 02665 N 40 35.0452 W 011 46.1054 isec    start turn west
97+220:15:56:00.319 02713 N 40 34.2893 W 011 47.2488 isec    southern extreme
```

Line 27 20 s

```
97+220:16:36:00.523 02833 N 40 36.4559 W 011 49.9514 isec    westerm extreme
97+220:16:53:00.253 02884 N 40 37.4550 W 011 48.8387 isec    on line heading east
97+220:20:22:00.372 03511 N 40 37.5317 W 011 26.5707 isec    start turn south
97+220:20:38:00.300 03559 N 40 36.6634 W 011 25.5457 isec    eastern extreme
```

Line 28 20 s

```
97+220:21:21:00.222 03688 N 40 34.4160 W 011 28.6456 isec    southern extreme
97+220:21:36:00.424 03733 N 40 35.1652 W 011 29.7127 isec    on line heading north
97+221:02:23:00.372 04594 N 40 58.5104 W 011 29.5972 isec    start turn west
97+221:02:38:00.427 04639 N 40 59.2173 W 011 30.7405 isec    northern extreme
```

Line 29 20 s

```
97+221:03:05:00.577 04720 N 40 58.3543 W 011 33.2139 isec    on line heading 182°
97+221:06:11:20.171 05279 N 40 43.2830 W 011 34.3700 isec    start turn west
97+221:06:26:00.588 05323 N 40 42.5960 W 011 35.4439 isec    southern extreme
```

Line 30 20 s

```
97+221:07:06:00.217 05443 N 40 44.8604 W 011 38.3296 isec    western extreme
97+221:07:19:20.307 05483 N 40 45.5705 W 011 37.4539 isec    on line heading east
97+221:11:47:40.473 06288 N 40 45.6216 W 011 07.0244 isec    start turn north
97+221:12:00:40.462 06327 N 40 46.4145 W 011 05.9302 isec    EOL
```

Line 10 20 s

```
97+221:12:07:00.165 00100 N 40 47.0170 W 011 05.8766 ise     BOL heading north
97+221:12:53:00.208 00238 N 40 50.9804 W 011 05.8999 ise     start turn west
97+221:13:07:00.607 00280 N 40 51.7912 W 011 06.9304 ise     on line heading west
97+222:03:58:00.402 02953 N 40 51.8315 W 012 46.9202 ise     start turn north
97+222:04:13:00.581 02998 N 40 52.7235 W 012 47.9030 ise     western extreme
```

Interline segment 20 s

```
97+222:04:18:00.350 03013 N 40 53.1237 W 012 47.7909 ise     on line heading 34°
97+222:06:44:00.428 03451 N 41 02.7459 W 012 38.6675 ise     start turn east
```

Line 11 20 s

```
97+222:06:52:00.573 03475 N 41 03.0327 W 012 37.9216 ise     on line heading east
97+222:21:17:00.474 06070 N 41 03.0464 W 011 05.4968 ise     start turn north
97+222:21:21:40.440 06084 N 41 03.1828 W 011 05.0425 ise     EOL
```

Interline segment 20 s

```
97+222:21:25:00.145 00100 N 41 03.3597 W 011 04.7694 isee    BOL
97+222:21:31:00.251 00118 N 41 03.7883 W 011 04.4783 isee    on line heading north
97+223:02:10:40.384 00957 N 41 27.0343 W 011 04.4092 isee    start turn west
```

Line 13 20 s

```
97+223:02:25:00.591 01000 N 41 27.8026 W 011 05.4512 isee    on line heading west
97+223:20:15:00.521 04210 N 41 27.7517 W 013 01.0636 isee    start turn north
```

Interline segment 20 s

```
97+223:20:28:00.272 04249 N 41 28.4573 W 013 01.9799 isee    on line heading north
97+223:21:45:00.359 04480 N 41 34.6646 W 013 01.7680 isee    start turn east
```

Line 14 20 s

