The Quebrada-Discovery-Gofar Transform Fault Experiment

Cruise Report, Leg 1: Passive Deployment
R/V Thomas Thompson TN214 12/15/07-1/17/08

Project Background

The goal of this cruise was to deploy 40 ocean bottom seismometers (OBS) and 7 seafloor geodesy tripods at the Quebrada/Discovery/Gofar (QDG) transform fault system on the equatorial East Pacific Rise (EPR) for a period of 1 year to study the mechanical processes that control earthquake nucleation and the relative partitioning of seismic and aseismic fault slip. The QDG fault system is the most prolific known oceanic transform fault in terms of generating large earthquakes that are preceded by an immediate foreshock sequence. Approximately 50% of magnitude ⩾5.0 earthquakes on these faults are preceded by a foreshock (m>2.5) in the hour before the mainshock. This spectacular behavior directly reflects the fundamental mechanics of faulting and detailed recordings of the sequences can be used to test competing hypothesis about earthquake nucleation. No other oceanic transform fault can guarantee recording this behavior with a ~1 year deployment (the current battery limit) of OBSs. Additionally, the factors controlling whether a fault fails seismically or aseismically can be evaluated at QDG owing to the juxtaposition of three morphologically similar, high slip-rate transforms that exhibit nearly opposite styles of deformation. Earthquake locations determined from T-phases indicate that all three transforms produce abundant micro-seismicity. However, the Discovery and Gofar transforms repeatedly rupture with $M_w > 5.5$ earthquakes while the Quebrada transform has had only one event of this size in the last 25 years. This difference is best quantified in terms of the seismic slip deficit, which is roughly 80-87% for Gofar, 69-81% for Discovery and 98-99% for Quebrada. The significantly higher level of seismic activity on the Discovery than on the Quebrada is quite surprising given that Discovery is shorter and warmer. Understanding the origin of these differences in behavior should provide fundamental new insight into the physics of faulting.

