Mendocino Triple Junction Seismic Experiment
Cruise Report
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Cruise Objectives

The Mendocino Triple Junction represents a region where three plates, the Gorda, Pacific, and North American are in contact. North of the triple junction the Gorda plate (a remnant of the Farallon plate) is subducting beneath North America, while south of the triple junction the Pacific and North American plates form a transform margin. Relative plate motion between North America and oceanic plates located to the west has been oblique throughout the Neogene, causing the location of the triple junction to migrate up the coast California. As the triple junction migrates northward, subduction ceases south of the triple junction and transform motion begins. Our objective is to image and map the geometry of these three plates at depth, particularly in the region where they come together in order to study the transition from convergence to transform motion. In this study we combine vertical incidence and wide-aperture seismic profiles to image structure and measure the velocity structure of the crust and upper mantle. We collected a grid of MCS profiles both north and south of the triple junction region as well as across the Mendocino Transform fault (the boundary between the Pacific and Gorda plates). Six of the profiles were also recorded by OBS and OBH instruments deployed by the R/V WECOMA, and five of the profiles were recorded onshore by an array of PASSCAL REFTEK seismometers.

MCS Experiment

In June 1994, we collected 1712 km of marine multichannel seismic (MCS) reflection profiles using the R/V Ewing (figure 1, table 1). The MCS data set consists of five east-west transects

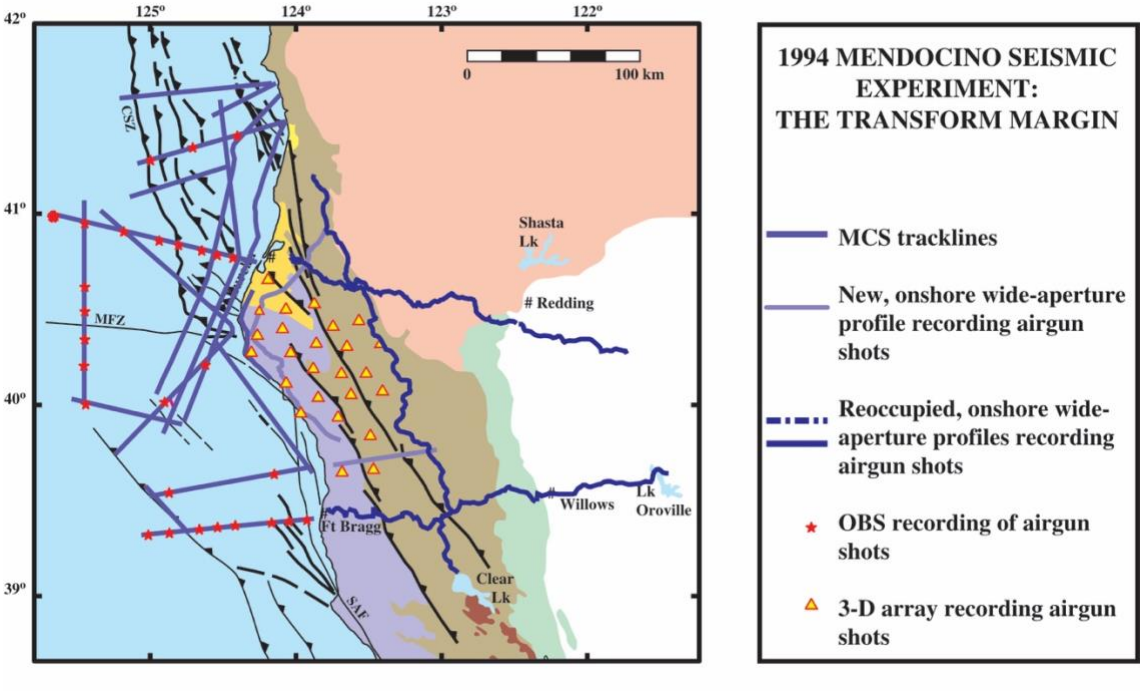

Figure 1. Location Map

north of the triple junction where the Gorda Plate is subducting beneath North America and three transects to the south where the Pacific and North American Plate are in strike-slip contact providing data that sample the crust and upper mantle before and after passage of the MTJ respectively. Additional north-south transects, provide an image of the transition between the subduction and transform margins, and provide images of the Mendocino Ridge and transform fault to look at Gorda-Pacific plate interaction.

The MCS data were collected using an 8300 cubic inch tuned airgun array and a 4.2 km, 160 channel streamer (figure 2).