```
97+223:21:57:00.538 04516 N 41 35.3813 W 013 00.8820 isee    on line heading east
97+224:17:58:00.324 08119 N 41 36.6092 W 010 52.2511 isee    start turn north
97+224:18:14:00.208 08167 N 41 37.5649 W 010 51.2574 isee    eastern extreme
```

Interline segment 20 s

```
97+224:18:19:00.248 08182 N 41 37.9554 W 010 51.3867 isee    on line heading 320°
97+224:21:52:00.220 08821 N 41 50.7949 W 011 06.6249 isee    start turn west
```

Line 15 20 s

```
97+224:21:58:00.525 08839 N 41 51.0170 W 011 07.2287 isee    on line heading west
97+225:06:43:40.227 10416 N 41 50.9187 W 012 03.0647 isee    EOL
```

Appendix B

Iberia Experiment UTIG OBS Deployment, Recovery and Data Summary

Station	Chassis S/N	Sphere S/N	Deployment			Recovery			Acquired Data			
			Time	Location	Depth m	Time	Location	Depth m	Channels	Period	Hrs.	Mb
106	94-10	55427	7/13 09:20	42°05.10'N 12°31.50'W	5187	7/20 06:39	42°04.80'N 12°31.47'W	5190	1,2,3,4	7/14 12:00 - 7/20 04:40	136.7	706.5
107	94-7	55467	7/13 08:49	42°05.10'N 12°28.83'W	5157	7/20 05:38	42°04.82'N 12°28.68'W	5152	1,2,3,4	7/14 12:00 - 7/20 03:42	135.7	701.5
108	94-6	56962	7/13 08:10	42°05.15'N 12°24.99'W	5063	7/20 04:48	42°05.04'N 12°24.93'W	5075	1,2,3,4	7/14 12:00 - 7/20 02:43	134.7	696.5
109	94-18	29034	7/13 12:22	42°05.23'N 12°19.98'W	4974	7/20 12:00	42°04.98'N 12°19.82'W	4987	1,2,3,4	7/14 12:00 - 7/20 10:16	142.3	735.5
110	94-15	55478	7/13 13:10	42°05.34'N 12°13.44'W	4759	7/20 13:30	42°05.19'N 12°13.32'W	4768	1,2,3,4	7/14 12:00 - 7/16 23:00	59.0	305
									1,4	7/16 23:00 - 7/20 00:05	73.1	195
111	94-16	55472	7/13 13:54	42°05.38'N 12°06.90'W	4215	7/20 14:48	42°05.39'N 12°06.14'W	4154	1,2,3,4	7/14 12:00 - 7/16 23:01	59.0	305
									1,4	7/16 23:01 - 7/20 00:07	73.1	195
120	93-4	55496	7/13 07:35	42°01.46'N 12°25.01'W	5111	7/20 03:36	42°01.26'N 12°25.09'W	5106	1,2,3,4	7/14 12:00 - 7/20 01:35	133.6	691
121	94-14	52239	7/13 11:37	42°08.54'N 12°25.00'W	4916	7/20 10:51	42°08.10'N 12°24.85'W	4941	1,2,3,4	7/14 12:00 - 7/20 09:00	141.0	731
122	94-13	57112	7/13 11:01	42°12.05'N 12°25.03'W	4817	7/20 09:52	42°11.62'N 12°24.93'W	4827	1,2,3,4	7/14 12:00 - 7/20 07:57	140.0	728.5
125	94-11	57113	7/13 09:50	42°08.57'N 12°31.50'W	5010	7/20 07:30	42°08.28'N 12°31.47'W	5030	1,2,3,4	7/14 12:00 - 7/20 05:42	137.7	711.5
126	94-12	55454	7/13 10:20	42°12.06'N 12°31.51'W	5019	7/20 08:45	42°11.67'N 12°31.62'W	5020	1,2,3,4	7/14 12:00 - 7/20 06:45	138.8	558

Station	Chassis S/N	Sphere S/N	Deployment			Recovery			Acquired Data			
			Time	Location	Depth m	Time	Location	Depth m	Channels	Period	Hrs.	Mb
227	94-18	55472	7/21 22:08	42°05.73'N 10°56.44'W	2640	8/3 04:32	42°05.67'N 10°56.72'W	2640	1,2,3,4	7/23 17:00 - 7/31 13:04	188.1	973
228	94-6	55427	7/21 23:35	42°05.68'N 10°41.79'W	2779	8/3 03:04	42°05.69'N 10°42.03'W	2767	1,2,3,4	7/23 17:00 - 7/31 04:42	179.7	931.5
229	94-7	57113	7/22 00:57	42°05.62'N 10°27.30'W	2764	8/3 01:23	42°05.68'N 10°27.52'W	2769	1,2,3,4	7/23 17:00 - 7/31 10:12	185.2	957
