Lamont-Doherty Earth Observatory
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Data Reduction Summary

EW9911 – Lae, Papua New Guinea - Townsville, Australia

September 21, 1999 - October 22, 1999

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Project Summary

Geothermal Study of Continental Rifting in the Woodlark Basin

This study proposed to perform a series of marine heat flow measurements in sedimented continental basement areas of the Woodlark Basin to examine the thermal evolution of active extension from the rift stage to fully developed conjugate margins separated by a young oceanic basin. Because this process is now active and is rapidly evolving in the Woodlark Basin, thermal effects have not dissipated and provide an opportunity to examine the pattern and evolution of lithospheric deformation and conjugate passive margin formation. The heat flow measurements will also provide constraints on the strongly temperature dependent mechanical properties of the lithosphere during extension. Oceanographic studies indicate perturbing environmental effects should be small. Hydrothermal effects in the sedimented continental basement areas should also be small compared to oceanic basement settings. Existing geophysical data from the area include swath bathymetry, sidescan imagery, and closely spaced and coincident gravity, magnetic and seismic reflection profiles. Thus, the proposed heat flow measurments can be acquired and interpreted within and integrated with a well controlled tectonic, structural and geophysical framework. The heat flow transects will examine the geothermal profiles of areas at different stages in the evolution of rifting to address the following questions:

- How is lithospheric scale extension distributed as extension increases as reflected in the heat flow pattern and how is this themal pattern related to observed changes in earthquake seismicity, faulting styles, and the nucleation and development of seafloor spreading?

- Are the thermal patterns in the rifting stage and conjugate margins symmetric or asymmetric and does this pattern change along the rift and when crossing structural boundaries? Are observed structural asymmetries between conjugate margins reflected in their thermal patterns?

- Is a thermal effect of rift-induced asthenospheric convection expressed in the Woodlark Basin? This effect is suggested by observed differences in bathymetry, gravity, and ridge axis morphology abd depth between eastern and western oceanic parts of the Woodlark Basin correlated with differences in the margins and their opening geometry. Heat flow measurments could thus obtain important information on the parameters controlling this effect which has been proposed to have a major influence in the development of passive margins and early seafloor spreading.

Data Reduction Summary

Lamont-Doherty Science List

Name	Position	Email Address
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Science Party List

Chief Scientist:	Fernando Martinez
Party Members:	John Bailey
	Andrew Goodliffe
	Simon Kawagle
	Trevor Lewis
	Anton Obermueller
	Joel Pfeiffer
	Alan Tayllor

Cruise Notes

All times specified within this report are GMT.

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 (261-263) for quality control purposes.

Gravity
Gravity meter roll gyro was replaced during this cruise resulting in a 3 hour time lapse on October 6th (julian day 269) between 1200 and 1510 GMT. Gravity ties were taken in Papua New Guinea and at the end of cruise in Townsville, Australia.

Hydrosweep
There were a couple problems with hydrosweep during the cruise in which the bathymetry got stuck at a single depth. Most notably during the transit on julian day 288. These errors are listed in the hydrosweep table below. This erroneous data has been cut from all the hydrosweep data of this cruise.