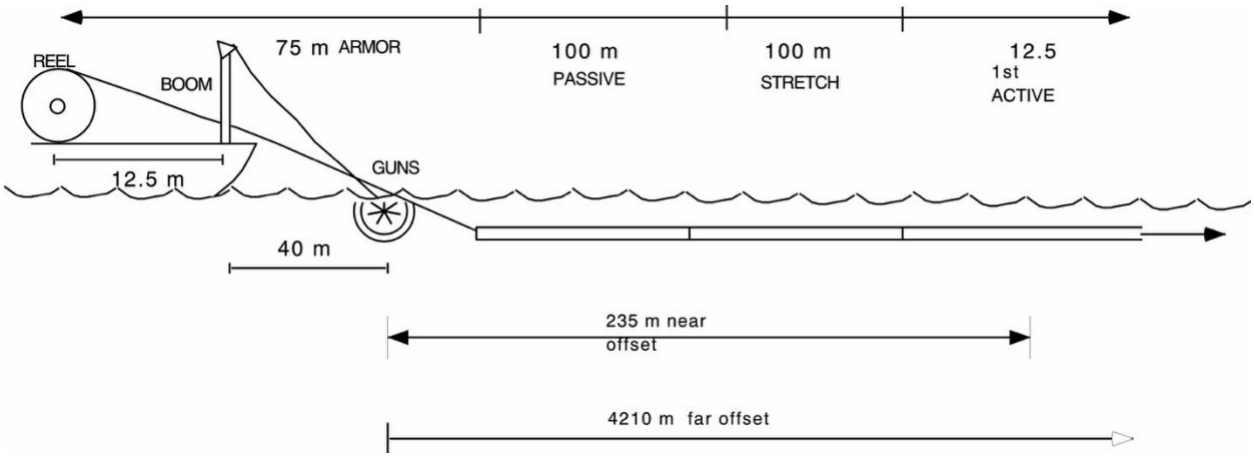

Figure 2. Line Geometry

Resulting CMP gathers are nominally 40 fold with midpoints spaced every 12.5 m. We recorded 14 seconds of data at a 2 ms. sample interval. The airgun array on the EWING also served as a source to record a series of coincident OBS profiles and several onshore-offshore 2-D wide-aperture profiles, and were also recorded by a 3-D array of REFTEK receivers centered on the triple junction region (figure 1). The WA designation in the table refers to profiles shot with a larger shot interval (nominally 125 m). Lines without the WA designation were shot with a 50 m shot interval. Locations and orientations of several of the MCS profiles, particularly lines 1, 3, and 6 were constrained by the location of receivers onshore, which were in turn constrained by the sparse road network in coastal Northern California.

A summary of the mcs transects, line locations, shot points, field file numbers, bad files and missed shots is detailed in Table 1.