230	94-10	55478	7/22 02:13	42°05.53'N 10°12.74'W	2687	8/2 23:32	42°05.45'N 10°12.82'W	2684	1,2,3,4	7/23 17:00 - 7/30 18:28	169.5	877
231	94-11	57112	7/22 03:27	42°05.43'N 9°58.18'W	2370	8/2 21:33	42°05.12'N 9°58.28'W	2331	1,2,3,4	7/23 17:00 - 7/31 13:02	188.0	972.5
232	94-12	56962	7/22 04:57	42°05.32'N 9°45.76'W	2252	8/3 09:33	42°01.84'N 9°49.62'W	2219	1,2,3,4	7/23 17:00 - 7/31 13:05	188.1	966.5
233	94-13	29034	7/22 05:15	42°05.20'N 9°33.76'W	1692	8/2 18:09	42°05.18'N 9°33.91'W	1692	1,2,3,4	7/23 17:00 - 7/31 13:04	188.1	973
234	94-14	52239	7/22 06:55	42°05.01'N 9°21.79'W	237	8/2 16:32	42°04.97'N 9°21.89'W	238	1,2,3,4	7/23 17:00 - 7/31 13:00	188.0	975
235	93-4	55496	7/22 08:02	42°04.82'N 9°09.45'W	146	8/2 14:31	42°04.56'N 9°09.15'W	146	1,4	7/24 17:00 - 7/25 17:11	24.2	64.5
									1,2,3,4	7/25 17:11 - 7/27 17:01	47.8	247
									1,4	7/27 17:01 - 7/30 00:30	55.5	148
250	94-15	55467	7/23 03:21	41°18.46'N 11°56.03'W	3514	8/1 08:26	41°18.35'N 11°56.03'W	3536	1,2,3,4	7/23 15:00 - 7/25 15:05	48.1	248.5
									1,4	7/25 15:05 - 7/29 13:10	94.1	251.5
251	94-16	55454	7/23 05:21	41°18.18'N 12°21.18'W	5148	8/1 11:04	41°18.12'N 12°21.16'W	5145	1,2,3,4	7/23 15:00 - 7/25 15:02	48.0	247.5
									1,4	7/25 15:02 - 7/29 13:37	94.6	252.5

Station	Chassis S/N	Sphere S/N	Deployment			Recovery			Acquired Data			
			Time	Location	Depth m	Time	Location	Depth m	Channels	Period	Hrs.	Mb
352	94-18	55472	8/5 06:23	40°13.80'N 11°11.53'W	4993	8/14 15:45	40°13.70'N 11°11.80'W	4997	1,2,3,4	8/06 07:00 - 8/13 12:04	173.1	894.5
353	94-6	55467	8/5 07:58	40°27.63'N 11°11.54'W	4955	Not recovered						
354	94-7	52239	8/5 09:31	40°40.80'N 11°11.50'W	4750	8/14 11:22	40°41.09'N 11°11.47'W	4745	1,2,3,4	8/06 07:00 - 8/13 12:04	173.1	894.5
355	94-10	29034	8/5 11:12	40°55.23'N 11°11.53'W	4426	4/9/99 17:	16°15'N 61°32'W	0	1,2,3,4	8/06 07:00 - 8/13 12:02	173.0	894.5
356	94-11	57112	8/5 12:48	41°07.36'N 11°11.50'W	4180	8/14 06:44	41°07.26'N 11°11.33'W	4158	1,2,3,4	8/06 07:00 - 8/13 12:02	173.0	894
357	94-12	55427	8/5 14:05	41°17.38'N 11°11.46'W	3961	8/14 04:40	41°17.31'N 11°11.48'W	3962	1,2,3,4	8/06 07:00 - 8/08 07:02	48.0	248.5
									1,4	8/08 07:02 - 8/12 05:32	94.5	251.5
358	94-13	56962	8/5 15:07	41°25.78'N 11°11.53'W	3615	8/14 03:03	41°25.65'N 11°11.50'W	3613	1,2,3,4	8/06 07:00 - 8/13 12:04	173.1	894.5
359	94-15	55454	8/5 16:41	41°39.01'N 11°11.49'W	2103	8/14 00:35	41°38.85'N 11°11.52'W	2133	1,2,3,4	8/06 07:00 - 8/08 07:05	48.1	249
									1,4	8/08 07:05 - 8/12 05:21	94.3	251
360	94-14	55478	8/5 18:09	41°51.00'N 11°11.50'W	2264	8/13 22:41	41°51.05'N 11°11.48'W	2268	1,2,3,4	8/06 07:00 - 8/13 12:05	173.1	897
361	94-16	57113	8/5 19:37	42°01.79'N 11°11.52'W	2277	8/13 20:46	42°01.73'N 11°11.63'W	2249	1,2,3,4	8/06 07:00 - 8/08 07:04	48.1	248.5
									1,4	8/08 07:04 - 8/12 05:42	94.6	251.5
362	93-4	55496	8/5 20:59	42°11.98'N 11°11.51'W	2164	8/13 18:18	42°11.85'N 11°11.86'W	2166	1,2,3,4	8/06 07:00 - 8/13 12:04	173.1	895
										Total	5031	24,109

All times are in UTC   Water depth uncorrected for sound speed

Appendix C. Key clock calibration data

Deployment 1