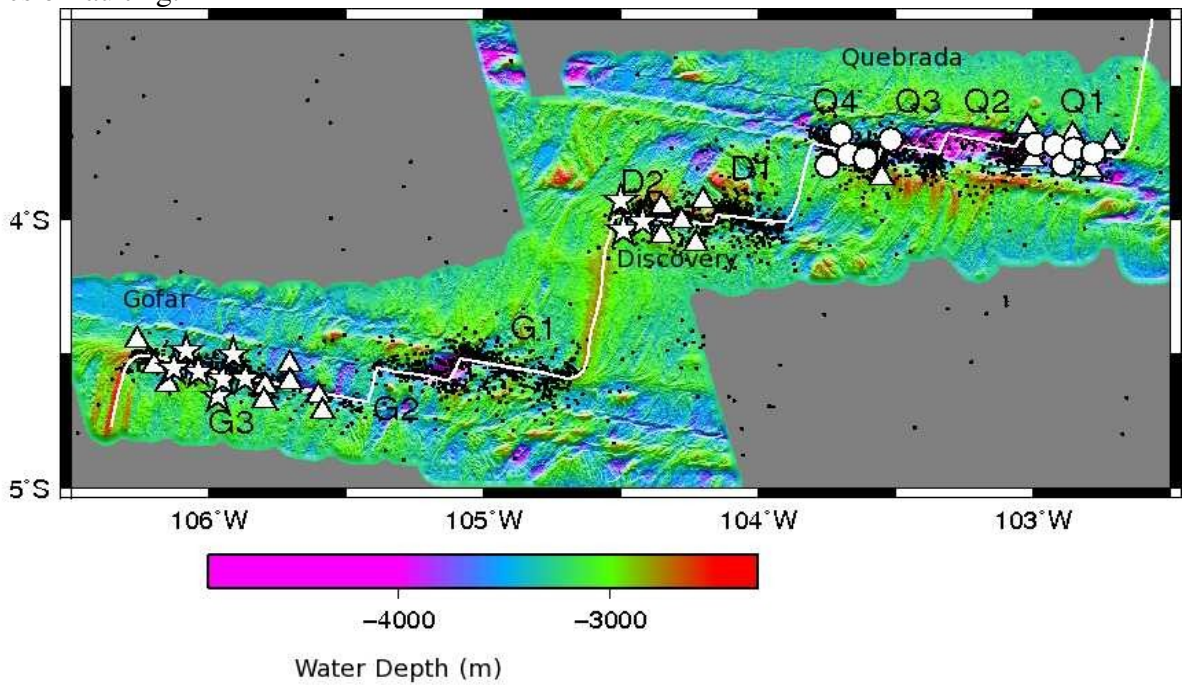

Figure 1. Map of the QDG OBS deployment. Stars are Keck OBSs, triangles are NSF broadband, and circles are NSF short period instruments.

Science Party

The science party consisted of:

Jeff McGuire	Chief Scientist	WHOI
John Collins	Co-Chief Scientist	WHOI
Ken Peal	Engineer	WHOI
Rob Handy	Engineer	WHOI
Jimmy Ryder	Engineer	WHOI
Dave Dubois	Engineer	WHOI
Alan Gardner	Engineer	WHOI
Margaret Boettcher	Scientist	USGS
Emily Roland	Grad Student	MIT-WHOI
Robert Pickle	Grad Student	Brown

Figure 2. Members of the science party (from left) Rob Handy, Robert Pickle, Emily Roland, Jeff McGuire, Dave Dubois, Jimmy Ryder, Margaret Boettcher, Ken Peal, John Collins, and Alan Gardner.

OBS Deployments

We deployed 3 different types of OBS. Ten of the instruments, which were funded by the W. M. Keck Foundation, carried both a broadband seismometer and a strong motion accelerometer, in addition to a differential pressure gauge (DPG). These Keck OBS are capable of recording, without clipping, the full range of earthquake magnitudes that we expect to occur on these faults (roughly from M0 to M6.5). Twenty OBS from the NSF Ocean Bottom Seismograph Instrument Pool (OBSIP) carried a broadband seismometer and a DPG. The final ten OBS, termed D2s, carried a short-period seismometer and hydrophone. All OBS deployments were carried out by the WHOI OBSIP group, which also provided the 30 OBSIP OBS.

Figure 3. The WHOI OBSIP group (left to right) John Collins, Alan Gardner, Rob Handy, Dave Dubois, Jimmy Ryder, and Ken Peal with the final broadband OBS to be deployed.

Figure 4. Gardner, Dubois, Handy, and Ryder deploy the first Keck OBS.

