Czmutto

Cruise Report

leg EW9503
R/V Maurice EWING

May 1-May 13, 1995
Manzanillo, Mexico-San Diego, California

Chief Scientist
Suzanne Carbotte

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Seismic study of the shallowest, most robust East Pacific Rise: Magmatic and spreading rate influences on axial and young ocean crustal structures.

1. Objectives

The primary objectives of EW9503 were to study the nature of crustal magma bodies within a region of the NEPR inferred to have a very robust magma supply.The study was centered on 2 ridge segments directly north of the Orozco fracture zone (Fig. 1) within which a survey of closely-spaced multichannel seismic lines was planned. The ridge north of the Orozco fracture zone is the shallowest and broadest segment along the entire length of the EPR from 23°S to 23°N (Fig. 2). Based on correlation's between axial morphology and ridge magmatic state inferred from studies elsewhere, this region has been predicted to have an excess magma supply and may be associated with a shallow and broad magma chamber. However, spreading rates in the region are within the intermediate-fast portion of the spreading rate spectrum (86 mm/yr) and compilations of existing data predict that the axial magma chamber should be deeper in this area than along the faster spreading EPR previously studied to the south. Given the unique combination of slower spreading rate and inferred robust magma supply, this location provides an ideal site to evaluate the influence of spreading rate and magma supply on the depth, width, and spatial distribution of crustal magma bodies. Additional secondary objectives were to study the effect of variations in magma budget on the thickness of layer 2a and the oceanic crust in an area where we infer these variations to be extreme.

2. Tectonic Setting

Figure 3 shows bathymetry for the study region available prior to our survey. In addition to the SeaMARC II bathymetry and widely spaced Seabeam bathymetry which comprise this map, previously collected data for the region included SeaMARC II side scan sonar data, gravity and magnetics, and geochemical data from 1 dredge and 9 rock cores.

North of the Orozco fracture zone the EPR extends uninterrupted for 115 km, curving continuously along this length. Axial depths rise to 2200m over an exceptionally flat summit region 3-4 km wide on average, swelling to a width of greater than 10 km at its broadest part (15°40'N). Further north, this broad ridge becomes more triangular in shape and forms the left limb of a right stepping OSC located at 16°20'N. North of the OSC the ridge is narrower and deeper than to the south, with an average axial depth of 2700 m. A local depth high is reached at 16°33'N, adjacent to the westward projection of a small seamount chain. The recent history of ridge segmentation in the area is complicated and has involved both southward and northward propagation of ridge segments and the abandonment of an OSC. This history is described by the complex pattern of relict overlap basins and ridges left on the ridge flanks which comprise a swath of disturbed terrain extending over 60 km N-S.

Extending west from the southern ridge segment is a prominent off-axis ridge possibly marking the location of a hotspot. It is over 50 km in length with depths as shallow as 1300 m. It appears to be a continuous feature rather than one made up of well defined individual cones and strikes 280°, parallel to Pacific absolute plate motion.

3. Data Acquisition Parameters

MCS data were obtained using a 4 km long streamer comprised of 160 active groups at 25m intervals. The streamer was made up of 2400 m of the new CANTO section with internal digitizing cans and 1400 m of old style streamer with external digitizing cans (Fig. 4). 18 Syntron depth controller ("birds") were attached. A 20 sec shot interval with 250 msec shot randomization was used throughout the survey. For nominal ship speed's of 5 kts this results in a shot spacing of

50 m. This shot interval was chosen to avoid sampling energy reverberating in the water column after 10 sec at times coincident with arrivals of interest. Shot randomization was used to prevent harmonic buildup of previous shot multiples. With the Digicon DMS2000 recording system, 8 or 10 sec records were written to 3M 3480 cartridge tapes in SEGD format using a 2 ms sampling rate. Day plots of shot spacing and interval are included in Appendix 3. Fig. 5 shows the configuration of the tuned 10 gun 3005 cu. in. airgun array used throughout the survey. During acquisition of line 1331 streamer depth was set at 12 m but subsequently changed to 8 m to be coincident with average gun depth and to optimize the high frequency content of the seismic source.

4. Survey Summary

A detailed cruise narrative follows in section 7. In this section, a brief summary of the data acquisition and survey coverage is given.

Because the data acquisition system must be shut down in order to change line numbers, we chose to record through all turns and note start and end times of each line in the logs. A few tape drive swapping problems occurred at various times during the survey but these were minor compared to what had been reported from previous legs. However, changing of NAV tapes was awkward and in some instances was associated with premature swapping of the data tape drives and some confusion about what was being recorded on which drive. The guns fired well with only a few periods of one gun auto firing or not firing at all and minor repairs required. However, from 127JD on, the streamer towed heavy at its front section. This may have been due in part to the inadvertent lack of birds along 700m of section at the streamer head. During streamer deployment birds were attached at collar locations marked with yellow tape. These locations produced an imbalance in bird positions with birds every 100m near the middle of the section and then only one bird left for the final 700m. Four compass sections were added during streamer deployment but from the beginning we were not recording information from any of these sections. A seriously frayed portion of the tow leader was discovered shortly after deployment (see narrative), and the tow leader was shortened as a result reducing the streamer length by 10 m in the near offset range. Throughout the rest of the survey we kept a careful watch on streamer tension and maintained speeds of 4-4.5 kts in order to keep streamer tension below 2500 lbs. The low survey speeds and excellent weather resulted in very clean Hydrosweep data which required little editing. Sonobuoy data were recorded on auxiliary channels 177, 178.

Throughout the survey Peter Buhl's recently developed real-time multichannel seismic display system called "Splitter" was used to generate real-time stacks. NMO is applied to traces 1 through 160 using a fixed velocity model tied to the travel time to seafloor reflection. For this study we used the velocity model of Vera et al. (1989) derived from ESP#1 located 10 km off axis at 9°N. The outside mute implemented in Splitter was adjusted to operate at offsets greater than 1500m. After NMO and mute, traces are input to 25m CDP bins assuming a 50m shot spacing and stacked. Two EPC recorders are devoted to output from Splitter, one for the real time stack and the other for a single channel record (channel 150). In addition to the real-time EPC record, the stacked data is also written to disk as a segy file. These segy files become very large and at least once a day splitter should be restarted to ensure that this file does not become unmanageable in size. After 4 days of data acquisition, we filled the disk and needed to remove the segy stack files generated up to that time. The capability to generate real time stacks was a great asset to our study and allowed decisions to be made regarding survey targets based on what we had just imaged.

Figure 6 shows track coverage within the main survey area. Data acquisition began with a flow line transect, line 1331, from east flank crust ~ 3 my old, extending across the ridge, over several abandoned OSC ridge tips and to west flank crust ~2 my old. Returning to the ridge along line 1332 we commenced a detailed survey of the southern ridge segment with a short line north

(1333) through the current overlap basin. Line 1334 was run down the center of the ridge axis with course adjustments made as required to keep the ship centered on the ridge axis. Based on where an AMC reflector was observed in this line, three additional closely spaced (~1-2 km) along-axis lines were shot (1347, 1348, 1353). Data were collected on 14 ridge crossings in total ranging from 15 km to 60 km long. The longer ridge perpendicular lines were located to compare crustal thickness, Layer 2A thickness, and seafloor fabric at locations near the transform fault and mid-segment. One line (1351) was shot in an attempt to image beneath the NE trending volcanic terrain between the ridge axis and the seamount chain at 15°37'N. Line 1335 was shot in an attempt to image Moho within the Orozco transform domain.

The southern survey ended with a long isochron line (1355) heading north and crossing a recently abandoned overlap basin. Survey of the northern ridge segment began with a line run along the ridge axis to a small discontinuity and local depth maximum at ~16°50'N. In the northern area, 6 ridge crossing lines were shot. An additional short along-axis line was located within the region where an AMC had been observed in line 1355. Our last profile, line 1365, was a west flank flow line starting at the ridge at 16°32'N and was shot to allow comparison of crustal and Layer 2A thickness on the southern and northern ridge segments.

Sonobuoys were deployed at various times during the survey when shooting along isochron lines and hence relatively flat terrain. In total, 768 nm of MSC data were acquired and 25 successful sonobuoys launched out of a total of 28 (89% success rate). A complete listing of MSC line numbers, locations, shot and file numbers is given in Appendix 1. Appendix 2 gives a summary of sonobuoys launched.

5. Preliminary Results

From the real time stacks, an AMC reflector, Moho, and the seismic event from the base of Layer 2A could often be identified. At some locations, other coherent mid-crustal reflectivity was also imaged. Sample stack sections are shown in Fig. 7. Based on these brute stack images we make the following observations:

An AMC reflector is observed beneath both ridge segments. Along the southern ridge a very bright AMC event is observed from 15°50'N to 15°27'N, 10 km north of the Orozco transform fault (Fig. 7a). Ridge crossing lines show that the AMC is generally shallowest under the center of the axis but may extend asymmetrically beneath one flank or the other (Fig. 7b). Depths under the center of the ridge are ~0.6-0.62 sec twtt, comparable to AMC depths within the 9°N area. However, in a few local spots, the AMC reaches shallower depths up to 0.56 sec. The event appears to be widest where it is most distinct and bright. Coverage with 4 parallel along-axis lines spaced ~1-2 km apart allows us to estimate AMC widths of greater than 4 km in the vicinity of the broadest portion of the ridge. Continuing north to 16°02'N, a less distinct AMC event is observed at approximately the same twtt as the bright event to the south.

On the northern segment a bright AMC is imaged beneath the shallowest portion of the ridge, from ~16°25 to 16°32'N (Fig. 7c). In this region the AMC is observed at depths of 0.63 -0.85 sec twtt, in places as shallow as at the southern segment. From the inverse relation between spreading rate and depth to the axial low velocity zone apparent in the compilation of Purdy et al (1992), we would predict AMC depths closer to 0.7-0.8 sec twtt for the north Orozco segment. The compilation of Purdy et al (1992) has provided compelling evidence for a thermal control on the depth to which the axial magma chamber rises. However, the shallow depths we observe along both ridge segments north of Orozco indicate that other factors may be operating.

The AMC is not flat in either the along-axis or cross-axis direction (Fig. 7). In both directions it appears to have relief of up to 0.4 sec twtt. With our multiple along-axis coverage we identify the AMC at depths of ~0.6 sec beneath the center of the ridge but as deep as 0.9-1.1 sec along parallel lines located 1-2 km away where the otherlying seafloor remains flat. It is possible

5. The **DMS2000** recording system worked well and is a significant advance of the DSS240 that was in decline and experiencing considerable operating problems. We continue to face the potential for operating problems with the new system however based on its uniqueness. At least the following steps need to be taken

a. Obtain the system software from Digicon and/or Syntron

b. The DMS2000 system that will be removed from the Polar Search should be passed to Lamont at minimum or no cost to Lamont.

c. The operating agreement current with Digicon for support of acquisition hardware needs to be formally transferred to Syntron

d. Steps need to be set in place immediately to move all operational support to Syntron. The DMS2000 will undoubtedly become increasingly difficult to support as Syntron moves away from support of the system for servicing Digicon operations. Ideally we need to make a complete transfer of all acquisition hardware systems from Digicon to Syntron. A time frame for this transition should be established and concrete plans set to enact the change.

The first two of these were verbally agreed to by Digicon and Syntron personnel during the period in which the Digicon technology was being transferred to Syntron last year. We also have a nominal agreement for the third. Each needs to be solidified.

6. **General Ship board facilities.** There are currently 2 copy machines in the ship's office. It would be very useful to have one of these in the main lab. Installation of book cases in the science office or main lab with a selection of standard texts would be a useful addition.

7. Cruise Narrative

Monday May 1 (JD121). Departed from Manzanillo at 08:00l. We heard through our agent that Lt. Miranda of the Estacion de Investigacion Oceanografica de Ensenada, Direccion General de Oceanografia Naval de la Secretaria de Marina, had received no written orders to accompany us, and hence would not be arriving. We had a fire and boat drill at 15:20l followed by an introduction to workings on the ship from the Captain and Chief Engineer. Bruce Francis gave us an overview of watch procedures and the various data acquisition displays in the main lab. At 20:00l we had a brief science meeting to discuss objectives of the cruise and then began science watches. We arrived at our first waypoint at 23:15l to begin deploying the streamer.

Tuesday May 2 (JD122). Streamer deployment went very smoothly and was finished by 07:05l, 8 hours after deployment began. Four compass sections were added to the streamer and 18 Syntron birds attached. The streamer had lost a fair amount of oil since it was last used on EW9501 and Bruce Francis reported a telemetry problem at can #37 with the streamer on the reel. We filled flat sections as the streamer came off the reel and after the front of the section was in the water, the telemetry problem disappeared. A total of 140 gallons of oil were pumped into the streamer. 8 leaks were repaired while deploying, all within the front sections. After building the streamer, we were unable to communicate with bird #8 and this continued throughout the cruise. Bruce Francis ran diagnostics on the streamer and found 2 bad channels, #74 and 75.