```
T069707130813000 194:08:13:00.003849800
T069707130902000 194:09:02:00.003900500
T069707200643000 201:06:42:59.977545800

T079707130742000 194:07:42:00.031616200
T079707130827000 194:08:27:00.032000400
T079707200543000 201:05:43:00.088913100

T089707130638000 194:06:38:00.035365900
T089707130755000 194:07:55:00.036159400
T089707200452000 201:04:52:21.662047600

T099707131104000 194:11:04:00.021343000
T099707131206000 194:12:06:00.021672100
T099707201207000 201:12:07:00.047834500

T109707131140000 194:11:40:00.028144900
T109707131258000 194:12:58:00.028749500
T109707201336000 201:13:36:00.141979900

T119707131226000 194:12:26:00.008846300
T119707131342000 194:13:42:00.009051800
T119707201454000 201:14:54:00.003046200

T209707130635000 194:06:35:00.038114500
T209707130704000 194:07:04:00.038411800
T209707200341000 201:03:41:00.157868200

T219707131022000 194:10:22:00.012697600
T219707131122000 194:11:22:00.012883200
T219707201055000 201:10:55:00.048053300

T229707130952000 194:09:52:00.032756200
T229707131046000 194:10:46:00.033233500
T229707200956000 201:09:56:00.044127500

T259707130850000 194:08:50:00.014913500
T259707130942000 194:09:42:00.015077900
T259707200734000 201:07:33:59.993492400

T269707130922000 194:09:22:00.006734500
T269707131009000 194:10:09:00.006807800
T269707200850000 201:08:49:59.948514300
```

Deployment 2