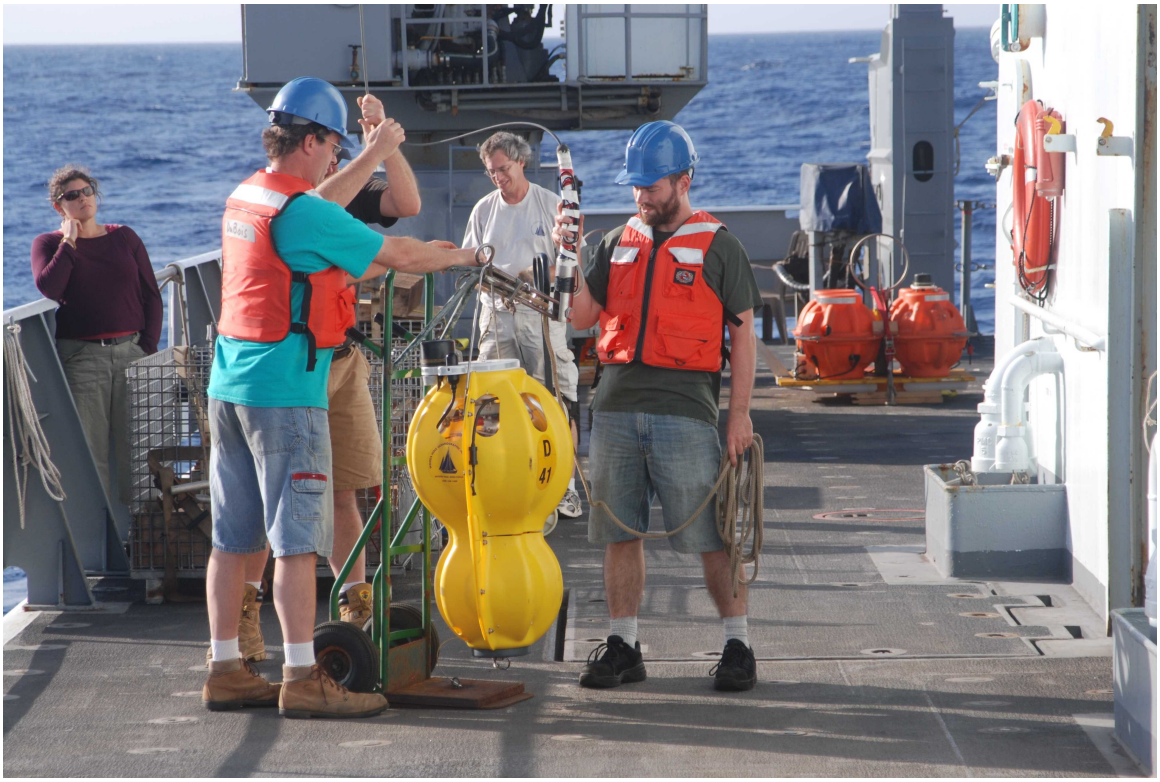

Figure 5. Gardner and Dubois prepare a D2 short-period instrument for deployment.

Each deployment consisted of preparing/programming the OBS on the way to the station, approximately 5-10 minutes on station to deploy the instrument using the hydro-boom on the starboard side, about 1 hour for the instrument to fall to the seafloor, and approximately 1 hr and 45 minutes to do a diamond shaped survey around the drop point at 4-5 knots. The radius of the diamonds was initially 1.25 km from the drop location but was reduced to 1.0 after a few (see log). The ranges from the survey were inverted by John Collins to determine the position of the OBSs (and tripods) on the seafloor. The final locations from the inversions are listed in Table 1.

