Lamont-Doherty Earth Observatory
Marine Office
61 Route 9W
Palisades, NY 10964

R/V Maurice Ewing

Data Reduction Summary

EW9910 – Anaga, Guam - Lae, Papua New Guinea

Collaborative Research: Natural Seismicity Investigation of Active Continental Breakup in the Western Woodlark Basin

October 30 - September 16, 1999

Table of Contents

Project Summaries

Natural Seismicity Investigation of Active Continental Breakup in the Western Woodlark Basin

John Mutter ***jcm@ldeo.columbia.edu***

Active low-angle normal faulting has been conjectured to be a fundamental process in passive margin evolution but presents a major paradox in which observational evidence for low-angle deformation conflicts with the basic Andersonian theory of frictional slip. In the Western Woodlark Basin, extensive geophysical and geological studies show that propagation of seafloor spreading is inducing active continental rifting and is providing a unique setting to study extensional processes. In particular, evidence from several moderate shallow earthquakes permit slip on low-angle normal planes dipping at 24 to 35 degrees. One earthquake in particular has been recently modeled and may lie on or very close to a north-dipping plane in the upper and middle crust which has been imaged by multichannel reflection profiling. Thus the Western Woodlark Basin provides perhaps the best opportunity to determine what special circumstances, if any, are required for active low-angle seismic deformation. Recorded earthquakes, which are necessarily large in magnitude, form a distinct band of seismicity suggesting strain localization where intra-continental rifting is transitioning to seafloor spreading. These conditions may create unusual boundary forces that favor low-angle normal faulting, but these circumstances cannot be determined unless close-in high-fidelity recordings of the seismicity are obtained, yielding precise locations, and well resolved estimates of kinematic and dynamic source properties.

Results from this study, together with those from funded ODP drilling and previous geophysical work, have the potential to resolve the paradox of low-angle normal faulting in the deformation of continental lithosphere.

ODP Site Survey

Andrew Goodliffe ***andrew@soest.hawaii.edu***

A primary objective of ODP leg 180 was to characterize the composition and in situ properties of an active low-angle normal fault zone to understand how such faults slip. The origin of weak faults in general, and of low-angle normal fault zones in particular, is an outstanding problem in global tectonics that the MARGINS program is committed solving. Trace hydrocarbons encountered at site 1108 and thick talus deposits at alternate sites, thwarted this goal. At a post-cruise review, PPSP endorsed an attempt to deepen site 1108, providing that additional seismic data is acquired to provide strike-line coverage at the drill site. This project was done to collect the additional seismic data.

Seismic Reflection Images of the Source Region of the Papua New Guinea Tsunami of July 17, 1998

Eli Silver ***esilver@es.ucsc.edu***

High resolution seismic images (using a single GI gun and a 1200 m, 96 channel digital streamer) and hydrosweep bathymetry in the expected source region for the tsunami show several possible features that could have generated the wave. East of Yalingi submarine canyon (located northeast of the point of first wave contact with the coast), two coast-parallel, east facing fault scarps are tectonic features capable of generating a local tsunami. The nearest fault to the coast is 20 km offshore and has a surface scarp of 165 m. However, the size of the wave and the excessive time delay between the mainshock and the wave generation is thought to indicate a slide origin. Several profiles crossed a submarine slide at 142 15 E, 2 52 S, measuring a maximum of 6 km from head scarp to toe. A set of discontinuous reflections at about 700m depth may record parts of the slide surface. Reconstructing basement across the slide surface yields up to 1.5 km of heave. Landward dipping reflections within the mass record rotational slip. This feature has adequate size and displacement to explain the tsunami. Two seismic lines shot parallel to the coast (8 and 12 km offshore of the region of first wave contact) show no candidates for a more nearshore tsunami source. However, the 3.5 kHz reflection data imaged a very small mud volcano (5 m high) at the surface and 8 km offshore of Sissano Lagoon, suggestive of local fluid release at the time of the earthquake. Such local diapirism may explain the reported gas smells and bubbles in the water near the time of the event.