Winch Logs

Heat Flows

Longitude	Latitude	Depth	Sea Temp
150.380143	-9.625619	1115.871	27.300
150.379063	-9.625664	1116.208	27.200
150.379169	-9.626391	1116.300	27.300
150.373328	-9.641940	1153.554	27.200
150.366445	-9.656465	1164.871	27.200
150.358653	-9.671533	1176.300	27.100
150.342207	-9.701624	1208.333	27.100
150.336152	-9.716067	1208.357	26.900
150.329471	-9.732407	1203.353	26.700
150.323099	-9.746280	1203.148	26.700
150.315212	-9.760562	1202.300	26.699
150.308519	-9.775041	1198.390	26.800
150.300663	-9.791295	1193.380	26.900
150.242441	-9.911488	1312.300	27.700
150.234712	-9.926675	1319.064	27.600
150.228593	-9.941493	1329.102	27.600
150.221474	-9.956912	1344.029	27.600
150.212568	-9.971539	1352.300	27.700
150.207246	-9.986002	1359.104	27.700
150.198827	-10.002449	1363.300	27.700
150.192524	-10.016850	1362.300	27.600
150.184431	-10.031603	1362.300	27.700
150.177370	-10.047167	1278.954	27.600
151.337202	-10.316121	803.651	26.800
151.399842	-10.303833	869.966	26.900
151.316613	-10.275335	1394.840	27.000
151.318169	-10.270267	1338.065	27.000
151.316708	-10.257627	1370.648	26.900
151.318327	-10.246958	1388.738	27.000
151.316565	-10.235527	1486.495	27.000
151.317069	-10.224464	1417.614	27.000
151.316626	-10.213344	1419.961	27.000
151.316563	-10.201785	1410.002	27.100
151.316244	-10.191445	1497.310	27.100
151.316830	-10.179697	1394.706	27.100
151.316419	-10.168477	1424.533	27.100
151.316620	-10.151124	1361.300	27.100
151.316371	-10.137277	1436.656	27.100
151.315725	-10.111586	1451.920	27.000
151.399469	-10.017953	2803.862	26.900
151.399490	-10.012643	2804.200	26.900
151.399865	-10.001620	2799.289	26.900
151.399797	-9.990178	2801.643	26.900
151.399339	-9.978176	2791.060	26.900
151.572301	-9.999522	3025.043	26.900

Longitude	Latitude	Depth	Sea Temp
151.572115	-9.984943	3029.664	26.900
151.571854	-9.975248	3029.100	26.900
151.572240	-9.965309	2962.682	27.000
151.573415	-9.953188	3022.659	26.900
151.572416	-9.941527	3014.088	26.900
151.572220	-9.929757	2993.619	26.800
151.572372	-9.919101	3061.673	26.800
151.316307	-9.785393	1563.034	26.900
151.316490	-9.785320	1422.477	26.900
151.316554	-9.809918	1643.318	27.000
151.316251	-9.823464	1783.037	27.001
151.371143	-9.852699	2136.378	27.000
151.549771	-9.692925	3236.803	27.200
151.550093	-9.698938	3260.100	27.200
151.549847	-9.704718	3253.064	26.800
151.478885	-9.284392	1492.039	27.100
151.483158	-9.304839	1552.474	27.200
151.483455	-9.327233	1625.375	27.200
151.483685	-9.350031	1599.447	27.400
151.483787	-9.372705	1839.586	27.400
151.483669	-9.395625	1815.134	27.700
151.484525	-9.440729	2004.820	27.500
151.483100	-9.486251	2207.120	27.500
151.482936	-9.530823	2042.476	27.397
151.483655	-9.576877	2141.710	27.200
151.484228	-9.599305	2006.368	27.200
151.483920	-9.628139	2310.041	26.900
151.483328	-9.642357	2406.997	26.900
151.483111	-9.663059	2660.736	27.100
151.483263	-9.674350	2693.352	27.300
152.216118	-9.399855	1241.771	27.900
152.216669	-9.424189	1372.915	27.800
152.249822	-9.436584	1586.852	27.800
152.262069	-9.468779	1741.263	27.800
152.266960	-9.480905	2138.033	27.800
152.216797	-9.527140	2258.118	27.900
152.216655	-9.547973	2406.823	27.900
152.216527	-9.571307	2429.868	28.200
152.216680	-9.593096	2560.225	28.000
152.216851	-9.615564	2367.876	27.900
152.226747	-9.625977	2660.005	27.900
152.233890	-9.640840	2638.341	27.900
152.216223	-9.683668	1834.735	27.900
152.216785	-9.694770	1765.409	27.900
152.216964	-9.722966	2186.369	27.900
152.272416	-9.736541	2030.515	27.900
152.299811	-9.761961	2273.200	28.100
152.299947	-9.785857	2597.959	28.200
152.299607	-9.808189	2668.474	28.400
152.300031	-9.829827	2636.018	28.400