Site Number	OBS I.D.	Station Latitude (deg)	Station Latitude (min)	Station Latitude (hemi)	Station Longitude (deg)	Station Longitude (min)	Station Longitude (hemi)	Station Latitude (decimal degrees)	Station Longitude (decimal degrees)	Station Depth (m)	Type
G01	S73	4	27.094	S	106	15.627	W	-4.45157	-106.26045	3209	NSF
G02	S72	4	32.790	S	106	11.953	W	-4.54650	-106.19922	3050	NSF
G03	S70	4	36.966	S	106	8.988	W	-4.61610	-106.14980	3187	NSF
G04	S82	4	33.32	S	106	7.6	W	-4.55528	-106.12662	3170	KECK
G05	S80	4	29.44	S	106	4.81	W	-4.49072	-106.08010	3558	KECK
G06	S85	4	34.17	S	106	2.16	W	-4.56943	-106.03593	3601	KECK
G07	S86	4	39.55	S	105	58.11	W	-4.65912	-105.96848	3195	KECK
G08	S88	4	35.77	S	105	56.89	W	-4.59617	-105.94812	3358	KECK
G09	S84	4	30.13	S	105	54.58	W	-4.50218	-105.90973	3258	KECK
G10	S83	4	35.59	S	105	52.01	W	-4.59318	-105.86687	3395	KECK
G11	S46	4	37.23	S	105	47.51	W	-4.62055	-105.79175	3238	NSF
G12	S65	4	40.67	S	105	48	W	-4.67783	-105.80000	3192	NSF
G13	S14	4	32.4	S	105	42.39	W	-4.54003	-105.70645	3402	NSF
G14	S37	4	36.3	S	105	42.14	W	-4.60505	-105.70240	3926	NSF
G15	S30	4	39.4	S	105	36.06	W	-4.65665	-105.60095	3313	NSF
G16	S74	4	43.01	S	105	35.06	W	-4.71690	-105.58425	2961	NSF
D01	S87	4	0.55	S	104	25.16	W	-4.00915	-104.41933	3269	KECK
D02	S81	3	55.88	S	104	29.96	W	-3.93128	-104.49925	3020	KECK
D03	S89	4	2.49	S	104	29.51	W	-4.04157	-104.49182	3031	KECK
D04	S71	4	3.58	S	104	21.09	W	-4.05958	-104.35152	3124	NSF
D05	S67	4	5.43	S	104	13.69	W	-4.09057	-104.22820	3088	NSF
D06	S66	3	55.83	S	104	11.95	W	-3.93045	-104.19912	3241	NSF
D07	S68	4	0.35	S	104	16.69	W	-4.00590	-104.27813	3238	NSF
D08	S38	3	57.08	S	104	21.08	W	-3.95127	-104.35128	2681	NSF
Q01	D29	3	47.89	S	103	44.97	W	-3.79820	-103.74952	3391	D2
Q02	D18	3	40.79	S	103	42.01	W	-3.67988	-103.70010	3653	D2
Q03	D41	3	45.27	S	103	40.23	W	-3.75443	-103.67057	3845	D2
Q04	D58	3	46.18	S	103	36.55	W	-3.76968	-103.60917	3315	D2
Q05	D56	3	41.97	S	103	31.05	W	-3.69955	-103.51755	3632	D2
Q06	S19	3	50.31	S	103	32.96	W	-3.83842	-103.54927	2961	NSF
Q07	S28	3	46.13	S	103	0.1	W	-3.76875	-103.00173	3910	NSF
Q08	S01	3	39.21	S	103	1.19	W	-3.65357	-103.01975	3036	NSF
Q09	S20	3	41.01	S	102	51.33	W	-3.68347	-102.85550	3309	NSF
Q10	S33	3	42.68	S	102	42.86	W	-3.71128	-102.71425	3344	NSF
Q11	S48	3	48.53	S	102	47.37	W	-3.80882	-102.78953	3348	NSF
Q12	D60	3	44.96	S	102	46.79	W	-3.74925	-102.77982	3874	D2
Q13	D21	3	47.56	S	102	53.41	W	-3.79258	-102.89010	3368	D2
Q14	D16	3	44.04	S	102	51.02	W	-3.73407	-102.85038	3822	D2
Q15	D35	3	43.33	S	102	55.19	W	-3.72217	-102.91980	3680	D2
Q16	D17	3	42.96	S	102	59.4	W	-3.71603	-102.99007	4126	D2

Table 1. Final Surveyed OBS locations.

Geodesy Deployments

We did ten deployments of geodesy tripods. Three of the original 7 deployments (C2, P5, and P2) had to be recovered and re-deployed because they did not have line of sight ranging with their desired links. In particular, C2 and P5 were far enough up the southern bounding slope of the Discovery fault valley that they could not see each other (too much curvature/elevation change between them), and C2 could not see P4 in the center of the valley. Rather than trying to scale a smaller portion of the southern wall, we decided to shift P-5 to the northern side of the fault valley. Also, C1 could not see P2, so we decided to try and land P2 on the southern side of the fault, but it is not clear from the bathymetry if we succeeded. The currents were consistently pushing instruments 100-300 m to the WSW/SW so the 3 re-deployments attempted to account for this. From the surveyed locations, it appears likely that we successfully landed C2 on the southern side of the plate boundary, and thus we have at least two baselines that cross the fault.