Data Reduction Summary

Lamont-Doherty Science Crew List

Name	Position	Email Address
Mark Landow	Captain	captain@ewing.ldeo.columbia.edu
Joe Stennett	Science Officer	stennett@ldeo.columbia.edu
Jeff Turmelle	Data Reduction	jefft@ldeo.columbia.edu
John DiBernado	Gunner	johnd@ldeo.columbia.edu
John Byrne	Gunner	
Ropate Maiwiriwiri	Gunner/Core Bosun	
Chuck Donaldson	Electronics Tech	chuckd@ewing.ldeo.columbia.edu

Science Party List

Chief Scientist:	**John Mutter**	**Collaborative Research Project**
	Andrew Goodliffe	**ODP site survey**
	Eli Silver	**Study of PNG Tsunami**
Party Members:	Jeffrey Babcock	
	Jacqueline Floyd	jsfloyd@ldeo.columbia.edu
	Satoshi Hirano	
	Russell Johnson	
	Laura Kong	
	Ted Koczynski	
	Suzanne Sweet	ssweet@es.ucsc.edu
	Paul Zimmer	

Cruise Notes

All times specified within this report are GMT.

System Failures
There was one system failure at 252:01:15 GMT due to a faulty surge protector that lasted approximately 35 minutes. No data was recorded during this time, and part of the line had to be reshot. I believe this reflects the change in line from sixteen to seventeen on the ODP line.

GPS/Navigation processing
All shots were processed using the Pcode GPS; which is the source for all the navigation processing. The Pcode GPS has an inherent error of approximately 15 meters. There are approximately three days of data from port (239-241) for quality control purposes.

Tailbuoy Logging
The tailbuoy was not logged for any of the MCS portions of this cruise.

Gravity
Due to the malfunction of the gravimeter gyro at the start of the cruise, no pre-cruise gravity tie was possible. Therefore, no drift factor can be accounted for during this cruise. Gravity is completely relative to the output of the gravimeter.

Source Code
There is a directory of source code located on the tape for performing some custom requirements during the cruise:

> `calculate_guns`
> This will take the processed shot files and calculate the Lat/Lon position of the guns given a specified distance.
>
> `do_shot_hb`
> Given a processed shot file and a Hydrosweep “timed” centerbeam file, this script will use GMT programs to output a hydrosweep shot file: ts.n*day*.hb
>
> get_line_from_tsn.pl
> Perl script to extract line data into individual files from the ts.n files.

Cruise Data

See *Data Instruments* for more precise definitions of these fields.

Data Type	File	Description	Log Interval	Days Collected
UTC time	tr1	Truetime UTC time clock	60 seconds	239-259
Datum time	tr2	Datum UTC clock for shots	shot times	-
Furuno	fu	Furuno speed and heading	3 second	245-259
P Code GPS	gp1	Tasman Ycode receiver	10 second	239-259
Trimble GPS	gp2	Selective availability GPS	10 second	239-259
Gravity	vc	Bell gravimeter data	1 second	252-259
Sea Temp	ct	Sea Temperature	60 second	239-252
Meteorology	wx	Weather Station	60 second	239-252
Gun Depths	dg	Depths of each gun at shot	shot	-
Navblock	nb	Time/Position/Shotpoint	variable	-
Magnetics	mg	Geometrics Magnetics	12	243-257
Hydrosweep CB	hb	Hydrosweep Centerbeam	-	242-259

Logging
All logged data (*except GPS and Shot data*) is synchronized to the CPU time of the logging computer, which in turn is synchronized to the UTC time.

GPS time is extracted from the GPS fix.

Shot times are the UTC time.

Data Instruments

The following times are specified in GMT time. The following formats are the raw data formats.

Truetime UTC Time Clock **tr1.d*xxx***

The Truetime UTC clock is logged at 60 second intervals. CPU time is synchronized every 60 seconds to this clock.