Longitude	Latitude	Depth	Sea Temp
152.300021	-9.853723	2760.540	28.200
153.844444	-9.026168	1778.092	28.800
153.836500	-9.033024	1768.692	28.800
153.839350	-9.079885	1999.719	28.900
153.833300	-9.092993	1872.409	28.900
153.833042	-9.115101	1949.176	28.900
153.911454	-9.309215	1983.832	28.200
153.912555	-9.332906	2293.987	27.800
153.917244	-9.349505	2375.175	28.200
153.912174	-9.413781	2162.609	27.800
153.911992	-9.434600	1918.633	27.800
153.911006	-9.463526	2481.349	27.600
153.911260	-9.507634	1955.642	27.800
153.911203	-9.548339	2159.695	27.900
153.911796	-9.568832	2220.023	28.000
153.911168	-9.585542	2393.326	28.100
153.883094	-9.740789	2378.802	28.400
153.883167	-9.808575	2901.595	28.300
153.882800	-9.859180	3068.381	28.200
153.883019	-9.907908	3492.634	28.200
154.350144	-8.833268	3054.424	29.400
154.350315	-8.848355	3079.793	29.500
154.349962	-8.862444	3045.641	29.500
154.499923	-8.666532	2274.663	29.500
154.499858	-8.683387	2299.324	29.500
154.500186	-8.698240	2318.841	29.400
154.500113	-8.712502	2321.200	29.500
154.500167	-8.726645	2360.532	29.400
154.502629	-8.874153	2866.299	29.200
154.499838	-8.891066	2908.601	29.200
154.500273	-8.910085	3038.977	29.300
154.500000	-8.930237	3063.757	29.400
154.499751	-8.948205	2970.171	29.300
154.549294	-8.996617	3934.937	29.100
154.550219	-9.013526	3978.732	29.100
154.549665	-9.026187	4051.064	29.100
154.550706	-9.039726	3988.145	29.100
154.499580	-10.774952	1961.429	29.000
154.499534	-10.791093	1870.622	29.100
154.500071	-10.808003	1891.093	29.000
154.499970	-10.824672	1875.084	29.100
154.500043	-10.841731	1860.195	29.000
154.499733	-10.858489	1824.256	29.000
154.514484	-10.875266	1876.300	29.000
154.515290	-10.891920	1855.784	29.000
154.532165	-10.901500	1843.151	29.000
154.524565	-10.939759	1867.208	29.000
154.498991	-10.964460	1782.400	29.000
154.501573	-10.975076	1743.293	29.100
154.499738	-10.990939	1699.267	29.100

Longitude	Latitude	Depth	Sea Temp
154.499670	-11.006857	1622.825	29.300
154.499722	-10.532653	2864.843	29.600
154.500478	-10.547789	3070.956	29.500
154.499957	-10.558483	3042.430	29.300
154.499822	-10.575249	2679.872	29.300
154.499684	-10.594989	2611.388	29.300
154.499813	-10.685522	2341.476	29.200
154.500101	-10.699283	2342.421	29.200
154.500222	-10.724919	2005.061	29.200
154.499855	-10.738538	1939.384	29.200
154.499699	-10.748300	1996.157	29.300
154.499640	-10.758219	1889.362	29.400
154.399441	-10.985365	1723.037	29.500
154.400485	-11.057521	1757.643	29.300
154.384640	-11.093278	1831.947	29.200
154.376591	-11.174321	2360.200	29.200
154.383068	-11.199064	2344.250	29.100
154.000266	-10.828425	3380.513	29.100
153.999423	-10.835635	3371.933	29.200
153.999934	-10.873430	3419.095	29.200
153.999993	-10.890963	3352.567	29.400
153.999434	-10.907306	3409.944	29.500
154.000326	-10.921504	3403.096	29.300
153.999701	-10.946129	3128.124	29.300
153.996774	-10.962673	3015.126	29.201
153.999883	-10.974299	NaN	29.200
153.995889	-10.988336	NaN	29.200
153.999879	-11.010934	NaN	29.200
154.000393	-11.010117	NaN	29.200
154.000821	-11.020457	2972.970	29.100
153.999964	-11.051538	2558.910	29.200
153.999693	-11.065711	2327.494	29.100
153.999298	-11.078504	2401.316	29.100
153.999597	-11.094204	2385.976	29.100
153.999717	-11.114083	2448.007	29.100
154.000529	-11.127645	2213.873	29.200
154.000100	-11.144145	2284.753	29.100
153.999673	-11.160165	2353.872	29.100
153.966789	-11.168507	1799.615	29.100
153.966703	-11.184527	1839.810	29.100
153.966456	-11.201114	1715.751	29.000
153.966806	-11.217515	1663.714	29.000
152.268448	-10.540019	1580.765	28.200
152.268377	-10.529108	1497.919	28.200
152.268422	-10.510475	1727.668	28.400
152.268484	-10.500081	1840.479	28.300
152.266075	-10.460970	1931.739	28.700
152.268549	-10.442031	2104.989	29.000
152.269330	-10.405024	2437.521	28.900
152.300168	-10.395495	2531.525	28.800