Inst.	Surv. Lat. Deg.	Survey Lon Deg.	MB Grid Depth	Decimal Lat	Decimal Lon	Drop Lat	Drop Lon	Modem	Drift	Azim
C1	-3.9930	-104.4422	-3624	-3 59.58	-104 26.53	-3.9927	-104.4395	oadr 2	298	263
C2	-3.99645	-104.4473	-3455	-3 59.787	-104 26.684	-3.9958	-104.4447	oadr 1	68	184
P1	-3.9895	-104.4373	-3616	-3 59.37	-104 26.24	-3.9895	-104.4348	NA	286	268
P2	-3.9957	-104.4430	-3543	-3 59.744	-104 26.579	-3.9953	-104.4422	NA	94	239
P3	-3.9886	-104.4440	-3571	-3 59.318	-104 26.641	-3.9871	-104.4348	NA	235	260
P4	-3.9949	-104.4445	-3543	-3 59.691	-104 26.673	-3.9945	-104.4436	NA	110	250
P5	-3.9910	-104.4486	-3458	-3 59.46	-104 26.913	-3.9905	-104.4476	NA	121	239

Table 1. Final Tripod Positions

Figure 6. The first geodesy tripod is deployed.

Figure 7. Geodesy Tripod C2 is recovered by Rob Handy and the Thompson's crew after it failed to establish communications with other instruments at its first deployment location.

At our final visit to the tripods on 12/30 we uploaded all of the data that had been collected to date. Owing to the different deployment times and initial synch-ups, we collected different amounts of data for the various baselines as summarized below. We successfully uploaded about 1 MByte of data with the Linkquest modems with no problems. C1 was turned on at 12:00:00 UTC on 12/27/2007 (or maybe ~11:54 as I messed up and took the power cable out a few minutes early and then put the dummy plug on at 12:00). C2 was turned on on deck at 23:00:00 UTC on 12/29. For C2 we sent the mmt_wint command to P4 and P5 at 04:38 UTC on 12/30.

baseline	First Interrogation	Last Interrogation	Nominal Range (m)	# of ranges	
C1-P1	12/27/2007,21:54:57	12/31/2007, 15:54:58	641.8	59	just 10 hour delay
C1-P2	12/30/2007, 19:54:58	12/31/2007,15:54:58	304.7	22	repositioned
C1-P3	12/28/2007, 12:02:57	12/31/2007,18:02:58	518.4	52	took one 12 hour cycle
C1-P4	12/27/2007, 22:06:57	12/31/2007, 18:02:58.0	316.6	61	just 10 hour delay
C2-P4	12/30/2007, 14:53:35	12/31/2007,16:53:35.0	171.9	14	~10 hours after mmt_wint
C2-P5	12/30/2007,20:57:35	12/31/2007, 16:57:35	708.8	11	~16 hours after mmt_wint?

The ranging data we uploaded is shown in Figure 8. These are just nominal ranges using a 1500

m/s sound velocity that has not been corrected for CT or tide data. The data have not had cycle skips corrected so there are lots of missing data points, particularly for C1-P3.