CPUTIME TRUETIME

Date	Comment
242:05:06	Start UTC Sync
249:23:45 - 250:00:15	1/2 hour interruption during switch to Datum clock
242:01:15 - 252:01:57	interruption due to power loss
258:23:59	End UTC sync

Furuno Speed and Heading **fu.d*xxx***

The Furuno CI-30 2 axes doppler speed log and Sperry MK-27 gyro are logged at 3 second intervals. Interruptions greater than 10 minutes are logged here. The furuno was out of order from the beginning of the cruise until day 245. All navigation that relied on the furuno for processing used the GPS to determine the heading and speed in place of the GPS.

CPUTIME - speed over water course heading

Date	Comment
246:00:00	Furuno logging started
252:01:15 - 252:01:52	
258:00:00	Furuno logging ends

Compass Block Data **cb1.d*xxx***

Compass data is recorded after each shot for the streamer birds to give the orientation of each. All data gaps are accounted here for. Lines 0010 shots 1-23 should be the first part of Line 001A

CPU Time Stamp Line Shot Latitude Longitude
98+079:00:08:40.085 strike1 000296 N 15 49.6217 W 060 19.8019

2nd GPS Tailbuoy Furuno Streamer
Latitude Longitude Latitude Longitude Heading Compass Headings
N 15 49.6217 W 060 19.809 N 00 00.0000 W 000 00.0000 341.2 C01 2.3 C02 1 .7

Date	Comment

245:15:33 - 245:23:26	Line One	0 compasses
245:23:27 - 246:18:31	Line two	0 compasses
250:07:40 - 252:04:47	Lines one - seventeen	7 compasses
253:06:18 - 257:10:25	Lines 0010, 001A, 001 - 014	12 compasses

Magnetics Data **mg.d*xxx***

The Geometrics G-886 Marine Magnetometer was logged at 12 second intervals. There were several interruptions of data as well as some interference that has been removed from the processed navigation. The times quoted here are for processed navigation, with invalid times removed from the raw navigation. Data gaps greater than 5 minutes are accounted for here. Deployment of streamer also accounts for some of the data gaps here.

CPUTIME magnetic value signal strength

Date	Comment
242:10:12	Magnetics logging started
243:10:22 - 243:10:53	interruption
243:11:04 - 243:13:51	inconsistent data
243:20:44 - 244:09:39	interruption
245:13:05 - 246:19:52	magnetics logging stopped
246:23:29 - 246:23:35	interruption/bad data
249:16:32 - 250:07:47	stopped
252:01:15 - 253:07:53	stopped
253:11:20 - 253:18:00	interrupted
257:09:47	magnetics logging ends

Weather Station

R.M. Young Precision Meteorological Instruments 26700 Series is used to log a variety of meteorological events at 60 second intervals.

CPUTIME true_wind_spd true_wind_dir wind_spd_instant_1 wind_spd_avg60sec_1

wind_spd_avg60min_1 wind_spd_max1 wind_dir_current_1 wind_dir_avg60sec1

wind_dir_avg60min_1 wind_spd_instant_2 wind_spd_avg60sec_2

wind_spd_avg60min_2 wind_spd_max2_ wind_dir_current_2 wind_dir_avg60sec2

wind_dir_avg60min_2 temp_current temp_avg60min temp_min_60min

temp_max60min rel_humidity rel_humid_min60min rel_humid_max60min barom

Hydrosweep Centerbeam and Swath Data
Krupp Atlas Hydrosweep Centerbeam. Each Hydrosweep ping is logged, and center beam data is extracted and logged separately. During deployment of OBS data, the hydrosweep was disconnected for minutes at a time. All data gaps greater than 30 minutes are accounted for here.

HS centerbeam format is CPUTIME depth
HS swath data can be read and processed using MB-System software which can be found at the website of Dale Chayes: http://www.ldeo.columbia.edu/~dale

Date	Comment
242:02:10	HS logging begins
249:18:02 - 249:19:10	interrupted
249:20:10 - 249:20:58	interrupted again
249:23:49 - 250:00:39	interruption
252:01:13 - 252:02:00	interrupted
258:23:59	Logging ends

GPS Receivers

- gp1 = Tasman Ycode
- gp2 = Trimble Selective Availability

were logged at 10 second intervals. Navigation is processed and reduced to 1 minute intervals, which is later applied to hydrosweep bathymetry, magnetics and gravity. All data has been processed using gp1: Pcode navigation. This GPS has an error factor of up to 15 meters.