line	day/time	latitude	longitude	distance	file	shotpoint	bad files	tapes	missed shots
MTJ-1b	163:21:04:13	39°18.5994	124°42.3523		101	151	1133, 1134	1	393, 465, 721, 1187, 1188, 1210, 1223, 1288, 326, 328, 1330, 1332, 1505, 1553
	164:05:12:46	39°24.7179	123°53.1079	71.637	1532	1594		21	total = 14
MTJ-1c	164:18:35:55	39°16.5264	124°59.2441		101	137		1	152, 176, 180, 182, 184, 250, 252, 254, 256, 282, 308, 310, 340, 432, 462, 464, 466, 469
	164:22:26:07	39°18.9548	124°37.8144	31.137	701	756		10	total = 18
MTJ-WA-1	164:06:34:52	39°24.4930	123°53.1805		1-408	100-472		1	491, 501, 553-4, 573, 621, 624 or 5, 766 total=8 (?)
	164:16:46:34	39°16.7449	124°58.1617	94.459	1-327	524-854		12	
MTJ-2	165:06:40:04	39°29.7162	124°56.9150		1	100	1725	1	816, 1246, 1248, 1249, 1251, 1252, 1327, 1578, 1679, 1681, 1832
	165:17:50:23	39°40.8573	123°52.4284	94.604	1893	2000		28	total = 11
MTJ-3	168:19:14:56	40°58.5783	125°25.3428	97.698	102	100		1	481-2, 485, 506, 690, 992, 1002, 1364, 1366, 1375, 1377, 1379, 1381, 1738, 1765, 1801, 1803, 1823,
	169:18:16:58	39°41.4927	125°13.4929	102.522	4171	4225	997, 4032, 4171	59	1825, 1827, 1829, 1831, 1862, 1864, 1975, 1977, 2035, 2037, 2039, 2041, 2043, 2211, 2213, 2215, 2217
MTJ-4	170:00:20:03	39°52.5052	124°46.6634		101	100		1	2341, 2343, 2401, 2403, 2405, 2421, 2423, 2591, 2593, 2840, 3239, 3402, 3404, 3411, 3414, 3438-40,
	170:07:36:56	39°58.2290	125°32.4694	66.121	1422	1421		20	4085, 4088, 4225 total=57 / MTJ-4 total=0
MTJ-5	170:09:30:27	39°56.2799	125°26.9733		1	100		1	169, 339-344, 346, 1553 total=9
	170:23:40:43	41°01.6541	125°32.3991	121.231	1510	1616	70, 1447	23	
MTJ-6	172:23:38:58	40°56.8480	125°45.2632		1	100	139-146, 1615, 2468	1	238-44, 1714, 2567-8 total=10
	173:13:30:22	40°45.0162	124°18.8841	123.363	2469	2568		44	
MTJ-WA-6	172:02:29:37	40°45.3780	124°21.4460		109	116		1	102, 105-7, 109, 111, 114 total=7
	172:17:01:51	40°56.8245	125°45.3326	119.784	1060	1067		19	
MTJ-7	166:21:35:13	39°49.3166	124°54.2031		2	100		1	281 total=1
	167:00:03:41	40°00.2930	124°48.9093	21.668	433	532		8	
MTJ-7a	167:02:45:01	40°00.2818	124°49.0521		2	100	71, 1327	1	169, 466, 725, 727, 729, 1078, 1305, 1307, 1432, 1688, 2455, 2457, 2539, 2541, 2930, 2980-2990, 3253
	167:23:05:21	41°26.8789	124°35.3641	161.427	3327	3453		50	total=27
MTJ-7b	174:23:16:40	41°23.3621	124°34.6338		1	100		1	total=0
	175:01:56:10	41°35.9144	124°37.4778	23.569	473	572		7	
MTJ-8	171:03:42:11	41°14.1486	125°10.8897		1	110		1	1917 total=1
	171:13:54:60	41°30.1212	124°09.5695	90.474	1808	1917	1808	27	
MTJ-10	165:19:05:54	39°39.1174	123°52.3159		1	100		1	1734, 1736, 1748, 1750, 1759, 1762, 1771, 1773, 1775, 1781, 1788, 1309, 1313, 1345, 1347, 1349, 1368, 1382
	166:07:05:51	40°19.5663	124°35.1590	96.551	1911	2035		28	1382, 1384, 1420, 1422, 1437, 1439 total=22
MTJ-11	165:00:05:41	39°17.8977	124°41.4661		101	100		1	1/252-5, 427, 514, 516, 589, 591, 593, 606, 608, 610, 612, 614, 616, 634, 757, 761, 764, 766, 800, 822
	165:04:48:28	39°32.0900	125°00.1397	37.523	829	850		12	824, 826 total=22
MTJ-12	168:10:27:56	41° 14.7055	124°32.8723		102	107	746	1	106, 108, 170-3, 382, 666 total=8 (?)
	168:16:59:54	41° 03.4722	125°13.3238	60.293	1326	1247		18	
MTJ-13	175:04:15:42	41°31.0531	124°39.9444		1	100		1	total=0
	175:08:55:10	41°41.9003	124°14.5947	40.541	820	920		12	
MTJ-14	175:09:31:34	41°42.1985	124°16.6363		1	109		1	142 total=1
	175:19:24:50	41°34.8399	125°20.4005	89.584	1815	1924		27	
			TOTAL:	1544.186					
ER-an	171:14:36:11	41°30.0387	124°10.3072			103			
	172:00:26:24	40°43.6312	124°23.4157	87.834		1892			
ER-as	174:01:53:26	39 53.1009	124 45.8753						
	174:05:00:04	40 01.3659	124 58.1863	104.995					
ER-bn	168:04:33:31	41°38.3083	124°12.7802			99			
	168:09:55:42	41°16.2771	124°30.4532	47.631		1113			
ER-bs	174:05:00:04	40 01.3659	124 58.1863						
	174:22:03:54	41 18.5926	124 31.0445	147.958					
			TOTAL:	195.589					

Table 1.

Description of potential field data file formats - from: Mendocino Triple Junction Cruise EW-9407 Summary

Magnetic data files begin with the prefix mg. followed by Julian day.
Gravity data files begin with the prefix vk. (KSS-30 gravity) or vt. (BGM-3 gravity) followed by the Julian day.