Longitude	Latitude	Depth	Sea Temp
152.299870	-10.383644	2575.596	28.900
152.299951	-10.373384	2503.785	28.800
152.299414	-10.327224	1819.978	28.800
152.299772	-10.316786	2055.612	28.700
152.300150	-10.304911	2076.427	28.700
152.300096	-10.293290	2052.068	28.700
152.263488	-10.455883	1989.542	28.800
152.288260	-10.275849	1893.511	28.800
152.273021	-10.261799	1956.060	29.000
152.280886	-10.229651	1920.304	28.899
152.287886	-10.194813	2408.599	28.900
151.589974	-9.911437	2947.762	28.400
151.603664	-9.900572	3334.119	28.500
151.656967	-9.870191	2754.852	28.600
151.675420	-9.850628	2529.576	28.500
150.317563	-9.576736	815.327	28.100
150.339694	-9.576464	970.556	28.200
150.361853	-9.577002	966.875	28.300
150.384838	-9.580038	885.095	28.300
150.396565	-9.589890	858.790	28.300
150.392026	-9.602915	942.480	28.200
150.383913	-9.616453	1187.930	28.200
150.280018	-9.833878	1276.795	27.800
150.271582	-9.851130	1155.203	27.900
150.256466	-9.881085	1315.452	28.200
150.332738	-9.791098	1193.133	27.800
150.351204	-9.761072	1180.830	27.800
151.749782	-10.099924	2593.946	28.400
151.749572	-10.083536	2834.200	28.501
151.749538	-10.066204	2765.006	28.500
151.749522	-10.049750	2830.664	28.400
151.750145	-10.033020	2873.945	28.300
151.750025	-10.016621	2883.745	28.300
151.749681	-10.000055	2917.181	28.200
151.750037	-9.983306	3112.013	28.100
152.166565	-10.516971	1715.649	28.400
152.166719	-10.533144	1839.466	28.400
152.166391	-10.566538	1190.914	28.400
152.166611	-10.616478	1116.761	28.500
152.166791	-10.633245	1239.676	28.500
152.166438	-10.649920	1166.078	28.500
152.167057	-10.666495	1244.300	28.500
152.166759	-10.683352	1280.692	28.000
152.167125	-10.699783	1254.743	28.100
152.166363	-10.716781	1264.324	28.000
152.166352	-10.733457	1245.638	28.001
152.165928	-10.750262	1294.925	28.000
152.166605	-10.766820	1226.683	28.000
152.165408	-10.866321	1106.008	27.700
152.166698	-10.883467	1199.006	27.700

Longitude	Latitude	Depth	Sea Temp
152.166489	-10.900093	1324.512	27.700
152.165533	-10.917007	1356.385	27.700
152.166906	-10.933315	1395.040	27.800
152.166661	-10.949972	1425.831	28.000
152.167147	-10.966733	1394.332	28.100
152.167457	-10.983548	1384.958	28.101
151.949832	-10.111758	2388.236	28.400
151.949864	-10.123481	2407.815	28.300
151.949978	-10.134370	2402.908	28.300
151.949969	-10.145718	2401.715	28.200
151.949852	-10.157384	2397.507	28.200
151.950317	-10.169104	2393.200	28.200
151.950058	-10.179735	2389.631	28.200
151.950052	-10.202348	2394.012	28.400
151.949882	-10.220077	2146.140	28.500
151.949695	-10.224824	2177.890	28.600
151.973210	-10.230884	2206.274	28.602
151.992394	-10.248176	1956.108	28.400

Cores

Longitude	Latitude	Depth	Sea Temp
150.380143	-9.625619	1124.901	27.300
150.379063	-9.625664	1314.638	27.700
150.379169	-9.626391	845.400	26.900
150.373328	-9.641940	1988.402	27.100
150.366445	-9.656465	1378.721	27.900
150.358653	-9.671533	2205.593	27.800

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	261-302
Furuno	fu	Furuno speed and heading	3 second	261-302
P Code GPS	gp1	Tasman Ycode receiver	10 second	261-302
Trimble GPS	gp2	Selective availability GPS	10 second	261-302
Gravity	vc	Bell gravimeter data	1 second	261-302
Sea Temp	ct	Sea Temperature	60 second	261-302
Meteorology	wx	Weather Station	60 second	261-302
Magnetics	mg	Geometrics Magnetics	12	278-279
Hydrosweep CB	hb	Hydrosweep Centerbeam	-	261-302
Hydrosweep swath	hs	Hydrosweep Swath Data	-	261-302

Logging
All logged data (*except GPS*) 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.