At 08:57l (14:57z) data acquisition began along line 1331, less than 10 hours after arriving at way point #1. At 10:54l (16:54z), shooting of line 1331 was stopped. In an attempt to re-zero the tensiometer for the streamer, Chris and Bruce discovered that the armored tow leader was seriously frayed. On deployment we had noticed that the tow leader looked very worn, but it had apparently looked bad for quite some time. At 17:26z we resumed operation with a shortened cable (~7-10m). At 18:00l (00:00z) the decision was made to attach a kevlar line to the front of the first passive section as a safety should the tow line give way. On examining the cable as it was brought in, it appeared that the seriously worn part was confined to the frayed section which is the portion of the cable that is in and out of the water most frequently. For the remainder of the survey, streamer tension was watched closely and we slowed whenever it began to spike frequently above 2500 lbs. As a result of these precautions much of the survey was run at speeds of ~4.5 kts.

21:00l (03:00z May 3), After giving the bridge an approximate final way point, they calculated our return transit time and we discovered that our total science time was short by 30 hours, over a day. We discussed this with the Captain and he agreed to assume a return transit speed of 12 kts in order to give us a maximum of 6 hours of our funded eighth day. Given the very short length of the program, one whole day was clearly an unacceptably large portion of our program to loose due to miscalculation of transit time on the part of the marine office. I wrote an email to Michael Rawson, alerting him of the problem and requesting resolution of the discrepancy.

Wednesday May 3 (JD 123). The weather has been beautiful since leaving Manzanillo. Light winds at 8-10 kts, calm seas, sunny skies and temperatures of 25°-28°C. The projected weather forecast for the rest of the week is much of the same. At 12:31z we began line 1332, a west flank flow line profile extending to the ridge axis. During the turn, we had the streamer repositioned from 12m to 8m. The seas were sufficiently calm that maintaining the streamer at this shallow depth was not difficult. A shallower towing depth shifts the notch in the source spectrum due to the free surface ghost reflection to higher frequencies. The gravimeter reading that is output to the display in the lab is in counts, unfiltered for ship's motion, which show 8000 count oscillations. Budhy worked on sending filtered numbers to the display instead. At 14:00l (20:00z) I received a FAX memo from Michael Rawson agreeing to a 24 hour delay in our arrival at San Diego so that the full funded 8 days of science could be accomplished. At 21:20z during turn to begin line 1333 Bruce ran diagnostics on the streamer identifying the following problems; channels 73, 74 - bad; channels 28, 36 - open, channel 27 - water.

Thursday May 4 (JD124). At 00:18z we began shooting line 1334 along the crest of the southern ridge segment. A very bright AMC reflector, clearly polarity reversed relative to sea floor arrival, was imaged from ~ 15°44'S to ~15° 27.5'S, 10 km north of the Orozco transform fault. The character of the seafloor reflection changes along axis and is much brighter and broader above regions where the amc is brightest. At 15:22z we began line 1335 crossing the Orozco transform fault. Along this line we hoped to image Moho and so investigate any crustal thinning within the transform domain. At 17:55z we began line 1336, our southern most ridge crossing. This line was located at the southernmost end of where we had observed an AMC reflector in the along-axis line, but no amc was detectable at this crossing. At 21:06z, we began line 1337, the first of two long flowline profiles crossing the ridge axis and extending onto the eastern ridge flank. At this ridge crossing an asymmetric diffractive AMC event was observed, located at 0.58 sec twtt at its shallowest point. We hope to be able to use this line to investigate crustal thickness beneath the apparent abandoned ridge located just east of the current ridge axis. No Moho was apparent in the real time stacks. On turning north to begin this line we observed a very bright Moho reflector. Throughout our survey we often imaged lower crust well along the short isochron transits between flow lines.

We had a number of problems with the guns on this day. At 00:32 gun #4 (235 cu in) which had been firing outside range, was pulled for repairs and was back in the water at 00:40z. From 13:19z to 14:05z gun #8 (850 cu. in.) was out of the water for repair of a suspected leak. At 16:46 gun #4 (235 cu. in.), which had ceased firing, was pulled. This gun was back in the water at 18:42z but then gun #17 (200 cu. in.) was pulled for repair of a broken clamp from 19:01z - 19:44z.

We decided to use today and tomorrow (JD 124-125) as our funded Hydrosweep days. Three XBT's were launched, the second and third of which failed at ~200m but which showed a very similar velocity profile in the upper water column as that obtained on the one successful XBT. Five successful sonobuoys were launched along line 1334, and two which failed (sonobuoys 105-111). Of two launched on line 1335, one failed (112, 113).

Friday May 5 (JD 125). Continued with our survey of the southern ridge segment. Along line 1338 a possible Moho reflection was observed at ~ 2.15sec twtt beneath the abandoned ridge east of the axis, suggesting thicker crust beneath this feature. A very bright broad seafloor reflector was observed on this crossing of the ridge axis, coincident with where a bright seafloor event was observed in the along axis line and we wondered whether this character might reflect a real difference in character of the seafloor here. Perhaps the axis is covered with massive sheet flows in these areas where the seafloor return is exceptionally bright? Directly beneath the summit caldera, a bright broad diffractive amc event was observed, ~2.5 km wide, located at 0.6sec bsf at it's shallowest point. The AMC reflector was located at similar depths and with similar widths on the next 2 ridge crossings to the north, lines 1339 and 1340. Along line 1340, the amc was asymmetric deepening to the west.

Acquisition displays indicated that we were not recording compass information, and Bruce Francis confirmed this with examination of data tapes. He is uncertain of what the problem with the compass sections might be and documentation is sparse. We decided to have the bridge keep a 30 minute log of tail buoy heading.

Saturday May 6 (JD 126). Continued our survey with ridge-crossing lines (1341, 1342) through the broadest portion of the axis at 15°40-45'N. On these profiles two and possibly three separate amc events were observed located at different depths. Line 1343 was shot along an isochron line through a low relief plateau directly north of the west flank seamount chain during which sonobuoys 114 and 115 were successfully launched. Following the northern most ridge crossing, line 1346, a second along-axis line was begun (1347). This line was placed 1-2 km from line 1334, beginning west of the initial line but crossing to east of it in order to image an amc which was asymmetric to the east along lines 1341 and 1343. Along line 1347 a bright amc event was imaged well north of where we had imaged it well on our first along-axis line, highlighting the inadequacies of mapping the AMC with a single along axis line.

At 18:00z wild excursions in the magnetometer readings were noted and the maggie was pulled out of the water. On opening the magnetometer, a ruptured rubber diaphragm was found and replaced.

Sunday May 7 (JD 127). Upon finishing our second along-axis line at 1:22z, we turned 180° to begin a third axial line (1348) located ~ 1km to the west of line 1334. Adjacent to the broadest portion of the rise two overlying AMC reflectors were observed. The shallowest point of the two reflectors are at 0.72 and 0.78 sec with the deeper one located north of the shallower one. The same configuration was observed along a fourth axial line, 1353, located ~ 1km further west although the amc was observed in this location at greater depths of 0.9 to 1.2 sec. Line 1352 was shot through moderate relief volcanic terrain which extends between the ridge axis and the off-axis seamount chain. Abundant and pronounced seafloor diffractions obscured any sub-seafloor structure along this line.

At 12:05z gun #4 (235 cu. in.) stopped firing and was pulled. Gun had a broken clamp requiring replacement of the chamber. No 235 cu. in. chambers were available in reserve and so Johnny replaced it with a 250 cu. in. chamber instead. Gun was back in the water at 13:46z.

At 20:56z we began line 1335, an isochron line heading toward the northern ridge segment and ending our survey of the southern segment. A lot of discontinuous mid-crustal reflectivity was observed along this line. Some of it is very bright and approximately at AMC depths and may be similar to the frozen magma chamber top reflectors observed in the 1985 MCS data obtained to the south.

At 20:001 (128/02:00z) the alarm for the streamer tension sounded twice within 1 minute signaling readings of 3000lbs. The tensiometer was showing high/low excursions of over 1500lb indicating the streamer was stretching and recoiling. Discussions with John and Bruce focused on 2 main possibilities; the tail buoy is taking on water and is sinking, or something is caught in the streamer or tail buoy. Both the strobe and radio beacon on the tail buoy ceased functioning earlier in the evening and the combination of these circumstances pointed to the first possibility. The decision was made to send the Zodiak rescue boat out to examine the tail buoy first thing in the morning. Throughout the evening, the head of the streamer was dragging low ~ 3-4 m.

Monday May 8 (JD 128). The Zodiak was launched and after one failed attempt due to engine failure, the tail buoy was reached and checked out fine. Streamer tension was still oscillating and the head of the streamer was consistently lying 3-4m below target depth. We speculated that the cable had lost oil and taken on water in the front sections. Shooting continued but at speeds of 4-4.5 kts in order to keep tension from peaking above 2600 lbs. One turn corresponds with ~ 100 lbs increased tension on the streamer.

We began survey of the northern area at 04:00z continuing along line 1335 up the middle of the ridge axis. We observed a bright amc reflector beneath the shallowest portion of the ridge from ~16°25'-32'. We ended this along-axis line at ~16°50'N, near a small discontinuity, turning to begin a series of ridge crossing lines working our way south. Along line 1360 we crossed the northern edge of a small flat topped seamount, and imaged a very AMC-like event with it's shallowest point at 0.9sec bsf.

Tuesday May 9 (JD 129). We shot line 1361 south over the center of this seamount and observed a diffuse dipping event which doesn't appear to be polarity reversed relative to seafloor. Profile 1362 and 1363 were ridge crossing lines that extended onto the western ridge flank through an abandoned overlap basin. Some indication of a shallowing Moho reflector was observed beneath the overlap basin on 1363. The final line of the northern ridge survey was a short along-axis profile, 1364, located ~ 1km east of 1355. An AMC event was followed on this line at ~ the same locations that it was observed on the first along-axis profile. A final sonobuoy was launched at 12:56z (#132). At 15:33z we began shooting the last profile of the survey, line 1365, a flow line transect on the western ridge flank. A clear shallow Moho reflector (1.7-1.8sec) was imaged from ~ 13km from the axis to the end of the line.

From 16:59z-17:46z gun #20 (145 cu. in.) was out of the water due to auto firing problems.

At 23:15z our survey ended and we began retrieval of all gear. During retrieval the tow leader was removed and section #37 was swapped out. Compass sections were left in and one leak was patched. Bird number 8 checked out on deck, indicating the problem may have been with the bird collar location relative to the streamer coil. At 21:45l retrieval was finished. The magnetometer was re deployed and we were underway for San Diego.

Wednesday May 10 (JD130). Lab watches were continued with one person per watch. Hydrosweep, gravity and magnetics data were collected. The transit to San Diego took us over the Rivera transform and the Pacific-Rivera ridge. Due to difficulties in obtaining Mexican clearance in the past transit data through this region is somewhat sparse and the Hydrosweep data obtained should be useful.

Thursday May 11 (JD131). We picked up a 20-25 knot wind on our bow which slowed our transit. People worked on assembling data, compiling line and sonobuoy logs and other personnel projects.

Friday May 12 (JD132). At 11:00l the magnêtometer was brought in and the gravimeter and Hydrosweep were turned off, ending data acquistion on EW9503.