GPS data is in NMEA format.

Date	Comment
239:02:38	GPS logging begins
252:01:15 - 252:01:52	Power failure
258:23:59	Logging ends

Bell Gravimeter
The gravity meter is logged at one second intervals. . Gaps in recording greater than 60 seconds are accounted for here. The gravimeter gyro was broken at the beginning of the cruise, and was replaced on day 252, when gravity data began.

CPUTIME count_interval:count status

Date	Comment
252:05:00	Gravity logging started
258:23:59	Gravity logging ends

Omega DP-10 Sea Temperature
Sea temperature is logged at 60 second intervals.

Shot Data
There were three separate MCS sections of this cruise. Section one was shot using 2 GI guns and a 1 km streamer; section two was shot using 6 guns on the port side with a 1 km streamer; and the third section using 20 guns and a 6 km streamer at 100 second intervals. Use the files *ts.nxxx.status* to get these values.

Date	Shot Point	Comment
Eli Silver's Line	25 meter interval	There was an interval between shots 1750 - 2107 where shots were taken at 75 meters accidentally
245:15:33 - 245:23:26	2 .. 2107	Line one
245:23:27 - 246:02:02	2301 .. 3027	Line two
246:02:03 - 246:03:54	3028 .. 3633	Line three
246:03:54 - 245:07:21	3634 .. 4852	Line four
246:07:21 - 246:11:18	4852 .. 6239	Line five
246:11:18 - 246:14:33	6239 .. 7386	Line six
246:14:33 - 246:15:09	7387 .. 7585	Line seven
246:15:10 - 246:18:31	7586 .. 8742	Line eight
Andrew Goodliffe's Line	25 meter interval	Power failure on Line sixteen necessitated a partial reshoot : Line seventeen
250:07:40 - 250:11:10	1 .. 1146	Line 1
250:11:10 - 250:14:44	1146 .. 2378	Line two
250:24:45 - 250:17:14	2378 .. 3257	Line three
250:17:14 - 250:20:30	3257 .. 4359	Line four
250:20:32 - 250:23:41	1 .. 1109	Line five
250:23:43 - 251:02:49	1110 .. 2145	Line six
251:02:56 - 251:06:01	2146 .. 3230	Line seven
251:06:01 - 251:09:25	3230 .. 4311	Line eight
251:09:26 - 251:12:43	4312 .. 5470	Line nine
251:12:43 - 251:15:44	5471 .. 6491	Line ten
251:15:47 - 251:18:50	6492 .. 7568	Line eleven
251:18:51 - 251:19:46	7569 .. 7839	Line twelve
251:19:46 - 251:22:19	7840 .. 8702	Line thirteen
251:22:20 - 251:22:48	8702 .. 8852	Line fourteen
251:22:48 - 252:00:06	8852 .. 9312	Line fifteen
252:00:06 - 252:01:14	9312 .. 9699	Line sixteen - power failure
252:02:10 - 252:4:47	0 .. 884	Line seventeen - reshoot
John Mutter's Line	100 second intervals	Small naming problems at beginning of line: Line 0010 should be Line 001A for shots 1 - 23. Also, compass data was not logged to tape for initial shots. However, all compass data has been logged to disk and stored in cb1 files for all lines.
253:06:18 - 253:06:57	1 .. 23	Line 0010 - *001A*
253:06:59 - 253:09:40	24 .. 121	Line 001A
253:09:42 - 253:17:47	122 .. 413	Line 001
253:17:48 - 254:05:47	413 .. 844	Line 002