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
261:00:00:00	Start UTC
294:23:59:59	End UTC

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
261:00:00	Furuno logging started
294:04:05 -	Furuno hung, no data
294:23:59	Furuno logging ends

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.

CPUTIME magnetic value signal strength

Date	Comment
278:17:43	Magnetics logging started
278:19:04 - 278:22:05	Magnetic logging problems
292:10:22	Magnetic logging resumes
293:14:14 - 293:14:29	unknown interruption
294:19:24	Magnetic 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. The weather station ran with no interruptions during the cruise.

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 deployments of the heat probe, the hydrosweep was disconnected for long periods of time. There were 2 known failures of the hydrosweep which are recorded here.

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

HS centerbeam format is CPUTIME depth

Date	Comment
264:02:38	HS logging begins
280:14:49 - 280:16:02	HS Interruption
288:18:50 - 288:22:00	HS Interruption
294:22:24	HS 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
261:00:00	GPS logging begins
277:19:43 - 277:19:56	GP2 Logging interrupted
294:23:59	GPS Logging ends

Bell Gravimeter
The gravity meter is logged at one second intervals. . Gaps in recording greater than 60 seconds are accounted for here. There was one major failure of the gravimeter on day 279, where data was lost for 5 hours while the gyro was replaced.

CPUTIME count_interval:count status

Date	Comment
261:00:00	Gravity logging started
279:12:07 - 279:15:15	Break while gyro is replaced
294:23:59	Gravity logging ends

Omega DP-10 Sea Temperature
Sea temperature is logged at 60 second intervals, and there were no gaps in the data for the cruise.

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.

[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.**

Hydrosweep Processing

Centerbeam Processing steps

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

Gravity Ties

Due to a failure in the Gravity meter gyro halfway through the cruise, the drift rate may be incorrect over the length of the cruise. However, the drift rate of 0.02 mGals/day is too small over the course of the cruise to attempt to make a calculation determining if there was a jump between the 5 hours of downtime. The gravity has been processed assuming a constant rate of change over the course of the cruise.

LAE, Papua New Guinea

Date: September 20, 1999; JD 263
Operator: Jeff Turmelle
Reference Station:
Station was at the 'old' airport near the ticket terminal. Gravity base plate was long gone, so I took the reference between the benches near the entrance to the ticket terminal.
Gravity value: 978009.86 mGals
Date: 2/70
Position: S 06 44' E 147 00'
Pier/Ship's position:
Ship was docked at the main pier, close to the pilot station. Reading was taken next to the bollard marked 31 at the 450> marker. Pier was even with C Deck.
Position: S 6.7399, E 146.9822

TIME	LOCATION	L&R READING	G	Potsdam Corr?
0221Z	Pier	1699.71+- .05		
0241Z	Ref	1701.99+- .05	978009.86	NOT corrected
0408Z	Pier	1699.71+- .05		

READ FROM DEVICES BY DATA LOGGING COMPUTER:
0218Z BGM filtered mgals: 978010.7

"C" deck was 0 m BELOW pier; "C" deck is 5.5 m. above gravity meter.
Difference between pier and gravity lab: 5.5 + .0 = 5.5 m
Gravity at sensor calculation: Lacoste difference in LR units:
delta_LR = pier_LR - ref_LR
-2.28 = 1699.71 - 1701.99
Difference in mgal: (1 LR unit = 1.06 mGals)
*delta_mgal = delta_LR * constant*
-2.417 = -2.28 * 1.06
Pier gravity value in mgal: ref_val = G (+ 13.6 if Potsdam Corrected)
pier_grv_val = ref_val + delta_mgal
978007.443 = 978009.86 + (-2.417)
Height correction in mgal: (constant is + if meter is below pier)
*hgt_corr = hgt * constant*
1.705 mGal = 5.5 m * 0.31 mGal/m
Gravity at gravity meter level in mgal:
grv_at_meter_level = pier_grv_val + hgt_corr
978009.15 = 978007.443 + 1.705
DRIFT CALCULATION:
Recalculation of gravity using corrected scale factor and bias:
g(t) = (scale factor * filtered counts) + bias
where scale factor = 5.0940744 and
bias = 852645.3
Mistie in mgal:
mistie = BGM_filt_grv - grv_at_meter_level
1.55 = 978010.7 - 978009.15