MAGNETIC:
Instrument: Varian V75 magnetometer
Logging: 6 second intervals
Checking: visual check of plot of data
Reference field: International Geomagnetic Reference Field 1990 (IGRF 1990) model of the main field at 1985.0 and a predictive model of the secular variation for adjusting to dates between 1990.0 and 1995.0.
Residual field: Applied by bi-linear interpolation across a 1 degree square.

FORMAT: mg.nddd
yr+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234 41200.8 -367.1
yr. day time lat lon total intensity anomaly

Lamont Database: interpolated total intensity value at 00 second of each minute

NOTE:

DAY	TIME	COMMENTS
163	2337	started logging
166	0709-2108	maggie turned off; streamer deployed
175	1930	maggie off the water; end of logging

KSS-30 GRAVITY:

Instrument: Bodenseewerke KSS-30 marine gravity meter
Logging: 6 second intervals
Merge with navigation: calculate Eotvos correction and Free Air Anomaly.
Checking: visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.
Velocity smoothing: 5 point running average throughout the cruise
Processing:
The KSS-30 times tag is first adjusted for the filtering delay. For "Seastate" setting 2, the delay due to filtering is 75 seconds. Thus 75 seconds are subtracted from the time tag and a new, adjusted time is computed.

A smooth KSS-30 gravity mGal value at one minute interval is calculated on 00 second of the minute by computing the unweighted mean values from the raw values that lie between + - 30 seconds of 00 seconds of the minute.

Calculation:
eotvos_corr =7.5038*vel_east*cos(lat) + .004154 * vel*vel
corrected_grv =raw_grv + eotvos_corr - drift - dc_shift
faa =corrected_grv - theoretical_grv

1980 theoretical gravity formula:
Yo = 978.0327 x (1 + .0053024 x sin (Q) x sin(Q) - .0000058 x sin(2 x Q) x sin (2 x Q))

Format:vk.nddd
yr+ddd:hh:mm:ss.mmm N 10 20.1234 E 120 23.1234
yr. day time lat lon

1980 77.1 979317.5 64.1 1.5 10.2 -1.7 9.7 -1.6 9.8
theog FAA raw_grv eotvos drift dc_shift raw_vel smo_vel

Lamont database: Free Air Anomaly value at 00 seconds of each minute. 1930 International gravity formula.

NOTE:
A '-" sign after the year in the record signifies a flagged record due to turn.

As a result of the discussion among the MG&G group, Lamont Data Reduction will use Port's Gravity Referenced Value without Potsdam correction for gravity data sent to MG&G data base at Lamont. Further discussion also revealed that 1980 theoretical gravity formula has incorporated Potsdam correction in its formula.

At the start of the cruise, KSS-30 platform was found turned off. As a result, there is no data until the start of JD 164.

DAY	TIME	COMMENTS
164	0000	started data processing
176	1200	end of cruise; stopped data processing

BGM-3 GRAVITY:

Instrument: Bell Aerospace BGM-3 marine gravity meter
Logging: 1 second intervals
Merge with navigation: calculate Eotvos correction and Free Air Anomaly.
Checking: visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.
Velocity smoothing: 5 point running average throughout the cruise
Processing:
Since current BGM-3 output has double counts every few minutes the following scheme has been implemented until the hardware and interface code has been fixed:
1) run a 1 minute Gaussian filter through the data. This will narrow the output spikes and make them stand out better. Output interval has been hard-wired to every 15 seconds. 2) Pass the output through filter1d (see gmtsystem) using -FG480 (an 8 minute Gaussian filter with robust option, i.e. ignore "outlier" points (i.e. the spikes).

Calculation:
eotvos_corr =7.5038*vel_east*cos(lat) + .004154 * vel*vel
corrected_grv =raw_grv + eotvos_corr - drift - dc_shift
faa =corrected_grv - theoretical_grv

1980 theoretical gravity formula:
Yo = 978.0327 x (1 + .0053024 x sin (Q) x sin(Q) - .0000058 x sin(2 x Q) x sin (2 x Q))

Format:vt.nddd
yr+ddd:hh:mm:ss.mmm N 10 20.1234 E 120 23.1234
yr. day time lat lon

1980	77.1	979317.5	64.1	1.5	10.2	-1.7	9.7	-1.6	9.8
theog	FAA	raw_grv	eotvos	drift	dc_shift	raw_vel	smo_vel		

Lamont database: Free Air Anomaly value at 00 seconds of each minute. 1930 International gravity formula.