Personnel

Science Party

Suzanne Carbotte	Chief Scientist (L-DEO)
John Mutter	Scientist (L-DEO)
Marcia McNutt	Scientist (MIT)
Marc Spiegelman	Scientist (L-DEO)
Rodolfo Cruz-Orozco	Scientist (CICIMAR)
Gustavo Correa	Scientist (L-DEO)
Venugopal Bhat	Scientist (UW)
Bruce Francis	Science Officer
Stefanus Budhypramono	Systems Administrator
Chris Liedhold	Electrical Technician
Chuck Donaldson	Electrical Technician
Johnny DiBernardo	Airgun Officer
Gil Newton	Gun Technician
Carlos Gutierrez	Gun Technician
Paul Olsgaard	Gun Technician

Ship Crew

Ian Young	Master
Louis Mello	Chief Mate
Mark Landow	2nd Mate
Jeffrey Sylvia	3rd Mate
John Santini	Boatswain
Larry Barrows	A/B
David Graham	A/B
Darrell Hann	A/B
Scott Spangler	O/S
Steve Barrows	O/S
Albert Karlyn	Chief Engineer
Matthew Tucke	First engineer
Matthew Van Duyne	Second Engineer
Todd Greenfield	Third Engineer
Greenleaf Maker	Oiler
Michael Spruill	Oiler
Guillermo Uribe	Oiler
John Schwatrz	Electrician
Frank Paloney	Steward
Tim Hummel	Cook
Luke Moqo	Utility
Robert Powell	Radio Officer

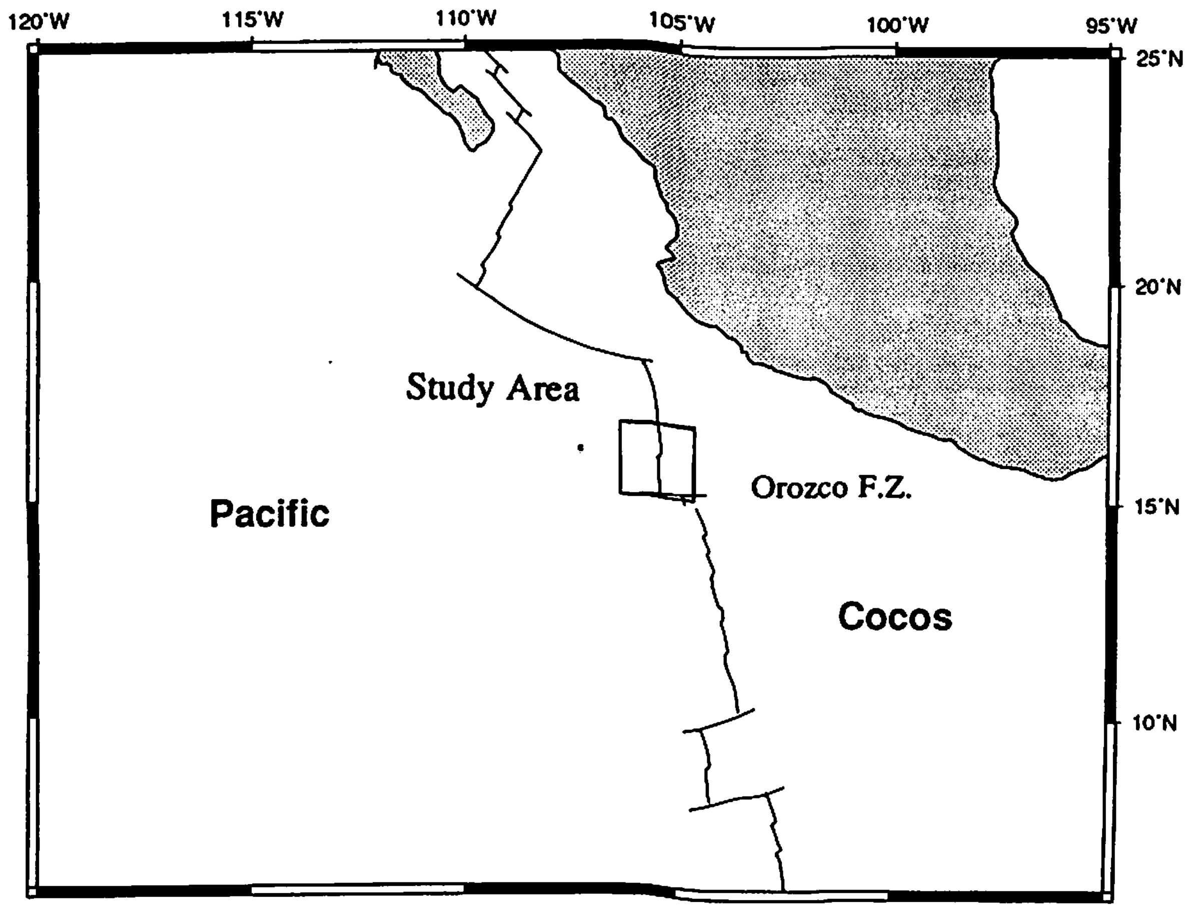


Figure 1. Location of the study on the northern East Pacific Rise

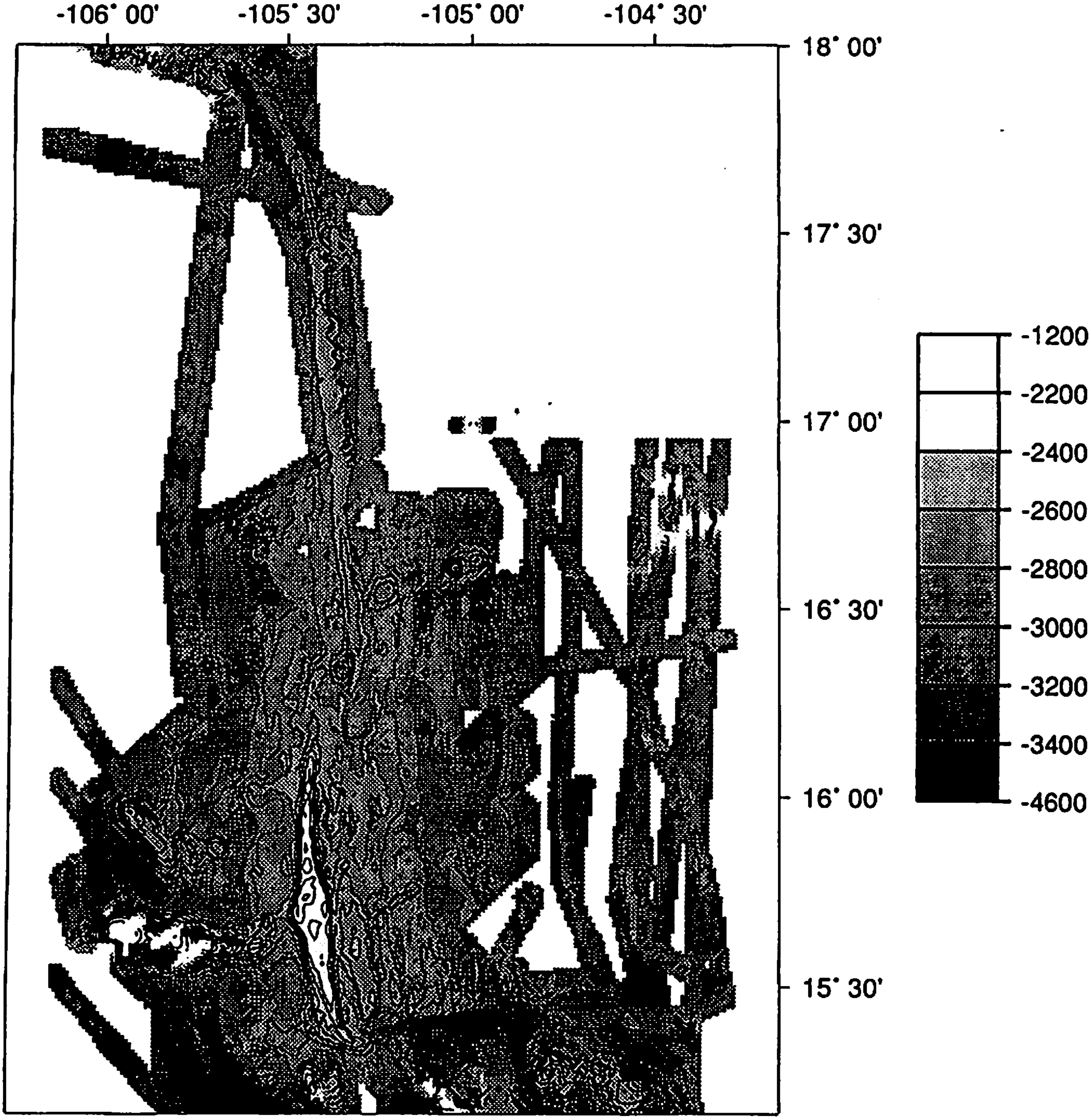


Figure 3. Existing bathymetry prior to EW9503. Map is compiled from SeaMARC II and Seabeam bathymetry gridded at a 1km interval. (from Macdonald et al., 1992)

EW9503, Streamer configuration at final pull-in

Section Number	Section Type	Sect. s/n	Can s/n	Remarks
--	50-m Tailrope	4435		Bird 1
01	100m DSS240 Active	9302	3078	Compass 1 S/N 8145
02	" " "	9513	3355	Bird 2
03	" " "	9385	3238	
04	" " "	9038	567	Bird 3
05	" " "	9360	1367	
06	" " "	1158	3283	Bird 4
07	" " "	9418	803	
08	" " "	9510	3255	Bird 5
09	" " "	9471	3114	
10	" " "	9492	654	Bird 6
11	" " "	9261	3278	Compass 2 S/N 8155
12	" " "	9564	798	Bird 7
13	" " "	9118	3061	Bird 8 Didn't work
14	" " "	9528	3139	
15	" " "	9529	3109	
16	" " "	9445	1248	
	Power Adapter	PWR1		Bird 9
17	100m CANTO Active	2021		
18	" " "	2046		
19	" " "	2014		Bird 10
20	" " "	2035		
21	" " "	2044		Compass #3 S/N 4221
22	" " "	2024		Bird 11
23	" " "	2011		
24	" " "	2025		Bird 12
25	" " "	2015		Bird 13
26	" " "	2043		Compass #4 S/N 8135
27	" " "	2003		Bird 14
28	" " "	2033		Bird 15
29	" " "	2049		
30	" " "	2004		
31	" " "	2039		Bird 16
32	" " "	2029		
33	" " "	2026		Bird 17
34	" " "	2009		
35	" " "	2019		
36	" " "	2022		
37	" " "	2005		removed on retreival
38	" " "	2017		
39	" " "	2038		
40	" " "	2045		Bird 18
41	50m CANTO Elastic	6001		
42	" " "	6003		
43	100m CANTO Isolator	6204		
44	Tow leader			
45	Deck leader			

During streamer deployment, birds were attached at collar locations marked by yellow tape. This resulted in bird locations every 100m for sections 24-28 and then 700 m without birds at the head of the streamer. Birds are attached directly in front of the associated sections.

Figure 4.