254:05:49 - 254:08:44	845 .. 950	Line 003
254:08:46 - 254:16:39	951 .. 1235	Line 004
254:16:40 - 255:02:43	1236 .. 1598	Line 005
255:02:44 - 255:05:51	1599 .. 1711	Line 006
255:05:52 - 255:15:49	1712 .. 2070	Line 007
255:15:50 - 255:17:32	2071 .. 2132	Line 008
255:17:33 - 255:23:40	2133 .. 2353	Line 009
255:23:41 - 256:03:55	2354 .. 2506	Line 010
256:03:56 - 256:10:31	2507 .. 2744	Line 011
256:10:31 - 256:12:31	2745 - 2817	Line 012
256:12:32 - 256:18:04	2818 - 3017	Line 013
256:18:05 - 257:10:25	3018 - 3606	Line 014

Data Processing

GPS Data Reduction/Processing
Navigation data is post-processed in order to accurately determine the position due to GPS accuracy errors. We perform slightly different processing depending on the type of receiver.

GPS Processing Steps

1. Check data for mutant records and non-sequential times.
2. If we have speed and/or DOP information, remove records that have excessive speed or too high of a DOP[1]
3. Convert from NMEA or proprietary format to a standard format

98+240:00:28:50.091 N 42 14.1536 W 063 25.5897 P-trimble

4. If we are processing known differential data, remove non-differential fixes from the file.
5. Interpolate and reduce data. Fixes are reduced to 30 second fixes and any minor gaps (< 3 minutes) are linearly interpolated.
6. Smooth data using a 9 point running average algorithm and further reduce data to 60 second fixes.
7. Perform dead reckoning using the smoothed Furuno speed and heading to fill in major gaps (> 3 minutes) and to insure the accuracy of the GPS data. By performing dead reckoning, we can determine the drift of the GPS vs. the speed and heading. Any huge distances will alert us to a problem.

Furuno Processing
Furuno speed and heading is processed by smoothing the data using a vector summing algorithm. Data is reduced and output at 1 minute intervals by taking the smoothed values and calculating the mean value for the 30 seconds before and after the whole minute.

Hydrosweep Processing

Centerbeam Processing steps

1. Remove all survey and calibration records from the raw data and all *0* level depths.

---

[1] Dilution of Precision, a term used to measure the accuracy of the fix based on the number of Satellites the GPS receiver is tracking, and the position of the satellites.

2. Reduce data to one minute intervals on 00 seconds of the minute by computing the median values from the raw values that lie between +-30 seconds of 00 seconds of the minute.

3. Merge the data with the processed navigation to end up with one minute hydrosweep centerbeam fixes with navigation.

Swath Processing
Hydrosweep swath data is processed using a package from Lamont-Doherty Earth Observatory called **MB-System**.

The processing includes hand-editing the beam data to insure an accurate hydrosweep survey. This process is too involved to document here; but the source code and documentation may be found at the website:
http://www.ldeo.columbia.edu/~dale

Gravity Processing

```
bias  = 852645.3;                 Dec  5, 1997
scale = 5.0940744                 July 9, 1992
mGals = raw_gravity_count * scale + bias;
```

Logging

- Raw gravity is logged to disk (roughly 1 sample/second) and broadcast to the network.

- A *real-time* gravity process reads the sampled data and applies a 6 minute gaussian filter to the raw sample to provide a running display of the current gravity. This value is used in the gravity ties to determine the local gravity. (Gravity Meter Value (BGM Reading))

Gravity Post Processing

- Raw gravity is filtered using a 6 minute gaussian filter and mGals are output. The raw mGals are represented by

```
mGals = gravitycount * scale + bias;
```

- A second filter is then applied; an 8 minute Gaussian filter using the GMT system:

```
    filter1D -G480 -R -E
```

- The filtered output is then reduced to 1 minute intervals by using the mean values of all data +/- 30 seconds from the 00 second mark of the minute to output:

```
98+254:00:07:00.000 980422.37
98+254:00:08:00.000 980422.38
```

- The data is merged with the navigation.
  See *Processed File Formats.*
  At this point eotvos corrections are determined by merging the daily navigation and raw gravity files and calculating the Eotvos correction as:

*Eotvos correction = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel*

_ The velocities used in the Eotvos calculation are smoothed to reduce the jitter in the corrected gravity and FAA values. The smoothing is done using a 9 point running average.