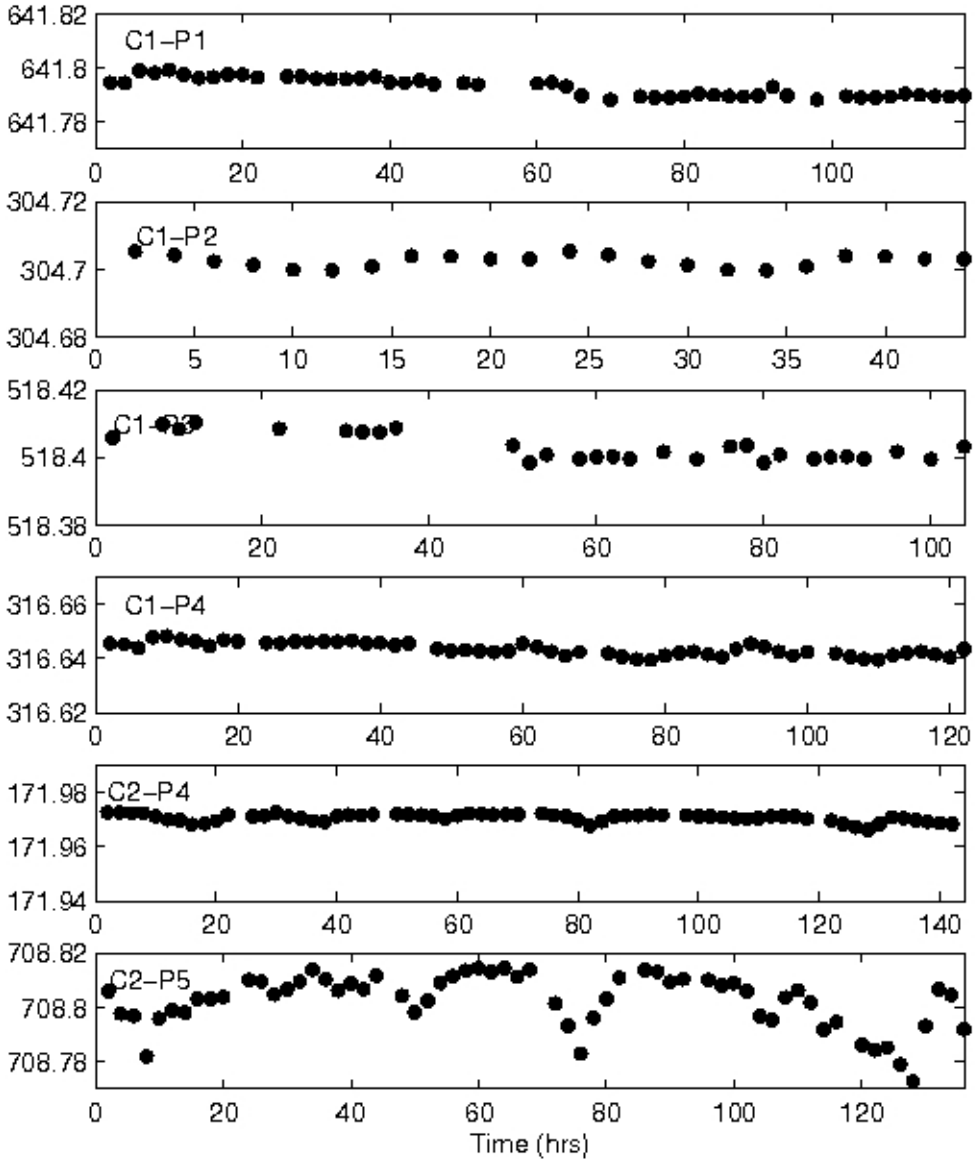

Figure 8. The initial uploaded ranging data from the C1 and C2 transcievers. Distances between the tripods in meters. These records have not been corrected for temperature variations so the longer baselines show more scatter. Also, the measurements have not been corrected for cycle skips so some samples are missing.

The Deployment Cruise Earthquake Swarm!

Shortly after we finished instrumenting the Gofar Transform, it had the first major earthquake swarm of our year long deployment! A quick look through the GSN data shows that at least 9 M>4.0 earthquakes happened on 12/28 and 12/29. Including:

'2007 12/28/07 19:57:30'
'2007 12/29/07 00:39:48'
'2007 12/29/07 00:48:00'
'2007 12/29/07 07:20:34'
'2007 12/29/07 08:07:41'
'2007 12/29/07 15:12:57'
'2007 12/29/07 18:26:53'
'2007 12/29/07 20:33:26'
'2007 12/29/07 21:48:32'

The earthquakes appear to be on the G1 segment of the Gofar transform, and were likely recorded by all 10 Keck Accelerometers including instruments on both Gofar and Discovery, ~15 DPGs, and a few broadband sensors on Gofar. With this many instruments within 100 km, this temporarily holds the record for best recorded swarm on an Oceanic Transform Fault!

Multibeam Mapping

We utilized the Thompson's EM300 multibeam system to make high-resolution bathymetry maps of three targeted areas, the Quebrada and Discovery fault-zones and the potential rotating microplate area north of the Discovery transform fault. Robert Pickle designed the surveys and processed the multibeam data.