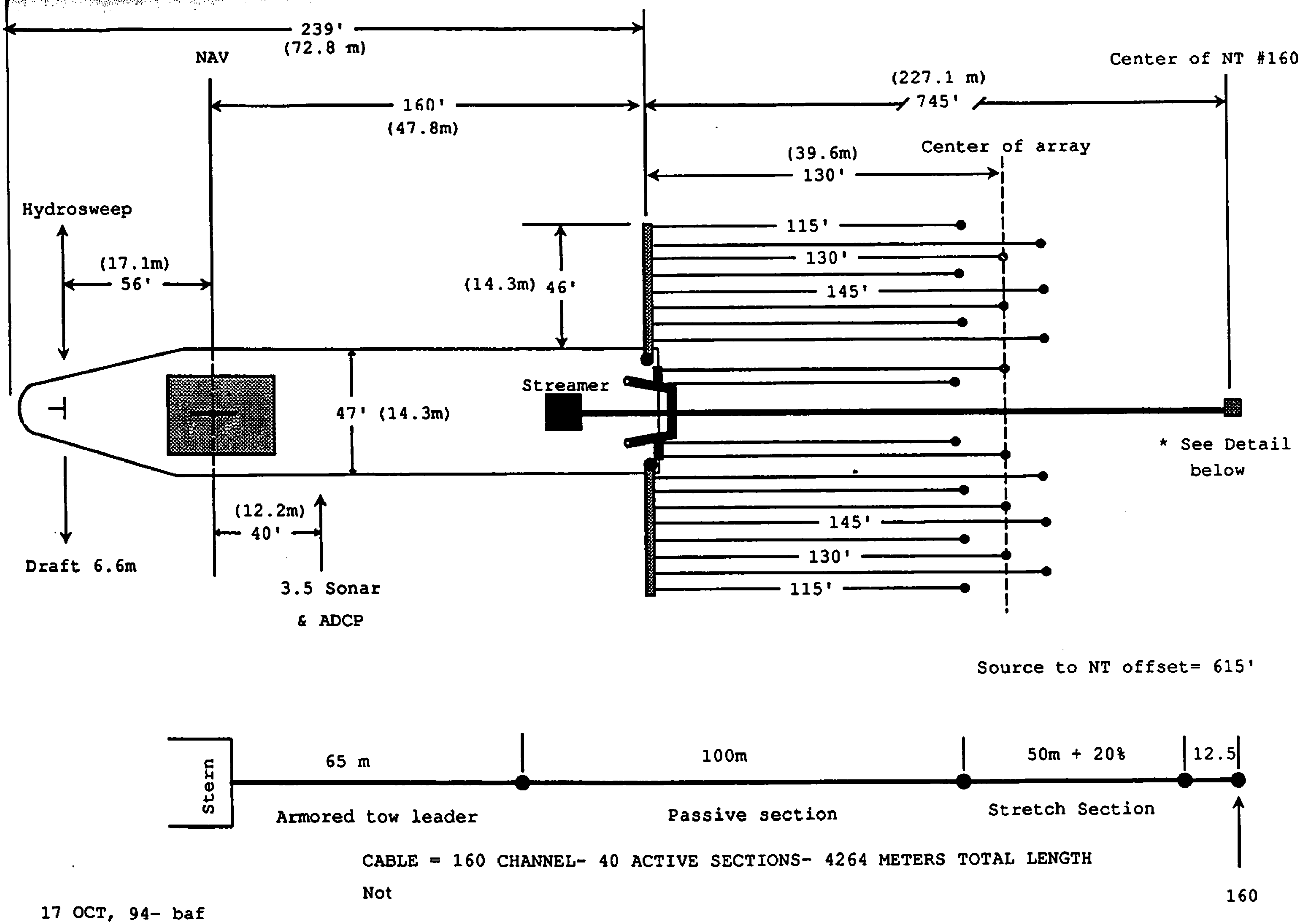


Figure 4. cont. Ewing setback and offset diagram

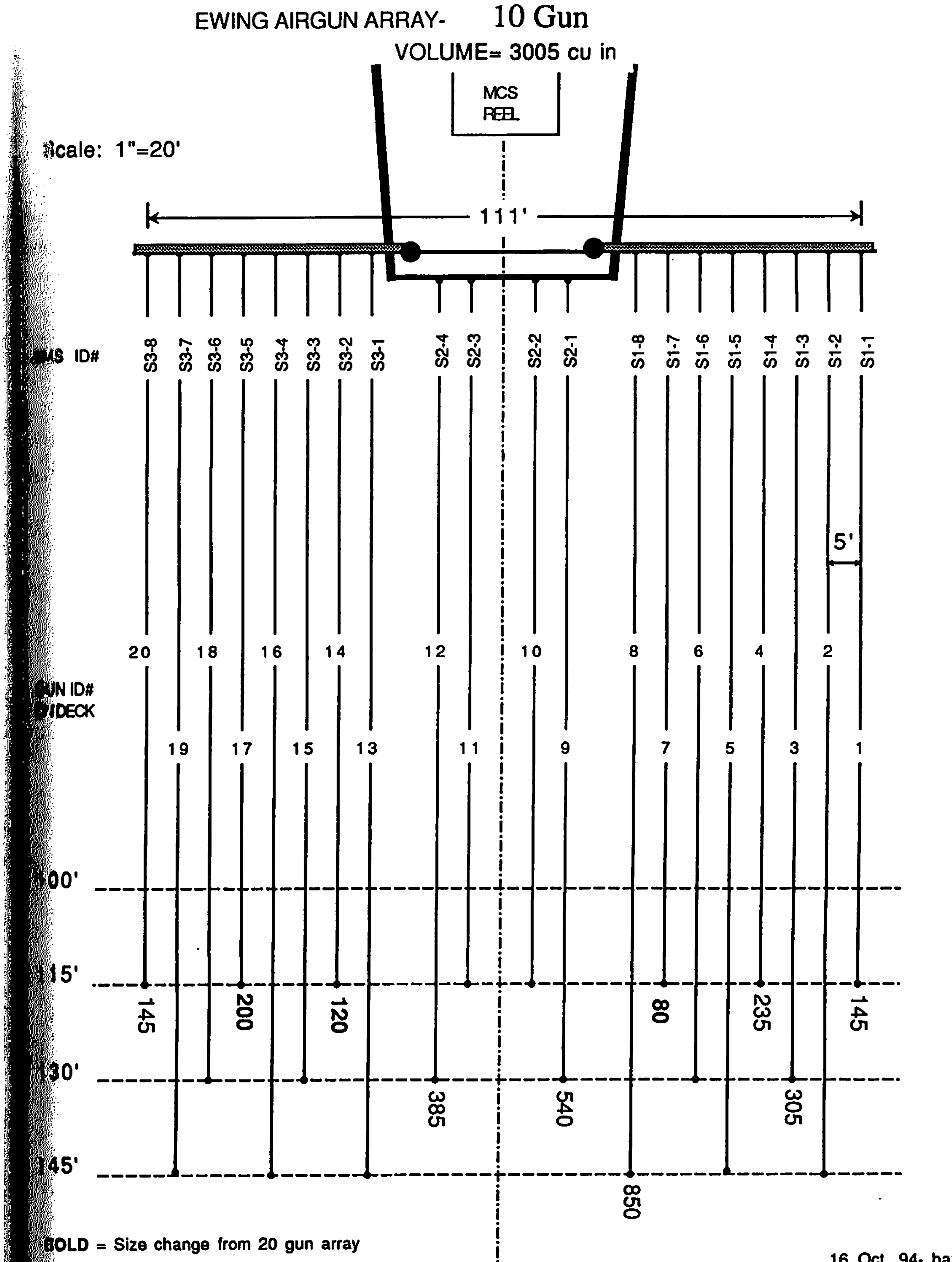
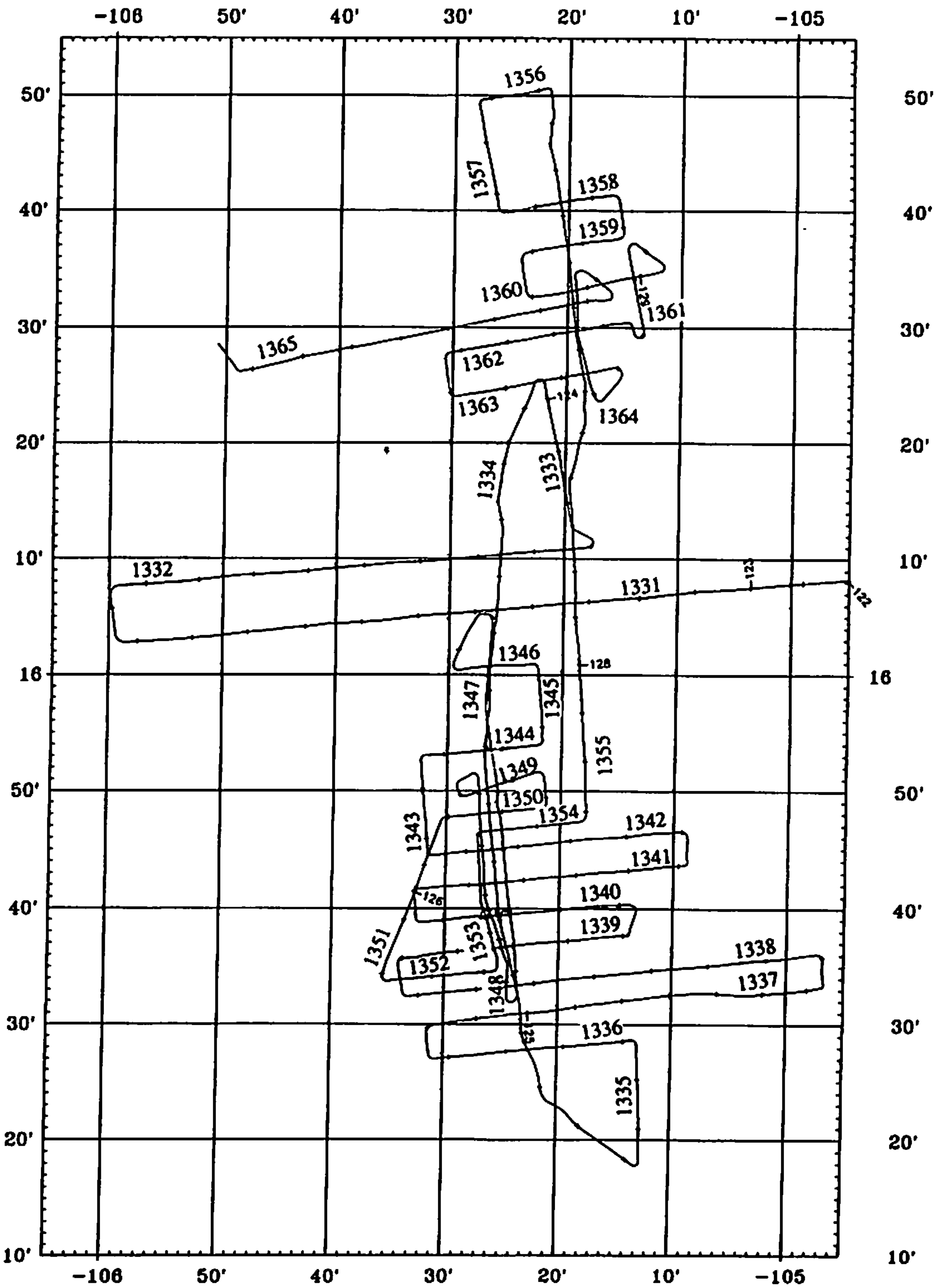


Figure 5. Configuration of 10 gun 3005 cu. in. array used in survey.



EW-9503 Navigation Track of Survey Area ; Scale = 5.4 inch/deg.

Figure 6. Track map

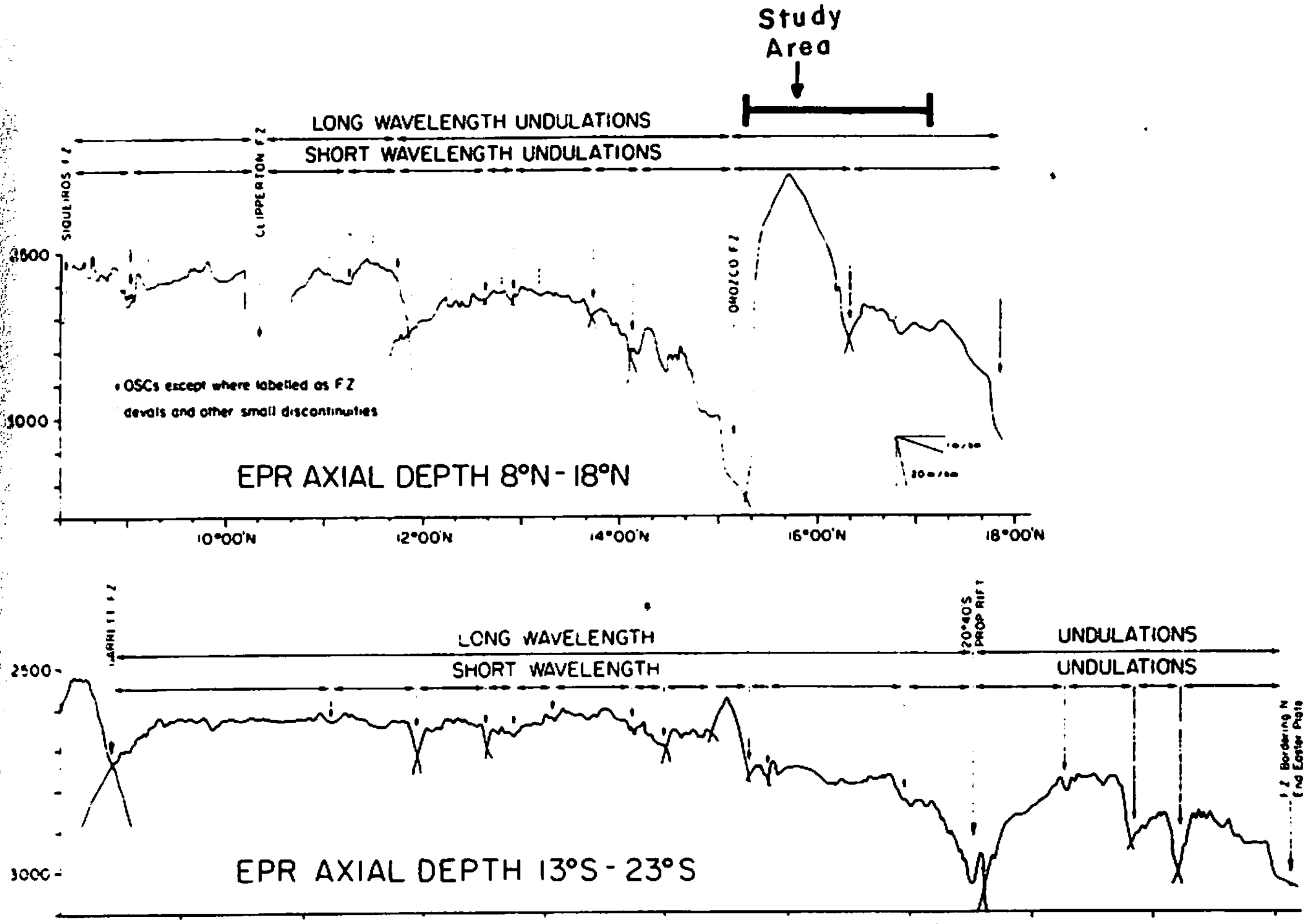


Figure 2. Depth to the shallowest point within the neovolcanic zone plotted vs latitude for the East Pacific Rise (EPR) from 8° - 18°N and 13° - 23°S, from Macdonald (1989). The axial region north of the Orozco Fracture Zone is by far the shallowest of any along this length of the EPR (note difference in horizontal scale for the two regions).