Gravity Ties
It is usual practice to have a gravity "tie" to a gravity reference base station during the port stay. A portable gravity meter, e.g. the Lacoste Model G #70, is used to make 1) a pier-side reading; 2) a reading at the base station; 3) an additional pier-side reading.

The pier-side gravity value, adjusted in value to correspond to the height of the BGM gravity meter, is compared to the real-time **BGM Gravity Reading** discussed previously.

The practice is not to adjust the BGM-3 so that its reading agrees with the pier-side gravity value, but to establish a "dc shift", which represents a constant correction to be applied to all gravity values on the next cruise.

For example, suppose the pier-side value equaled 980274.7 mGal and the BGM reading was 980279.9, the dc shift would be 5.2 mGal. In other words, the BGM is 5.2 mGal high. This value is subtracted from observed values of gravity following the cruise as a constant correction. The "drift" of the Bell gravity meter is determined from the two in-port gravity station ties. In the pre-cruise tie the BGM might have been found to be 5.3 mGal high and during the post-cruise tie it is 8.4 mGal high. The drift during the cruise is therefore equal to 3.2 mGal (8.4 - 5.2). The amount of drift per day is then calculated and gravity data is processed with the drift values corrected for the length of the cruise.

Thus, for daily reduction at sea the drift correction option cannot be used. However, the drift rate of the Bell gravimeter is very low, usually much less than 0.1 mGals/day; thus useful analysis of the FAA values while at sea is possible

A corrected gravity value is computed as:

corrected_grv = raw_grv + eotvos_corr - drift - dc_shift

The theoretical gravity value is based upon different models for the earth's shape.

1930 = 1930 International Gravity Formula
1967 = 1967 Geodetic Reference System Formula
1980 = 1980 Gravity Formula

The FAA is computed as: *faa = corrected_grv - theoretical_grv*

Raw File Formats

fu.r   Raw Furuno Log

CPU Time Stamp   Track Speed Hdg   Gyro

98+166:00:01:53.091 -   4.4   140.5 148.3

gp*x*.c - Formatted raw NMEA GPS

98+157:00:03:10.951   N 42 50.4311   W 061 18.8016   P-trimble

- **P-trimble Pcode Fix**
- **D-trimble Differential Fix**
- **trimble   S/A fix**

cb1.d   Streamer Compass Bird Block Data

This data does not contain processed navigation. The navigation comes directly from the raw shot points.

CPU Time Stamp   Line   Shot   Latitude   Longitude
98+079:00:08:40.085 strike1 000296 N 15 49.6217 W 060 19.8019

2nd GPS   Tailbuoy   Furuno   Streamer
Latitude   Longitude   Latitude   Longitude   Heading Compass Headings
N 15 49.6217 W 060 19.809   N 00 00.0000 W 000 00.0000 341.2   C01 2.3   C02 1 .7

vc.r - raw gravity counts

98+144:00:00:16.219   **01:022466 00**

CPU Time   pp dddddd ss

```
                                |     |              |__________ status:
                                |     |              00 = No DNV error; 01 = Platform DNV
                                |     |           02 = Sensor DNV;   03 = Both DNV's
                                |     |__________ count typically 025000 or 250000
                                |____________________ counting interval, 01 or 10
```

hb.m - median averaged hydrosweep centerbeam

98+144:00:00:16.123   400.3

CPU Time   Centerbeam depth

Processed File Formats

n. - final navigation at even minute intervals

```
98+074:00:03:00.000 N 13  6.2214 W  59 37.9399   gp1   0.0   0.0
yr  +day    time            Latitude           Longitude          gps    set    drift
```

hb.n - interpolated center beam merged with navigation

```
yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123.1234  2222.0
yr     day   time              lat               lon            depth (meters)
```