```
T279707212114000 202:21:14:00.002299400
T279707212154000 202:21:54:00.002550000
T279708030440000 215:04:40:00.048066000

T289707212233000 202:22:33:00.000471700
T289707212315000 202:23:15:00.000488900

T299707212347000 202:23:47:00.005708400
T299707220044000 203:00:44:00.006396700

T309707220117000 203:01:17:00.000842000
T309707220203000 203:02:03:00.000898600

T319707220233000 203:02:33:00.002223700
T319707220317000 203:03:17:00.002360200
T319708022137000 214:21:36:59.957240100

T329707220337000 203:03:37:00.000400900
T329707220447000 203:04:47:00.000413200
T329708030938000 215:09:37:59.904414700

T339707220503000 203:05:02:59.825039200
T339707220549000 203:05:48:59.825452300
T339708021816000 214:18:15:59.955079900

T349707220601000 203:06:01:00.003178300
T349707220642000 203:06:42:00.003338900
T349708021636000 214:16:36:00.075117400

T359707220704000 203:07:04:00.007946300
T359707220750000 203:07:50:00.008411200

T509707230201000 204:02:01:00.011687700
T509707230311000 204:03:11:00.012808800
T509708010831000 213:08:31:00.178445600

T519707230427000 204:04:27:00.003585800
T519707230508000 204:05:08:00.003746200
T519708011107000 213:11:07:00.036297600
```

Deployment 3

```
T529708050509000 217:05:09:00.004904200
T529708050615000 217:06:15:00.005353100
T529708141549000 226:15:49:00.042517700