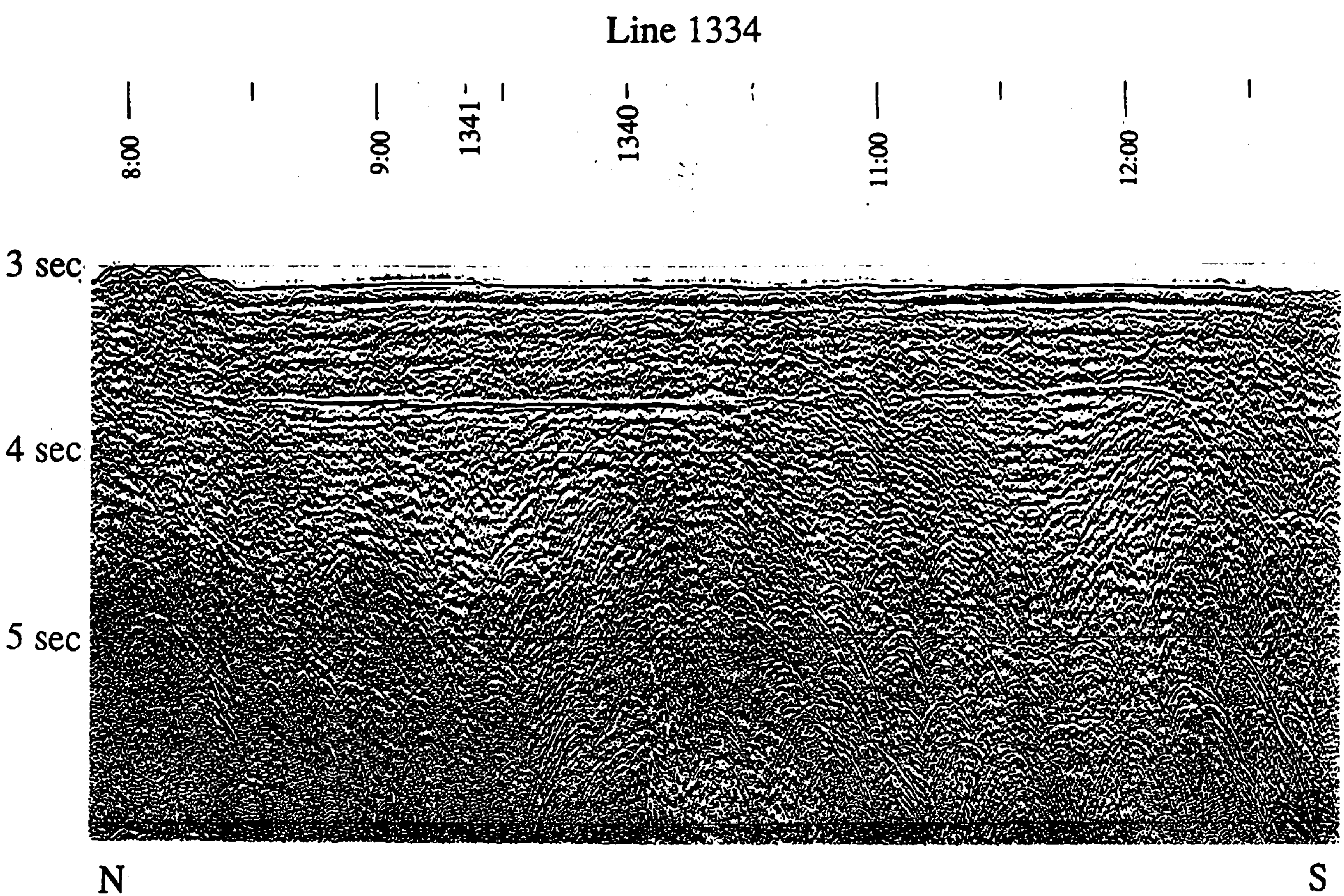


Figure 7a. Realtime stack of line 1334 shot along the axis of the southern ridge segment. AMC reflection is evident at ~ 0.6sec twtt below sea floor along most of this line. At ~12:00 on JD124 the AMC shoals to 0.56 sec.

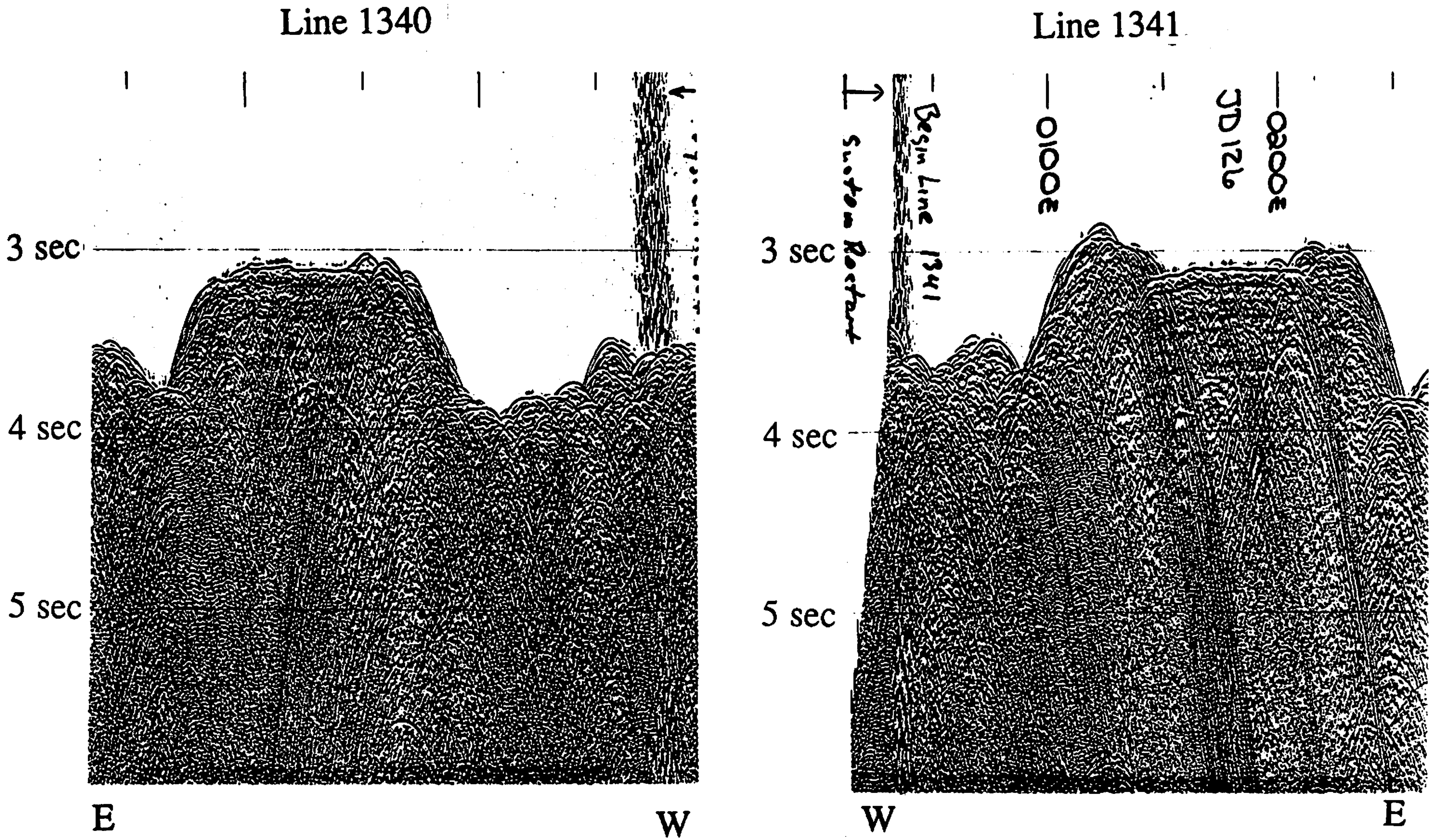


Figure 7b. Examples of cross-axis lines. On Line 1340 the AMC event dips asymmetrically to the west near the prominent seamount chain located at 15°40'N. Along line 1341 there appears to be 2 and possibly 3 separate AMC reflections.

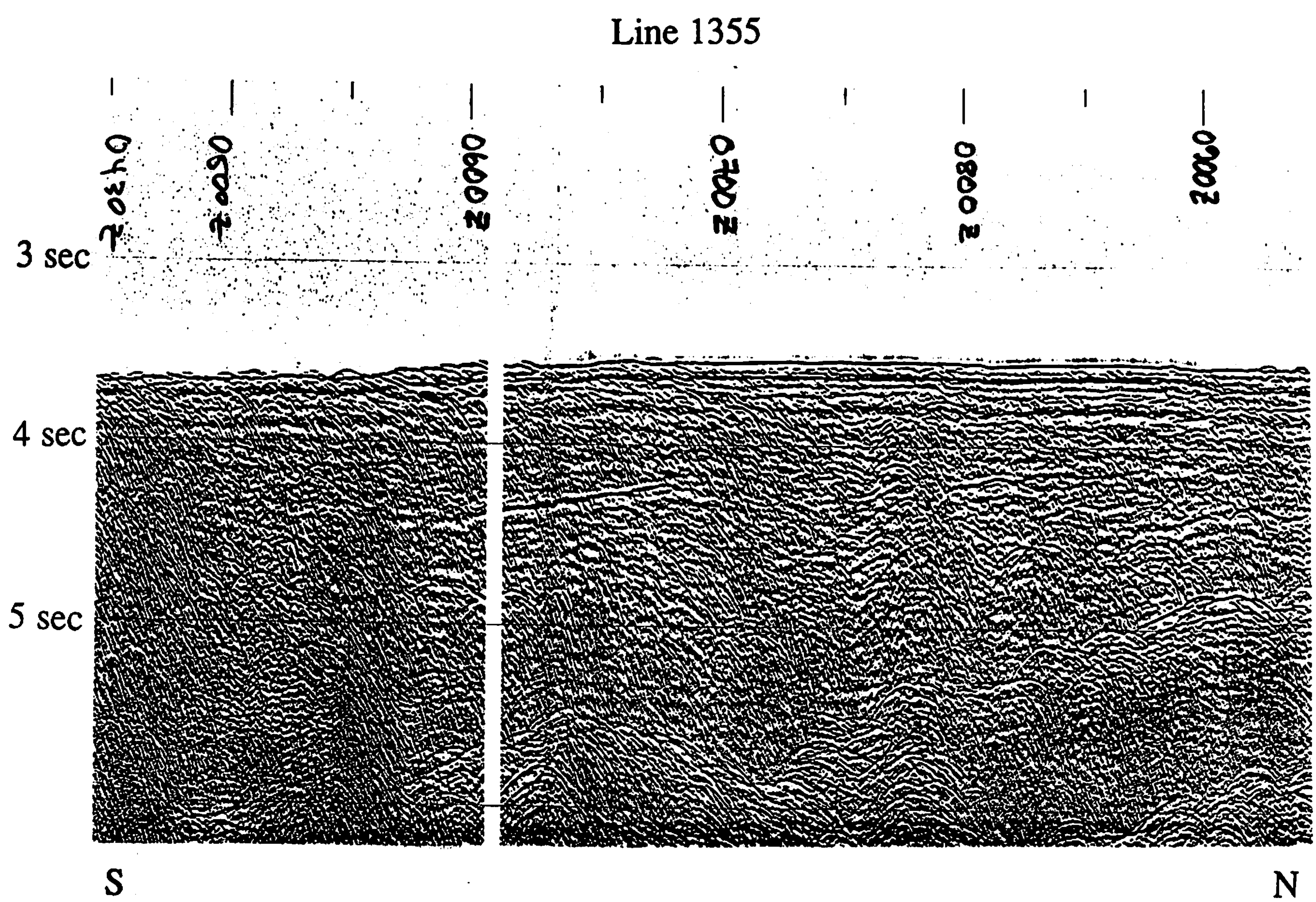


Figure 7c.Line 1355 shot along the axis of the northern ridge segment. A bright AMC reflector is imaged from ~05:55z -06:50z and ~07:55z-08:10z. The more northerly reflector is located at 0.63 sec twtt at it's shallowest point, comparable to AMC depths along the axis of the southern ridge segment.