m. - merged bathymetry, magnetics, gravity with final navigation.
mgd77 format

```
98+123:04:36:03.895  N 14  9.0555 W  67  2.3969   gp3 276.9  0.2
yr   day  time            lat              lon                 id    set     drift
5034.9    37401.8    17.2          -1.6     978349.0    13.1      9.1    13.2
depth       mag tot      mag          grv.    raw_grv      eotvos   tot    dc
           intensity    anomaly      faa                            drift   shift
```

vt.n - merged BGM-3 gravity with final nav.

```
yy+ddd:hh:mm:ss.mmm N 16  0.4273 W  73 20.3055  1980   -4.1
yr    day   time               lat             lon                theog   FAA
978416.9   27.6   9.9   13.2    -2.7   3.9     -2.8   3.8
raw_grav    eotvos drift   dc      raw_vel      smooth_vel
                               shift      N       E         N     E
```

ts.n - Shot Data

A - sign in the time stamp is flagged as a missing shot that has been interpolated. The shot was not present in the file, but the shot has been calculated using a very simple interpolation.

```
      CPU Time Stamp                    Shot #        Latitude         Longitude          Line
Name
      98+079:00:08:01.507 000295 N 15 49.5703   W 060 19.7843      strike1
```

ts.n.status -Shot Data Status

Occasionally the MCS system will miss a shot. In these cases it is nice to know what is going on. The ts.n.status files will report the lines that were shot for the day, the time the line started and if any shots are missing from that line:

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

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

On line strike one, shots 347, 410, 1727 were missing from the log. This doesn't necessarily mean the shots weren't fired. These shots were interpolated between the previous and following shots:

Original ts.n file:

```
98+079:00:40:49.662 000346 N 15 52.1994 W 060 20.6578 strike1
98+079:00:42:05.212 000348 N 15 52.3044 W 060 20.6907 strike1
```

Fixed ts.n file

98+079:00:40:49.662 000346 N 15 52.1994 W 060 20.6578 strike1
=>98-079:00:41:27.437 000347 N 15 52.2519 W 060 20.6742 strike1
98+079:00:42:05.212 000348 N 15 52.3044 W 060 20.6907 strike1

ts.n*xxx*.guns

98+079:00:40:49.662 000346 N 15 52.1994 W 060 20.6578 strike1

Same as ts.n, but with the Lat/Lon specifying the supposed location of the guns. In this case, the guns are officially 38 meters behind the GPS. The program `calculate_guns` **was used to determine these lat/lon positions.**

ts.n*xxx*.hb

CPU Time Stamp	Shot #	Latitude	Longitude	Line Name HS
98+079:00:08:01.507		000295	N 15 49.5703	W 060 19.7843
	strike1	403.222		

This file is a merge of the shot times and the hydrosweep centerbeam. Centerbeam depths have been fixed to the shot points using the GMT program sample1d with the script do_shot_hb. We use the ts.n file and the median values of the hydrosweep data.

Science Tape Contents

The tape contains the following items:

- DOCS
  Readme files for file formats, processing, etc.

- 9910.rtf
  This file in MS-Word RTF format (ascii)

- clean
  Daily processing files and intermediate processing files. Also some postscript plots of daily data for QC.

- hs
  Some HS data processed by Jackie Floyd, and some plot data for Eli Silver

- mggcdf
  Daily mgg-77 formatted files of 1 minute fixes

- processed
  Final processed data collected during the cruise and tied to navigation

- raw
  Data logged directly from all devices:

cb1:	Compass Block Data
ct:	Sea Temperature
dg:	Gun Depths
fu:	Furuno course, heading and speed over water
gp01,gp1:	Pcode GPS
gp02,gp2:	Trimble GPS (has some differential)
hb:	Hydrosweep centerbeam
hs:	ASCII hydrosweep swath data
mg:	Geometrics magnetic data
nb:	shot data (USE NB!)
tr1:	truetime clock vs. cpu
ts1:	datum shot times
ts2:	truetime times (most accurate; official shotclock!)
udp:	backup of all data
vc:	gravity counts
wx:	weather
plus/	realtime navigation

- source_code
  Source code of selected programs for generation of some of the custom processed data for this cruise.

- trackplots
  Daily postscript plots of cruise tracks