T549708050800000 217:08:00:00.011577200
T549708050917000 217:09:17:00.012631300
T549708141126000 226:11:26:00.145105500

T559708050933000 217:09:33:00.001442600
T559708051055000 217:10:55:00.001558900

T569708051114000 217:11:14:00.003173900
T569708051229000 217:12:29:00.003429200
T569708140648000 226:06:47:59.968474200

T579708051311000 217:13:11:00.000907600
T579708051352000 217:13:52:00.000933400
T579708140443000 226:04:42:59.927468200

T589708051409000 217:14:09:00.010492600
T589708051457000 217:14:57:00.010922300
T589708140306000 226:03:06:00.032944000

T599708051514000 217:15:14:00.020658300
T599708051632000 217:16:32:00.021907400
T599708140040000 226:00:40:00.139099800

T609708051647000 217:16:47:00.004396900
T609708051752000 217:17:52:00.004610600
T609708132245000 225:22:45:00.034422500

T619708051813000 217:18:13:00.009364300
T619708051920000 217:19:20:00.009799600
T619708132052000 225:20:52:00.038064100

T629708051939000 217:19:39:00.017332600
T629708052045000 217:20:45:00.018172700
T629708131823000 225:18:23:00.178045600
```

Appendix D. GEOMAR OBH Deployment Coordinates

Station	Time	Latitude, N	Longitude, W	Depth, m
101	7/13 01:37	42°04.81'	13°00.02'	5290
102	7/13 02:40	42°04.78'	12°54.23'	5282
103	7/13 03:44	42°04.92'	12°46.55'	5256
104	7/13 04:41	42°05.02'	12°38.54'	5242
112	7/13 14:45	42°05.54'	11°58.94'	3513
113	7/13 15:36	42°05.57'	11°50.95'	3737
114	7/13 16:25	42°05.60'	11°42.21'	2570
115	7/13 17:09	42°05.65'	11°33.49'	2454
116	7/13 18:03	42°05.66'	11°24.07'	2384
117	7/13 18:55	42°05.72'	11°15.26'	2412
118	7/13 19:57	42°05.73'	11°02.96'	2640
119	7/13 06:58	41°57.22'	12°25.03'	5087
123	7/13 06:16	41°57.20'	12°31.47'	5181
124	7/13 05:34	42°01.04'	12°31.54'	5196
236	7/21 09:16	42°41.50'	9°19.39'	124
237	7/21 11:02	42°40.53'	9°37.23'	1196
238	7/21 12:44	42°39.52'	9.56.01'	2124
239	7/21 14:20	42°38.49'	10°14.27'	2691
240	7/21 15:57	42°37.67'	10°32.55'	2283
241	7/21 17:31	42°36.21'	10°50.83'	2018
242	7/21 19:05	42°34.98'	11°09.12'	1723
243	7/22 13:03	41°18.01'	9°14.31'	301
244	7/22 15:08	41°18.29'	9°32.39'	2602
245	7/22 16:37	41°18.51'	9°50.32'	3047
246	7/22 18:43	41°18.68'	10°15.47'	3541
247	7/22 20:53	41°18.73'	10°40.64'	2542
248	7/22 22:58	41°18.75'	11°05.74'	3755
249	7/23 01:13	41°18.65'	11°30.92'	3464

Appendix E

Corrections applied to some raw OBS data

In addition to the usual byte-shift correction applied to all of the trimmed raw OBS data, the following special corrections have been applied to those data files indicated with an asterisk in the list of data files given earlier.

(1) Trimmed raw OBS data files for stations 126 and 232

In the raw OBS data from these two stations, both with OBS chassis 94-12, an extra byte was inserted in the data stream at several places on the disk. The problem appears to be hardware related because it was lessened after the disk drive was replaced for the second deployment and disappeared completely after the SCSI board was replaced for the third deployment. The extra byte was in each of the following record/blocks:

Station 126: 366/75, 376/123, 574/105, 613/103, 655/113, 686/27, 983/69
Station 232: 254/21, 585/53, 658/60

Special programs, correct126t.f and correct232t.f, were written to search for the affected data blocks and correct the problem by filling the data block where the extra byte was found with zero values and shifting backward the subsequent blocks within the record by one byte. Each zeroed data block is 2.55 s long.

(2) Trimmed raw OBS data file for station 361

A single 512-byte block of data at record 201, block 117, disk block 5 was written twice on the disk, pushing forward the remaining blocks by one block and missing the last 512-byte block of the record. The problem was corrected by shifting backward the affected blocks by 512 bytes and filling the last 512-byte block with zero-value data. The length of the zero-value data is 0.32 s, effectively extending the inter-record gap by this amount.

A similar problem was also notice at Taicrust station 23 and again at Chicxulub station 7. In all three cases, the common factor was a Toshiba disk drive S/N 94U11824W. Thus it is likely that this tape drive is the cause of the problem. However, it is not easy to ascertain this because the problem occurs only once in a long while.

(3) Raw SEG-Y data file for station 108

A new TCXO (temperature controlled crystal oscillator), S/N 9535, installed on OBS 94-6 to control its real time clock, malfunctioned while the instrument was acquiring data at Station 108, causing the clock to lose more than 21 seconds during the 7-day deployment. The clock drift rates of the instrument before the deployment and after the recovery were normal; thus the clock must have lost its time only while it was in the cold environment on the sea floor.

Fortunately, there were two sets of data that could be used to compute the clock correction during the data acquisition:

(a) Each OBS records in its data headers a 'residual count,' which is a measure of the slight difference in frequency of the crystal oscillator that controls the real-time clock, in this case the TCXO, and that which controls the data sampling. [The residual count counts the number of 0.5013 ms intervals from the completion of a data acquisition for a data record till the next real-time clock update. The real-time clock updates every 100 ms, and data acquisition starts at a clock update.] Although the purpose of recording the residual count is to calibrate the sampling interval precisely against the real-time clock, it can be used to calibrate the drift rate of the real-time clock against the rate of the sampling rate oscillator if the latter is known. For Station 108, the sampling rate oscillator was calibrated in an environmental chamber and had a nearly constant drift rate of -5.6×10^{-6} at around 4°C. This rate, however, tends to change with time by aging of the crystal. Thus, the present drift rate may be slightly different. However, the rate is expected to be steady throughout the duration of our shooting because of the nearly constant temperature expected on the sea floor.

(b) The Ewing passed over this station five times while shooting. Since a clock correction can be computed from the water-wave arrivals every time the shooting ship passes over an instrument, five independent clock calibrations during the shooting are available.

Using these available data sets, the following steps were taken to remedy the problem:

Step 1: Compute a set of estimated clock corrections from (a) post-recovery clock calibration, (b) residual counts recorded in raw OBS data headers, and (c) measured drift rate of the sampling rate oscillator. It was initially assumed that the TCXO drift rate declined linearly during the two-hour period from the end of the data acquisition to the time of the instrument recovery.

For a sampling rate oscillator drift rate of -5.6×10^{-6}, the residual count would be 195 if the real-time clock were perfect. The recorded residual count, nr, that is significantly different from this value indicates that the real-time clock rate is in error. The recorded nr increased gradually from 9 shortly after the start of the data acquisition to 34 shortly before the end of the data acquisition. From the recorded nr, compute the clock drift rate, r, by

$$r=((nr-195)x0.0005013+0.1)/326.4$$

The correction was then computed by integrating the drift rate backward from the post-recovery clock calibration to the time of each recording. Program clockcorr108.f did this computation.

The error in the assumed drift rate variation from the end of data acquisition to OBS recovery is expected to cause the estimated correction to be off by a constant amount. Also, the aging of the sampling rate oscillator crystal is expected to cause an addition error of the estimated correction that varies linearly with time. These errors would be corrected later.

Step 2: Replace all of the recorded residual counts in the original raw OBS data file with a constant value of 195. This is to force the OBSTOOL to think that there were no clock problem. Program replacerc108.f did this replacement.

Step 3: In OBSTOOL, input zero initial clock corrections for all times requested.

Step 4: Create a raw SEG-Y file in OBSTOOL.

Step 5: Correct the times in the raw SEG-Y file using the results of step 1 above. Program rawsegyclkcor108.f did this correction.

Step 6: Follow the normal OBSTOOL procedures to create a water-wave subset, pick water-wave arrivals, and locate the OBS using the data from all five passes together.

Step 7: The computed clock corrections at the five passes show the expected linear trend with time, although there is a curvature to the line. For the moment, ignore the curvature and compute the linear least-squares fit to the corrections. The computed values are an additional correction of 0.811 sec at the end of data acquisition and an additional drift of 2.96×10^{-6}. The additional drift, which represents the error in the sampling oscillator drift rate used in the initial estimation, corresponds to a change in the residual count of -2.

Step 8: Repeat step 1 above with a revised correction of 22.227 s at the end of data acquisition and a new drift rate computed using an updated residual count of 193. [program clockcorr108a.f]

Step 9: Repeat step 2 with the updated residual count.

Step 10: Repeat steps 4 and 5 using the updated clock corrections.

Step 11: Follow the normal OBSTOOL procedures for the rest of the processing.

These correction procedures produce usable SEG-Y files, but a few problems remained.

(a) The clock corrections computed from the five passes in step 7 are not completely linear with time, but show some curvature. A linear fit causes a clock error of as much as 50 ms at each pass, which, I believe, should be smaller.

(b) The linearly extrapolated clock correction at the end of data acquisition, 22.227 s, exceeds the clock error at recovery of 21.662 s.

It wad determined that this remaining error was due to the low resolution of the residual count, which has only 2 digits.