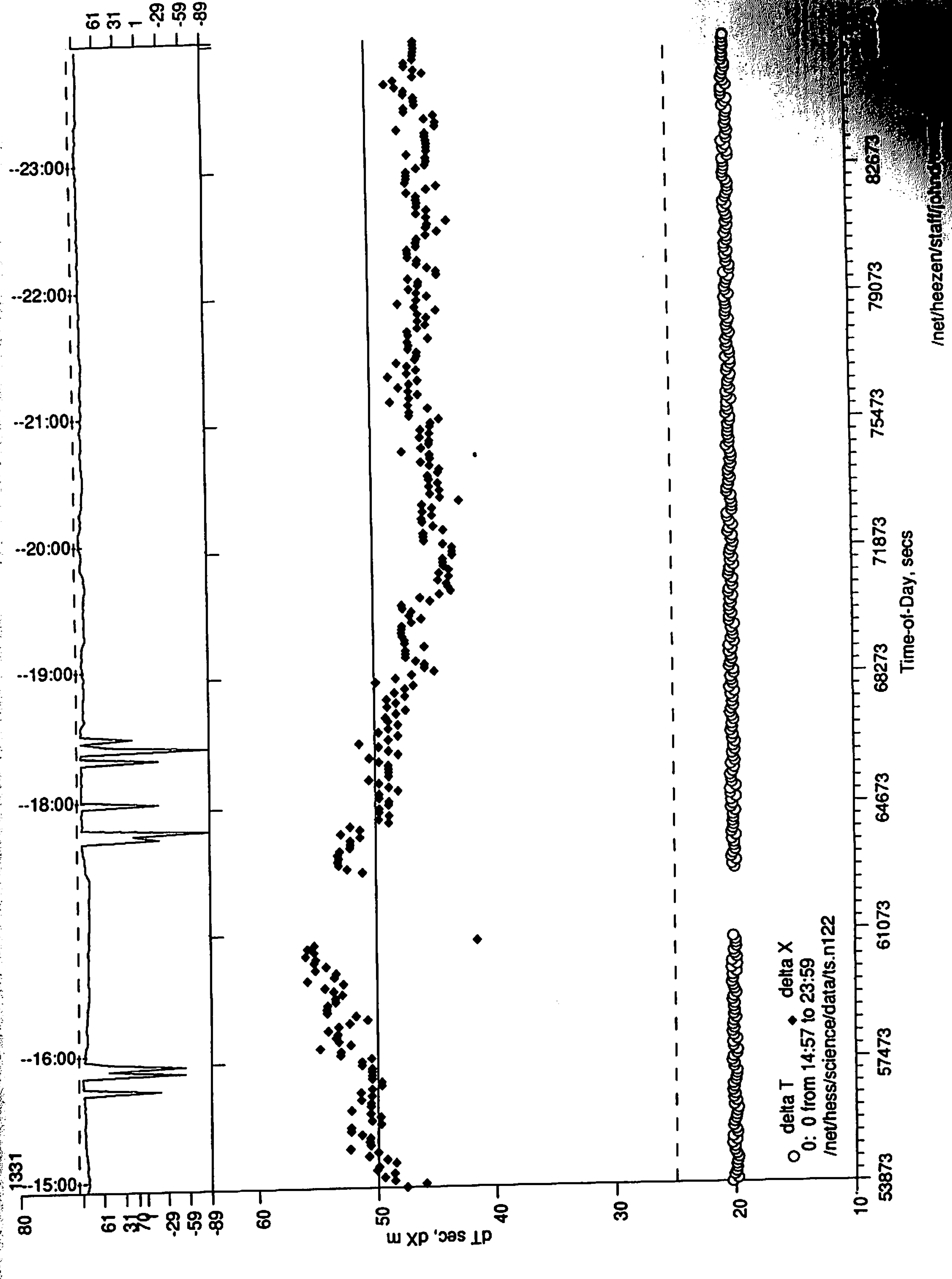
Line #	J.D.	Date	Time (GMT) (start/end)	Latitude (start/end)	Longitude (start/end)	Tape #	Shot #	File #	Record length (sec)
1331	122	May 2 1995	14:57	16°11.27	104°20.9	1	1	1	8
	123	May 3 1995	11:01	16° 02.805	105° 57.641	49	3541	3536	
1332	123		12:31	16°07.638	105° 59.027	52	3787	3782	8
	123		20:57	16° 11.32	105° 17.73	68	5314	5309	
1333	123		21:20	16°12.21'	105°18.52	69	5315	5315	10
	123	May 4 1995	0:17	16°23.241	105°21.584	75	5847	5846	
1334	124		0:18	16° 25.215	105° 21.973	76	5891	5890	10
	124		14:26	15 33.20	105 27.04	109	8392	8385	
1335	124		15:22	15°19.05'	105 12.698	111	8560	8553	10
	124		17:44	15 47.1628	105 21.64	117	8986	8978	
1336	124		17:55	15° 28.60	105° 13.86	117	9016	9008	10
	124		21:15	15°26.982	105°30.866	125	9620		
1337	124		21:06	15 29.9194	105 30.9208	127	9773	9762	10
	125	May 5 1995	6:18	15°33.225	104°46.944	147	11247	1237	
1338	125		7:19	15 35.979	104 58.376	150	11429	1419	10
	125		14:09	15 32.4000	105 33.1196	166	12661		
1339	125		15:02	15 35.68	105 33.71	168	12817		10
	125		19:02	15° 37.677	105° 14.171	177	13537	3526	
1340	125		19:36	15° 39.276	105°13.209	179	13714	3703	10
	125		23:16	15° 38.821	105 31.590	188	14317	4306	
1341	126	May 6 1995	0:08	15 41.68	105 32.05	190	14376	4376	10
	126		5:05	15 43.63	105 09.52	201	15271		
1342	126		6:03	15 46.53	105 09.91	203	15443		10
	126		10:37	15 44.4833	105 31.1797	214	16266		
1343	126		10:46	15 44.8834	105 31.5913	215	16293		10
	126		12:33	15 52.6238	105 32.3457	219	16613		
1344	126		12:42	15 53.0709	105 31.8868	219	16640		10
	126		14:37	15 53.9464	105 22.1032	224	16984		
1345	126		14:46	15 54.4130	105 21.6980	224	17011		10
	126		16:08	16 00.5911	105 22.1759	227	17258		
1346	126		16:16	16 00.9080	105 22.6299	228	17281		10
	126		17:34	16 00.3987	105 29.1485	231	17516		
1347	126		19:02	16 04.49	105 26.22	234	17779		10
	127	May 7 1995	1:22	15 32.54	105 23.53	249	18918		
1348	127		1:41	15 32.3000	105 24.5026	250	18975		10
	127		6:18	15 51.0755	105 24.5026	261	19806		
1349	127		7:06	15 49.60	105 28.12	263	19950		10
	127		8:27	15 51.6090	105 22.1687	266	20194		

1350	127		9:15	15 48.49	105 21.83	268	20336		10
	127		11:04	15 47.7244	105 30,1346	273	20663		
1351	127		11:11	15 47.3354	105 30.5034	273	20684		10
	127		14:00	15 34.31	105 35.43	280	21193		
1352	127		14:13	15 33.7541	105 34.7306	281	21232		10
	127		16:09	15 34.5851	105 25.6948	285	21579		
1353	127		16:21	15 35.1821	105 25.3510	286	21613		10
	127		18:55	15 45.9225	105 27.2114	292	22075		
1354	127		19:06	15 46.5015	105 26.7024	292	22108		10
	127		20:45	15 47. 3929	105 18.1913	296	22407		
1355	127		20:56	15 47.9700	105 17.7490	296	22438		10
	128	May 8 1995	12:40	16 50.3640	105 21.7009	339	25267		
1356	128		12:50	16 50.5943	105 22.2376	340	25300		10
	128		14:10	16 49.6243	105 27.7369	343	25539		
1357	128		14:31	16 48.0657	105 27.7155	344	25600		10
	128		16:16	16 40.2512	105 26.1849	348	25915		
1358	128		16:25	16 39.8166	105 25.6622	349	25944		10
	128		18:21	16 41.3660	105 16.1727	353	26292		
1359	128		19:14	16 37.6053	105 15.5886	355	26451		10
	128		21:07	16 36.3987	105 23.6869	360	26786		
1360	128		22:01	16 32.6194	105 23.0602	362	26949		10
	129	May 9 1995	0:23	16 34.81	105 11.90	368	27373		
1361	129		1:32	16 36.3049	105 14.6411	370	27581		10
	129		2:55	16 29.7378	105 13.2740	374	27830		
1362	129		3:35	16 30.3941	105 15.0390	375	27950		10
	129		7:14	16 27.7863	105 30.3142	384	28608		
1363	129		8:10	16 24.0153	105 29.4991	386	28774		10
	129		10:56	16 26.5022	105 15.8558	393	29272	9258	
1364	129		11:55	16 25.94	105 17.52	395	29449		10
	129		14:32	16 34.3477	105 19.3914	401	29920		
1365	129		15:33	16 32.3814	105 16.5025	404	30103	89	10
	129		23:15	16 26.1550	105 48.7258	422	31487		

Appendix 2

SB#	JD	Date	Line #	Start Time (Z)	Tape	Shot #	Latitude (Deg Min) (N)	Longitude (Deg Min) (W)	End Time (Z)	Tape	Shot #	Latitude (Deg Min)	Longitude (Deg Min)	Comments
105	124	4-May-95	1334	3:29	83	6420	16 10.83	105 25.54	5:27	88	????	16 01.29	105 25.30	ICOM Receiver (SB Rec #1) No Filter.. OBAD digitized
106	124	4-May-95	1334	5:31	88	6790	16 00.93	105 26.35	7:09	92	7084	?	?	channel #177
107	124	4-May-95	1334	7:16	92	7104	15 52.28	105 26.65	9:21	97	7478	15 42.06	105 25.53	
108	124	4-May-95	1334	8:53	96	7394	15 44.26	105 25.78						Cancelled (not working)
109	124	4-May-95	1334	9:26	97	7495	15 41.48	105 25.48						Cancelled (not working)
110	124	4-May-95	1334	9:43	98	7544	15 40.17	105 23.35	13:51	108	8287	15 21.66	105 18.47	
111	124	4-May-95	1334	10:55	101	7760	15 34.33	105 23.955	13:45	107	8267	15 22.029	105 18.848	
112	124	4-May-95	1335	15:45	112	8630	15	105						Cancelled (not working)
113	124	4-May-95	1335	15:52	112	8650	15 20	105 12	17:33	116	8952	15 27.55	105 12.95	
114	126	6-May-95	1343	10:53	215	16314	15 45.607	105 31.685	13:48	222	16838	15 53.53	105 26.18	Spiegs 1st SB
115	126	6-May-95	1343	11:53	217	16494	15 49.866	105 32.099	13:48	222	16838	15.53.53	105 26.18	
116	126	6-May-95	1347	19:16	234	17821	16 03.35	105 26.31	20:00	236	?	15 59.84	105 26.56	
117	126	6-May-95	1347	20:08	236	17978	15 58.99	105 26.615	?	?	?	?	?	
118	126	6-May-95	1347	21:30	240	18223	15 52.53	105 25.95	?	?	?	?	?	
119	126	6-May-95	1347	23:56	245	18660	15 40.01	105 24.38	1:22	249	?	15 32.54	105 23.53	
120	127	7-May-95	1348	2:12	251	19088	15 34.561	105 24.435	?	?	?	?	?	
121	127	7-May-95	1348	4:27	256	19474	15 43.23	105 25.621	11:24	274	20725	15 46.188	105 30.928	
122	127	7-May-95	1350	11:49	275	20798	15 44.307	105 31.499	13:50	280	21160	15 35.08	105 35.18	
123	127	7-May-95	1353	16:58	287	21724	15 37.85	105 26.00	19:32	293	22188	15 46.75	105 24.16	
124	127	7-May-95	1355	22:02	299	22636	15 52.93	105 17.97	1:39	313	23287	16 07.796	105 19.008	
125	127	7-May-95	1355	23:31	308	22897	15 58.90	105 58.91	2:20	315	23409	16 10.3	105 19.146	
126	128	8-May-95	1355	1:41	314	23294	16 07.796	105 19.008	5:11	322	23922	16 21.55	105 18.559	at 02:00 switched receivers
127	128	8-May-95	1355	2:32	316	23445	16 11.183	105 19.226	?	?	?	?	?	
128	128	8-May-95	1355	5:20	336	23950	16 22.271	105 18.336	?	?	?	?	?	
129	128	8-May-95	1355	7:25	327	24325	16 29.683	105 19.243	13:44	342	25459	16 49.907	105 26.074	
130	128	8-May-95	1355	9:40	332	24730	16 38.47	105 20.40	13:44	342	25459	16 49.907	105 26.074	
131	128	8-May-95	1357	15:19	346	25744	16 44.33	105 26.99	16:33	349	25968	16 39.91	105 25.00	60 ft. hydrophone setting; 3hrs; Phone took long time
132	129	9-May-95	1364	12:56	397	29634	16 28.092	105 18.375	14:46	402	29961	16 34.80	105 18.49	to drop (20 minutes!) Lots of surface noise
														for 1st 20 minutes of record