Fault Zones

High-resolution surveys were carried out on the Discovery and Quebrada fault zones. A 20 m grid bathymetry map for the portion of the Discovery transform near the tripod drop locations revealed significant topographic structures within the fault valley that required a re-design of the tripod array. Additionally, 50 m grids were resolved for the majority of the Discovery and Quebrada fault valleys. Surveys were typically carried out at ~5 knots but somewhat slower for the 20m grid.

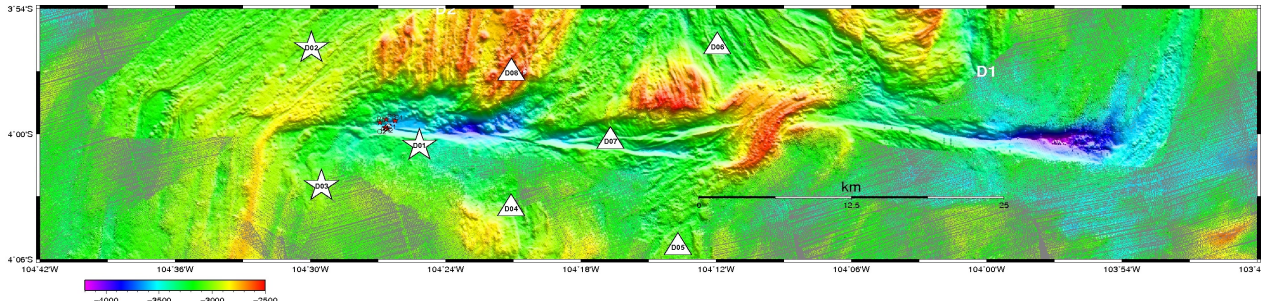

Figure 9. The EM300 multibeam map (50 m grid) of the Discovery Transform fault with OBS and geodesy instrument locations.

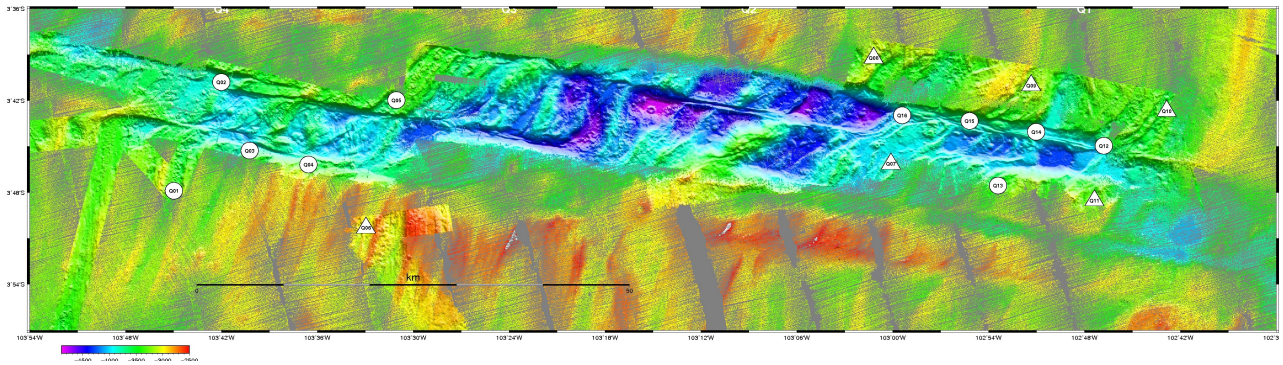

Figure 10. The EM300 multibeam map (50 m grid) of the Quebrada Transform fault with OBS instrument locations.