Fortunately, we had five passes over the station, and the data from these passes could be used to further refine the clock correction. In addition, we noticed that a small portion of line 3 just east of station 111 was tracked twice, once shortly after the start of the shooting and again towards the end of the shooting. The fact that the refracted seismic arrivals from these two segments must have the same arrival times at equal distance gave us another constraint to further refine the clock correction.

Consequently, a secondary clock correction was recomputed by cubic least-squares fitting the six arrival time errors, one from each of the five passes and another from the arrival time difference mentioned above. The resulting fit was within 2 ms at all passes. [In contrast, a quadratic fit gave errors of up to 22 ms. A liner least-squares fit, which the OBSTOOL employs, gives errors of 50 ms or more as demonstrated above.]

The final clock correction thus derived was applied to the raw SEG-Y data. The remainder of the processing can now be done with OBSTOOL.

Appendix F

Iberia Post-Cruise OBS Data Processing Plan

Although the onboard processing of the OBS data produced some processed data sets useful for preliminary interpretations, additional data are needed before the final processed data are produced, and these must await till after the cruise.

1. Clock correction: — The reason why we must defer this to a post-cruise processing is the yet unknown behavior of the TCXOs (temperature-compensated crystal oscillators) used first time in all OBSs during this cruise. As we did not have time to calibrate each of them precisely at low temperatures before the cruise, we are not certain how best we interpolate the pre-deployment and post-recovery clock calibration data to obtain the clock corrections during the shooting. We plan to do this low-temperature calibration in an environmental chamber after our return to Austin, and develop a clock correction scheme that is best suited for this new type of crystal oscillator.

2. Shot delay: — The results from the first two deployments indicate that there is a slight discrepancy between the shot times provided by the Ewing and the water-wave arrival times as observed on each OBS. The provided shot times appear to be about 15 ms or so later than the actual firing of the guns. We will make a better estimate of this 'shot delay' after the cruise using the data from all three deployments, and apply it to all data sets.

3. Navigation: — Although the navigation data provided to us onboard, which are based on non-differential GPS and ship's heading and speed from Furuno, are generally excellent, a still better navigational data may become available after the cruise using differential GPS with data from a land station in Spain. If this data set becomes available, and if we feel that the more precise navigation will significantly improve our data, which we are not certain at this moment, then we will reprocess the data using the set.

4. OBS location and orientation: — The location and orientation of each OBS as determined onboard are preliminary. Especially those for the first deployment need to be recalculated using proper water-wave velocity. Also, when two or more crossings over an OBS occurred while the instrument was recording in different modes (2-channel and 4-channel modes), programs currently available in OBSTOOL cannot handle the full data set, and thus a new program need to be written to fully utilize the available data.

5. Final SEG-Y format files: — For archival purposes, we will generate a single large SEG-Y format file containing data for all active channels for all shots for each OBS. However, since a single large file for each OBS for the entire shooting period may not be the most convenient data file to use, we will also generate a second set of SEG-Y format files, each of which contains data from a single channel for a single seismic line crossing over or near an instrument. Each SEG-Y trace of both data sets will cover 20 seconds starting at least one second before the first arrival and with an appropriate delay with offset (tentatively set to 8 km/s). For example, the near trace will start 1 second before the shot for an OBS in shallow water, and it will start 2 seconds after the shot for an OBS in deep (>4500m) water; at 120 km offset, the trace will start at 14 seconds and 17 seconds, respectively, after the shot.

6. Optional processing: — The following three basic processing techniques may be applied to the data if we find it necessary and appropriate to do so:

a) Deconvolution: An autocorrelogram will be produced for each OBS to determined the appropriate deconvolution parameters to use.

b) Filtering: Filter parameters will be determined by comparing the frequency spectra of signal and background noise.

c) Reduction of previous-shot noise: Traces are first lined up using the shot times of the immediately preceding shots, an f-k filter is then applied to suppress the water-wave arrivals, and the traces are restored to line up with the current shots.

The processed data may be plotted in the form of record sections with an appropriate reduced velocity (tentatively set to 8 km/s) for distribution.