Townsville, Australia

Port: Townsville, Australia
Date: October 22, 1999; JD 295
Operator: Jeff Turmelle

Reference Station:
Station was at the Townsville City College at the corner of Stanley and walker street. The Reading was taken outside of the back entrance of the C Block; near the bike racks as the old gravity tie had been carpeted over; so a firmer location was desired. This spot is about 30 meters from the original location.

Gravity value: 978623.30 mGals
Date: 2/70
Position: S 19 15.70 E 146 46.80
Elevation: 20 meters

Pier/Ship's position: from the Gravity Tie Report:
Berth 10, Townsville port, end of the pier (near last bollard marked 10). C Deck is approximately 1 meter below the pier.

Position: S 19 15.0657, E 146 49.8395

TIME	LOCATION	L&R READING	G	Potsdam Corr?
2341Z	Pier	2286.01+- .05		
0042Z	Ref	2281.58+- .05	978623.3	NOT corrected
0132Z	Pier	2286.03+- .05		

READ FROM DEVICES BY DATA LOGGING COMPUTER:
2213Z BGM filtered mgals: 978632.3

"C" deck was 1 m BELOW pier; "C" deck is 5.5 m. above gravity meter.
Difference between pier and gravity lab: 5.5 + 1 = 6.5 m

GRAVITY AT SENSOR CALCULATION: *Lacoste difference in LR units:*
delta_LR = pier_LR - ref_LR
4.44 = 2286.02 - 2281.58

Difference in mgal: (1 LR unit = 1.06 mGals)
delta_mgal = delta_LR * constant
4.7064 = 4.44 * 1.06

Pier gravity value in mgal: ref_val = G (+ 13.6 if Potsdam Corrected)
pier_grv_val = ref_val + delta_mgal
978628.006 = 978623.3 + 4.7064

Height correction in mgal: (constant is + if meter is below pier)
hgt_corr = hgt * constant
2.015 mGal = 6.5 m * 0.31 mGal/m

Gravity at gravity meter level in mgal:
grv_at_meter_level = pier_grv_val + hgt_corr
978630.02 = 978628.006 + 2.015

DRIFT CALCULATION:

Recalculation of gravity using corrected scale factor and bias:
g(t) = (scale factor * filtered counts) + bias
where scale factor = 5.0940744 and
bias = 852645.3

Mistie in mgal:
mistie = BGM_filt_grv - grv_at_meter_level
2.279 = 978632.3 - 978630.02

Drift in mgal since last tie:
prev_mistie: 1.55 mgal on date September 20, 1999 (JD 263)
drift = mistie - prev_mistie
.73 = 2.28 - 1.55
drift/day = .73/(294/263) = 0.0235 mGals/day

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**

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 Centerbeam Merged with Navigation**

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

m. **Merged Bathymetry, Magnetics, Gravity with 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 intensity mag anomaly gravity faa raw_grv eotvos tot drift dc shift

vt.n **Merged BGM-3 Gravity with Navigation**

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 shift raw_vel N E smooth_vel 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; gravity tie information.
- 9911.rtf
  This file in MS-Word RTF format (ascii)
- EW9911.cdf, EW9911.cdf_nav
- reduction
  Daily processing files and intermediate processing files. Includes postscript plots of daily data for QC.
- hs
  Processed hydrosweep.
- processed
  Final processed data collected during the cruise and tied to navigation.
- raw
  Data logged directly from all devices:
  - ct: Sea Temperature
  - 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
  - tr1: truetime clock vs. cpu
  - udp: backup of all data
  - vc: gravity counts
  - wx: weather
  - plus/ realtime navigation
- winch_logs
  Ewing winch logs and scripts to extract the lat/lon, depth and sea temperatures based on the log-times.
- hf_probedata
  Heatflow data probe data for the cruise.