Appendix 3



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--16:00
--18:00
--19:00
--20:00
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--22:00
--23:00
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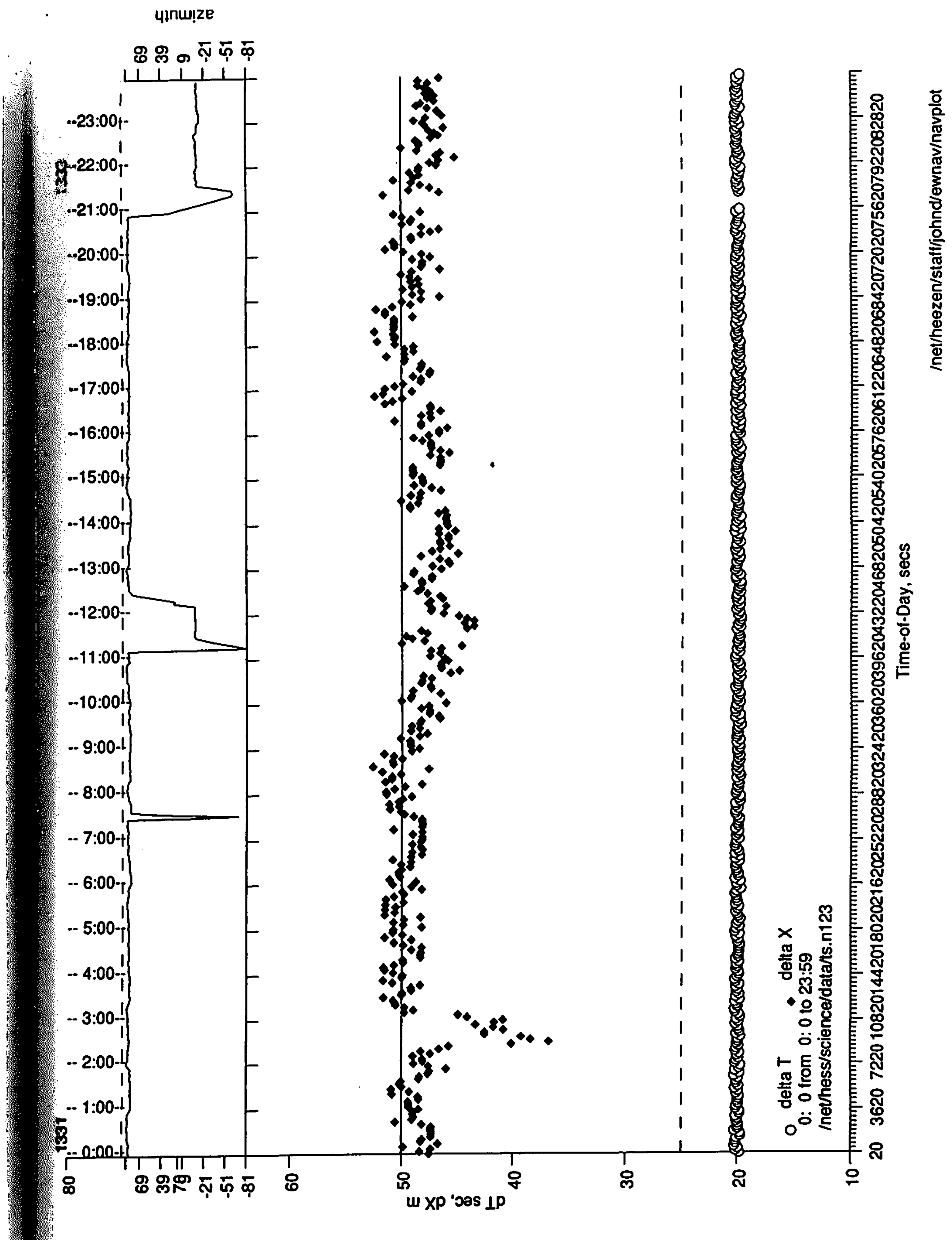
61073
64673
68273
71873
75473
79073
82673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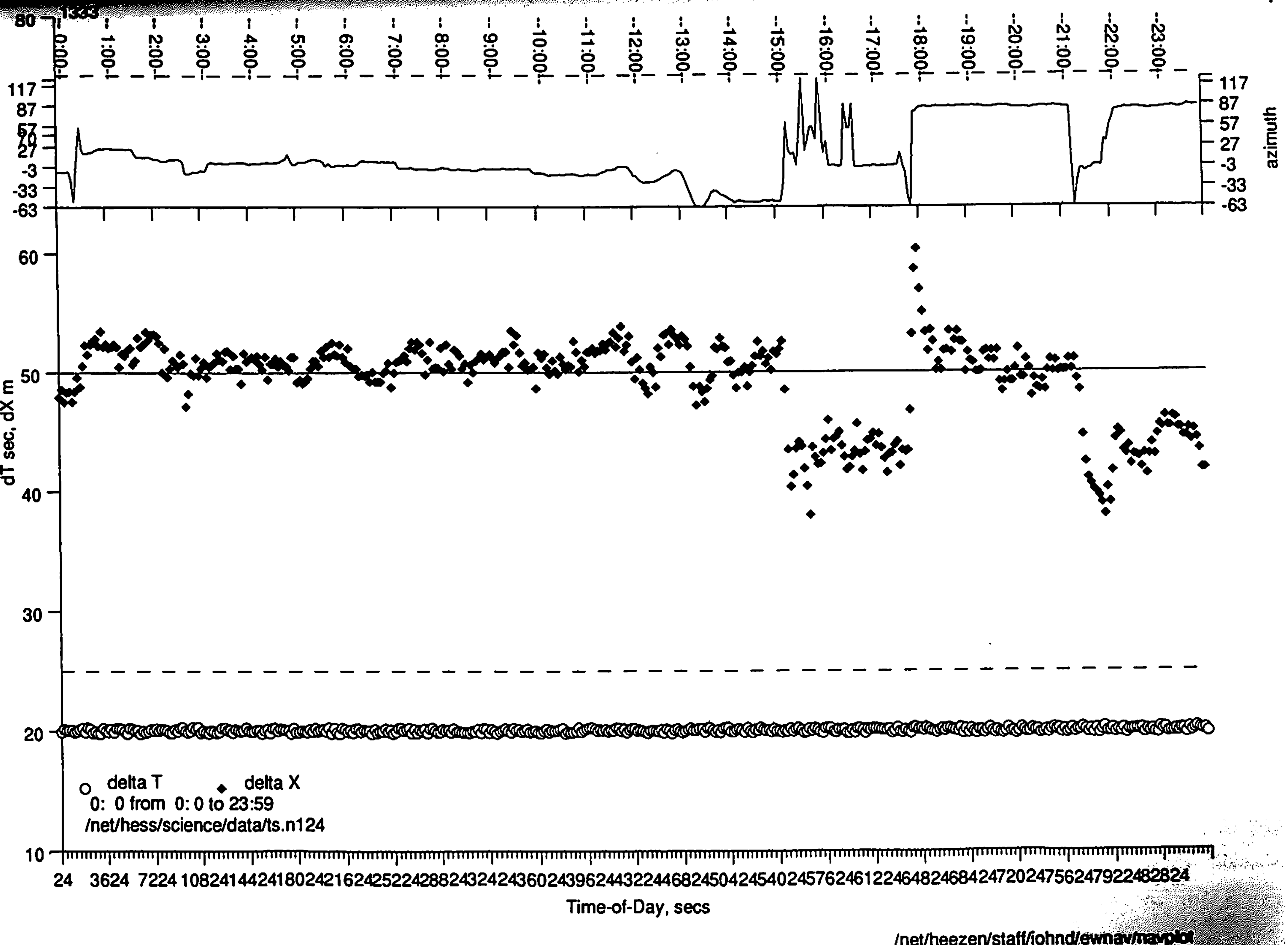

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Time-of-Day, secs
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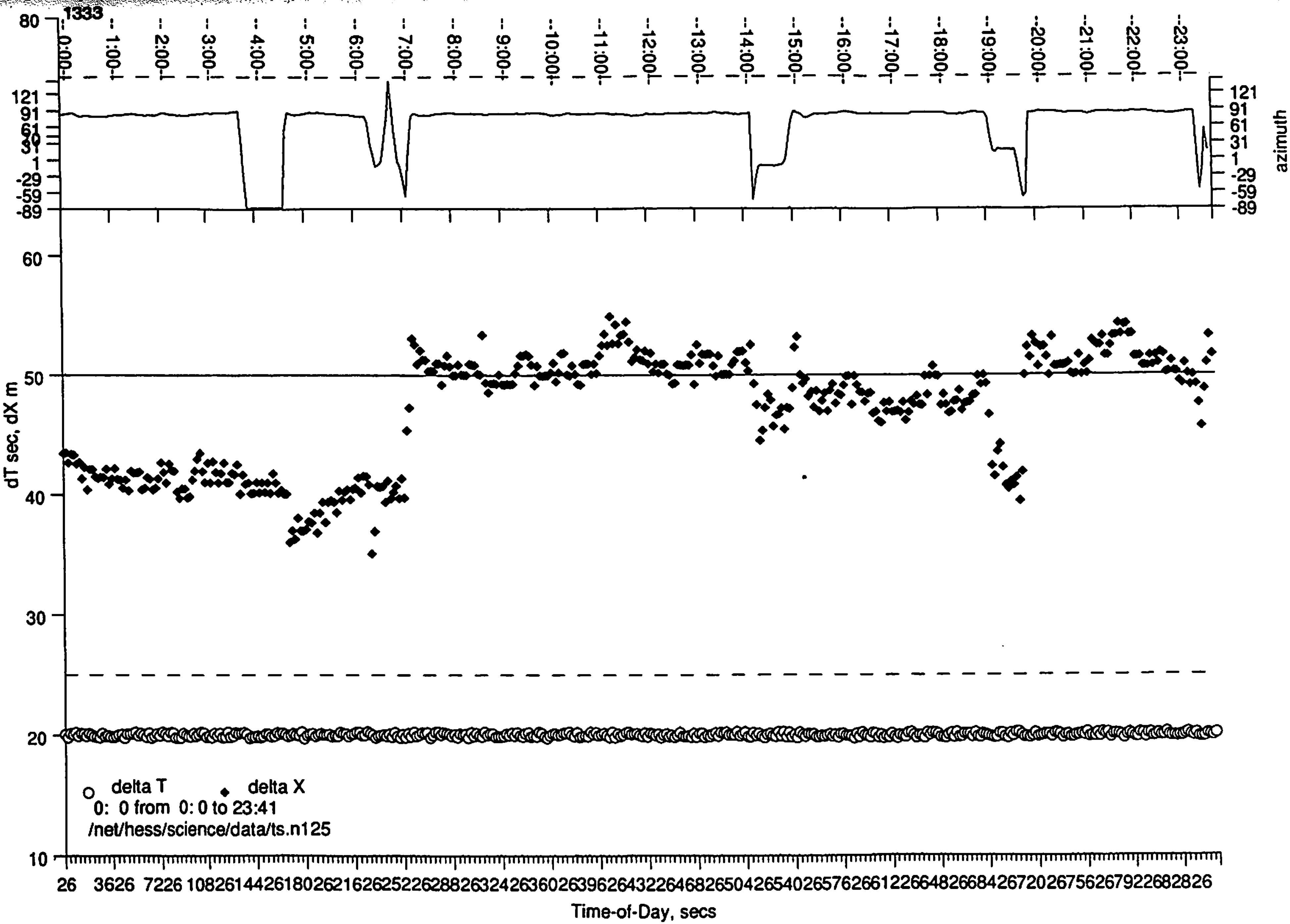