NOTE:
A '-" sign after the year in the record signifies a flagged record due to turn.

As a result of the discussion among the MG&G group, Lamont Data Reduction will use Port's Gravity Referenced Value without Potsdam correction for gravity data sent to MG&G data base at Lamont. Further discussion also revealed that 1980 theoretical gravity formula has incorporated Potsdam correction in its formula.

DAY	TIME	COMMENTS
162	2100	started data processing
176	1200	end of cruise; stopped data processing

PRE-CRUISE GRAVITY TIE-IN:

Port: San Diego, CA, U.S.A.
Date: 20 May, 1994 (JD 140)
Operator: Joe Stennett
Reference Station:
San Diego Base Station, Point Lima, CA 1975. (DOD 187-1)
Position: N 32 42' 15.7" W 117 14' 19"
Gravity value: 979535.53 mGals (DOD, 7/1973)
Station is at the Naval Ocean Systems Center, operated by the Marine Physical Lab of the Scripps Institute of Oceanography. NOSC is midway up the east side of Point Loma on the west edge of San Diego, CA, and at the northern end of the Naval Submarine Base. Station is at the former Gate 5, just south of the intersection of Rosecrans St. and Gate Road. Station is north of the northwest corner of BLDG 106 on the concrete sidewalk at the edge of the asphalt street. Actual tie reading was taken on a sidewalk near building 106 which is probably 1 meter below the benchmark.

Pier/Ship's position:
R/V Ewing was docked at Berth 5 of 10th Street Pier. Pier reference was at Bollard opposite door 43.

Gravity meter: L&R Model G, serial number 237.
Temperature of meter: 49° C.

Reading and Calculations:

TIME	LOCATION	L&R READING	G	Potsdam Corr?
1930Z	Pier	3136.60 + - .05		
1431Z	Ref	3159.34 + - .05	979535.53	YES!

TIME	GRAVITY	G READING
1930Z	BGM-3	979537.0
1930Z	KSS-30	-627.52

Pier reading 1.5 m above waist deck. Waist deck is 5.5 m above gravity lab.
Difference between pier and gravity lab : 5.5 + 1.5 = 7.0 m.

Lacoste difference in LR units:

delta_LR	= pier_LR - ref_LR
-22.74	=3136.60 - 3159.34

Difference in mGal: (1 LR unit = 1.06 mGals)

delta_mGal	=delta_LR x constant
-24.1	=-22.74 x 1.06

Pier gravity value in mGal: ref_val = G (+13.6 if Potsdam corrected)

pier_grv_val	=ref_val + delta_mGal
979525.0	=979535.53 + (-24.1) + 13.6

HEIGHT CORRECTION:
Height correction in mGals:
note: free-air constant of +0.31 mGals per meter going towards the center of the earth; -0.31 mGals per meter going away.

hgt_corr	=hgt x constant
2.17 mGals	=7.0 x 0.31 mGals/m

Gravity at gravity lab level in mGals:

grv_at_lab_level	= pier_grv_val	+	hgt_corr
979527.17	=979525.0	+	2.17

KSS-30:

KSS-30 value was smooth and time adjusted by 75 secs.

KSS_grav_val	=	kss_unbiased_output	+	bias
979542.77	=	-627.03	+	980170.29

Mistie in mGals:

mistie = KSS-grv_val - grv_at_lab_level
15.6 = 979542.77 - 979527.17

Drift in mGals since last tie:
prev_mistie: 6.62 mGals on date 14 April 1994 (JD 104)
drift = mistie - prev_mistie
8.98 =15.6 - 6.62

DC Shift =prev _mistie - bias
=6.62 - 980170.29 = -980163.67
Drift/Day =drift / (tot. # of day)
=8.98 / (140-104+1) = 0.2427 mGals/day

BGM-3:

BGM_filt_grv = (scale factor x counts) + bias = 979537.0 using s.f. 5.0940744 and bias 8526800, filter width 360. (6 minutes)

Mistie in mGals:
mistie = BGM_grv_val - grv_at_lab_level
9.83 = 979537.0 - 979527.17

Drift in mGals since last tie:
prev_mistie: 8.87 mGals on date 14 April 1994 (JD 104)
drift = mistie - prev_mistie
0.96 = 9.83-8.87

DC Shift = prev -mistie
= 8.87
Drift/Day = drift / (tot. # of day)
= 0.96 / (140-104+1) = 0.02595 mGals/day