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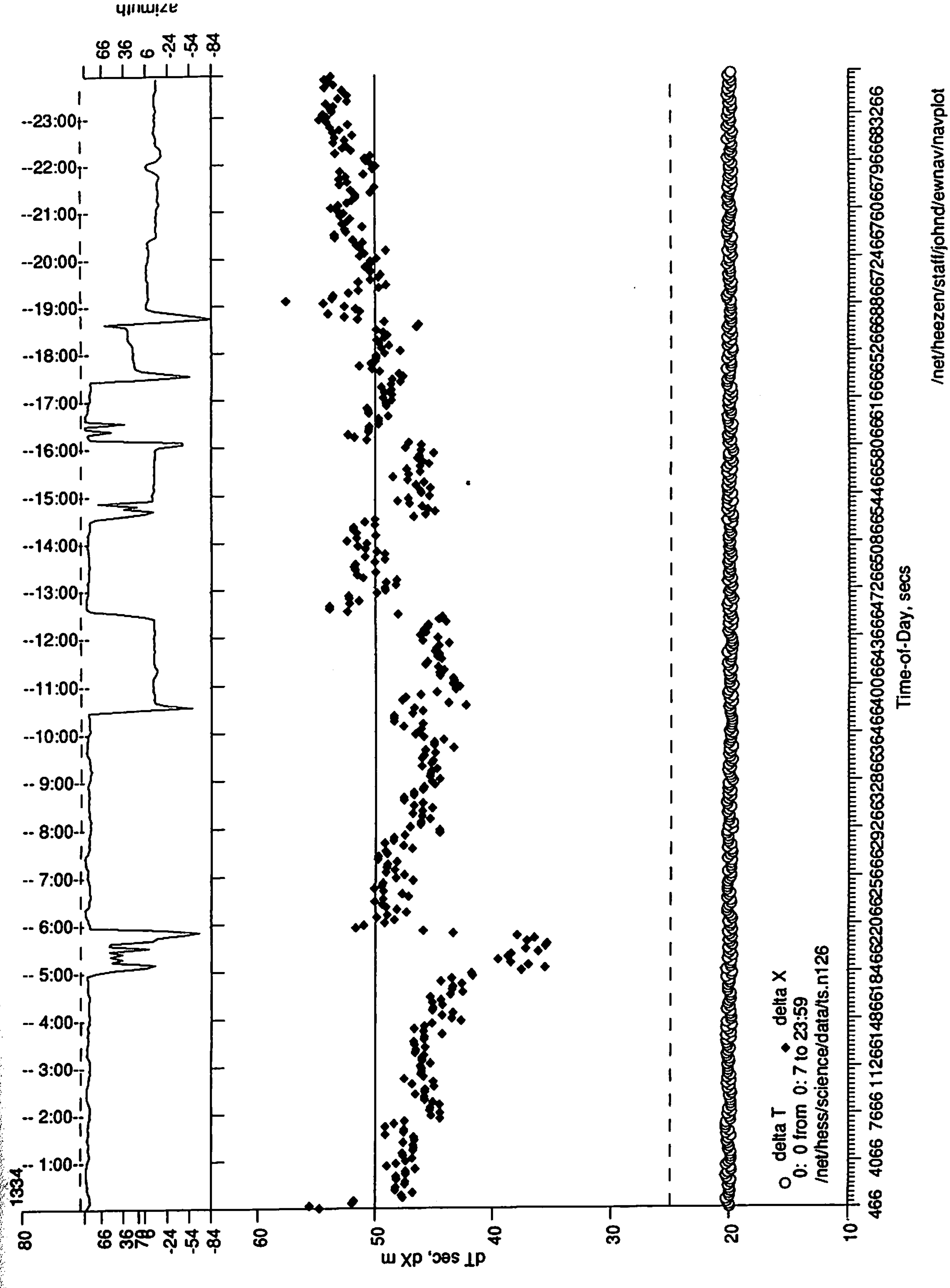
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-- 5:00
-- 4:00
-- 3:00
-- 2:00
-- 1:00
1334
80
66 36 78 -24 -54 -84
60
50
40
30
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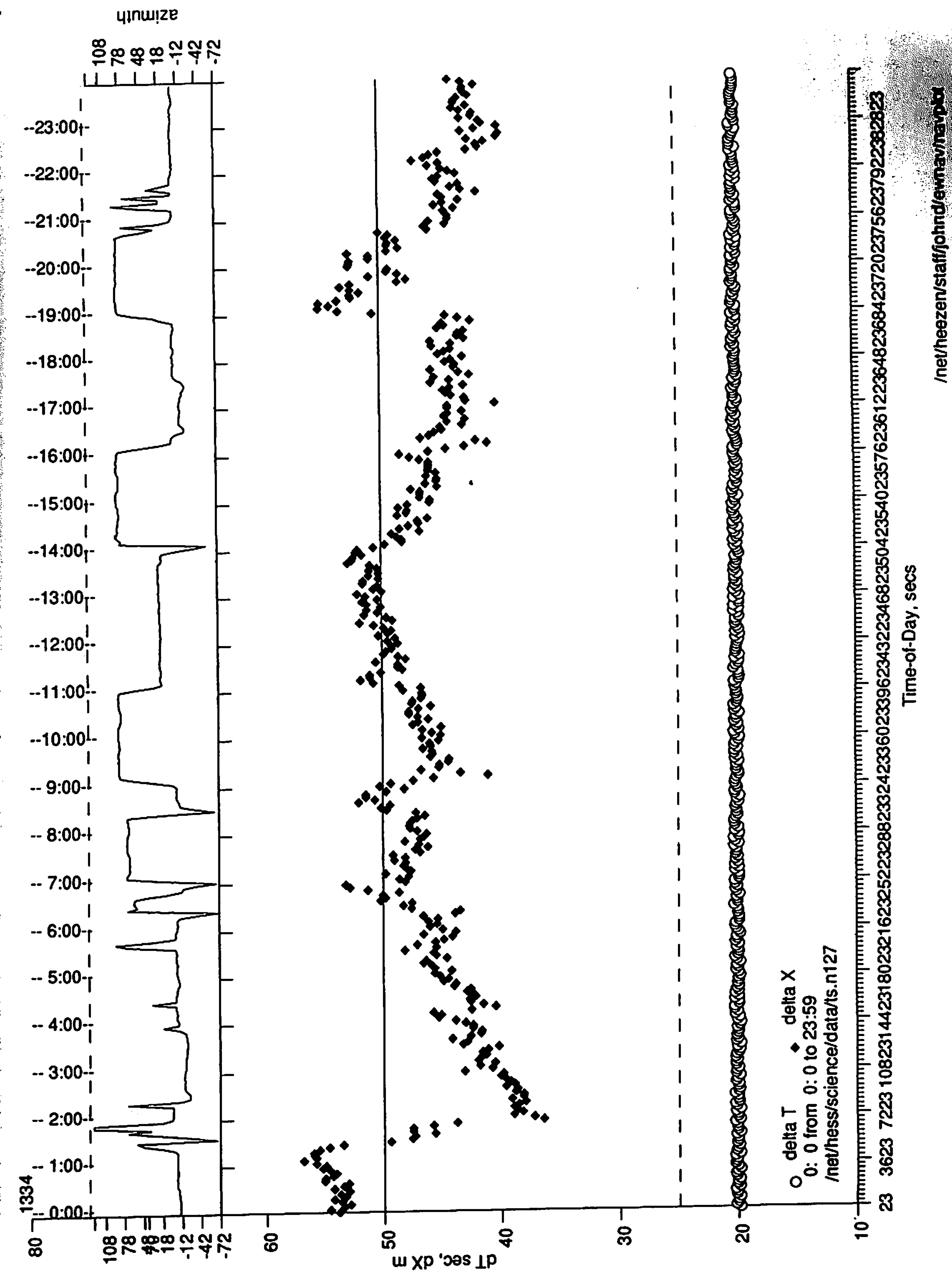
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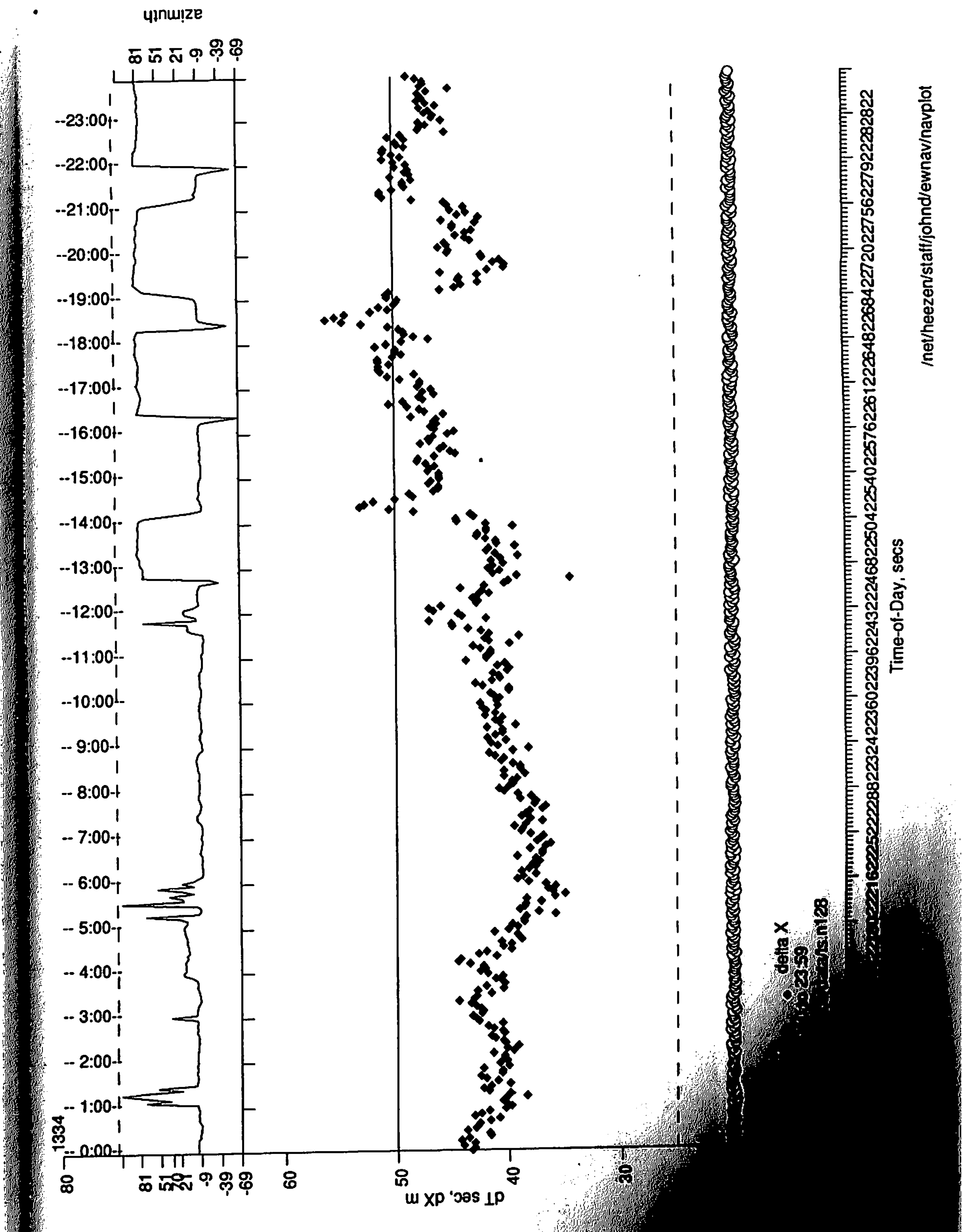
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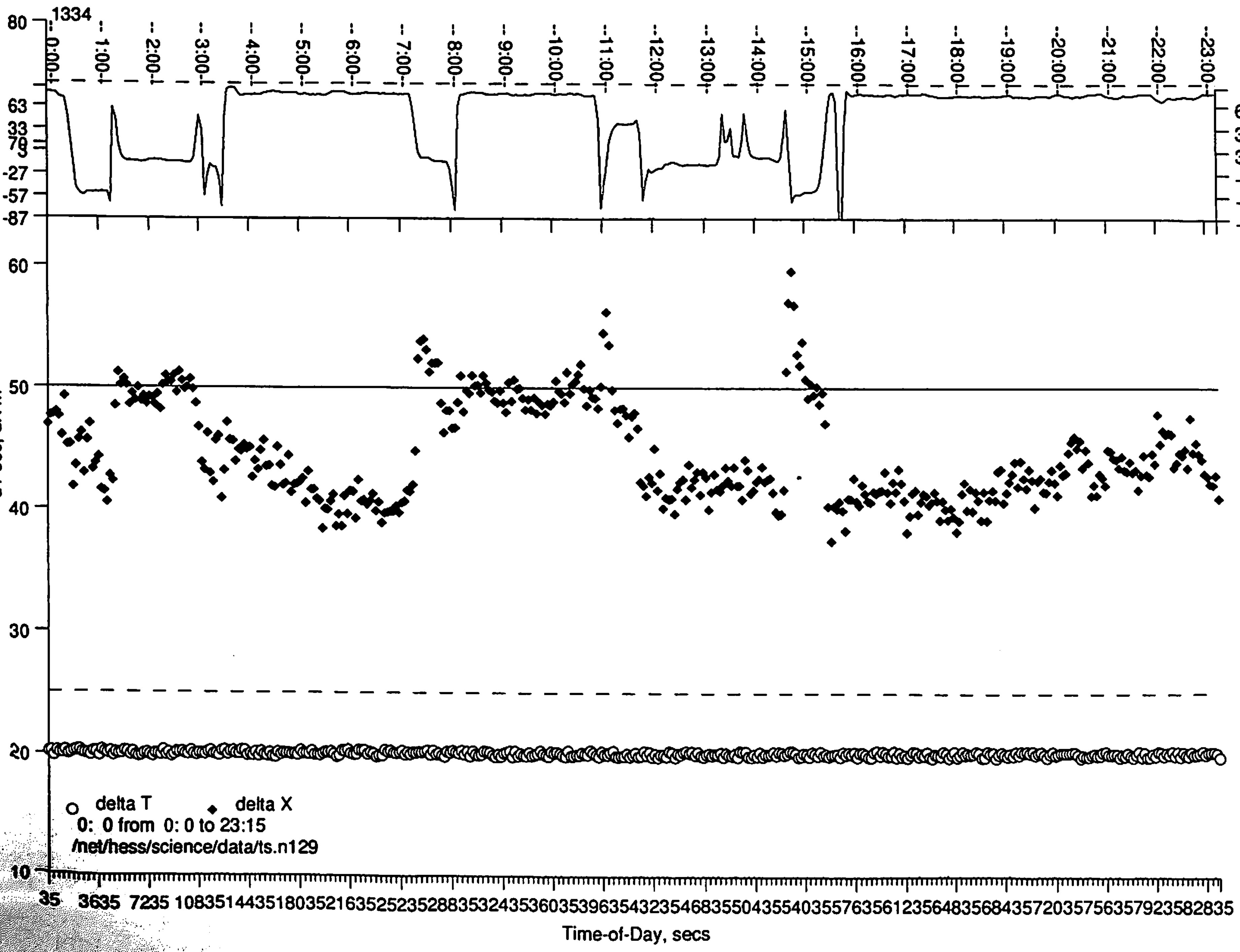

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