The Discovery Picoplate

On a previous cruise in the QDG study area (Forsyth & Saal, R/V Knorr, 4/2006) Seabeam bathymetry uncovered what appears to be a small "microplate" which had split and rotated from the western range

just north of the Discovery transform. In addition the sidescan "backscatter" images showed a continuation of reflective area from the terminus of the western ridge which had sharply bent ~30 degrees to the east. If beam reflectivity can be assumed as a proxy for young seafloor, this would indicate that the ridge bounding the western end Discovery had recently been significantly longer, possibly continuing as north as the Quebrada fracture zone. The mechanics and relationship between this ridge "snapping", the formation of the microplate, the anomalously shallow sigmoidal intra-transform spreading center beneath it, and the overall geometry of the Discovery transform are currently under active research by Forsyth & Pickle et al.

In an effort to supplement the coarse (~200 m) bathymetry and sidescan data acquired on the Knorr, we used ~48 hours of leftover cruise time to remap the area at 4.5 knots with a fixed swath width of 4 km (with 135 beams/ping), achieving a raw precision of 50 m or better. We had considered mapping uncharted seafloor to the west and/or north, but by then we had found the Thompson's multi-beam system (SimRad EM300) ill-suited for broad scale deep sea mapping, with a maximum swath width on the order of 4-5 km and susceptibility to poor quality data at speeds greater than 6 knots. Moreover, the Thompson is lacking both a gravimeter and magnetometer, so what little new seafloor uncovered would not necessarily enrich current geophysical models or tectonic interpretations. By slowly remapping this area we were able to increase the previous bathymetry and sidescan resolution nearly 8 fold and have since discovered faults, seamounts, and reflective areas previously lost in the wash. This new data will be of particular benefit in planning any future dredges and/or deployments for the inevitable return to the area.

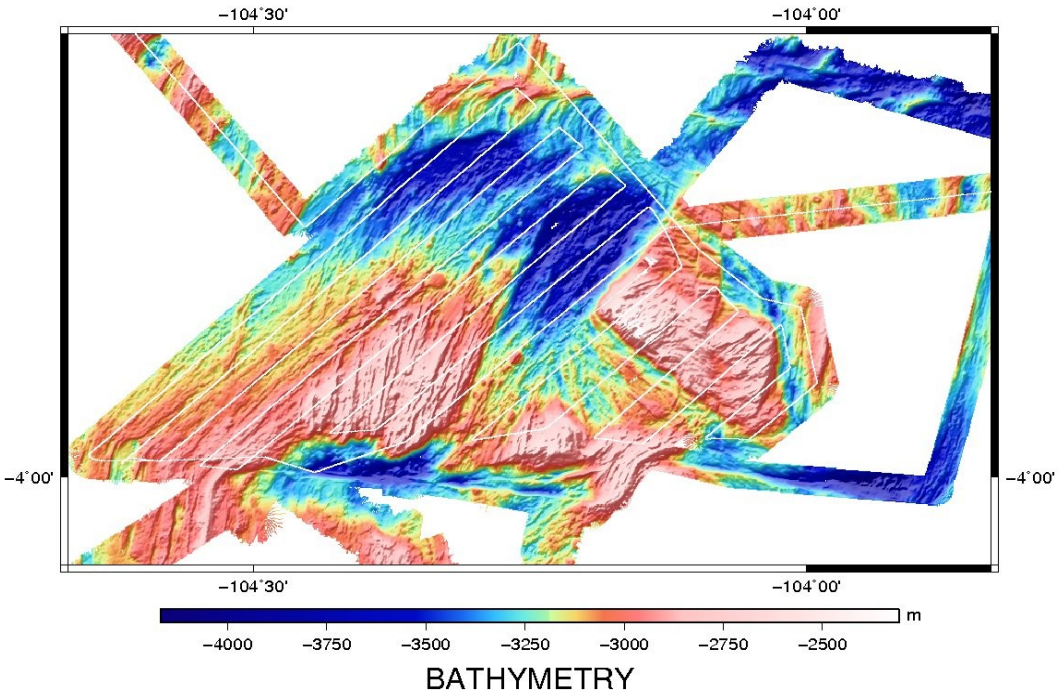

Figure 11. Bathymetry and track lines of the potential microplate north of the Discovery Transform Fault.

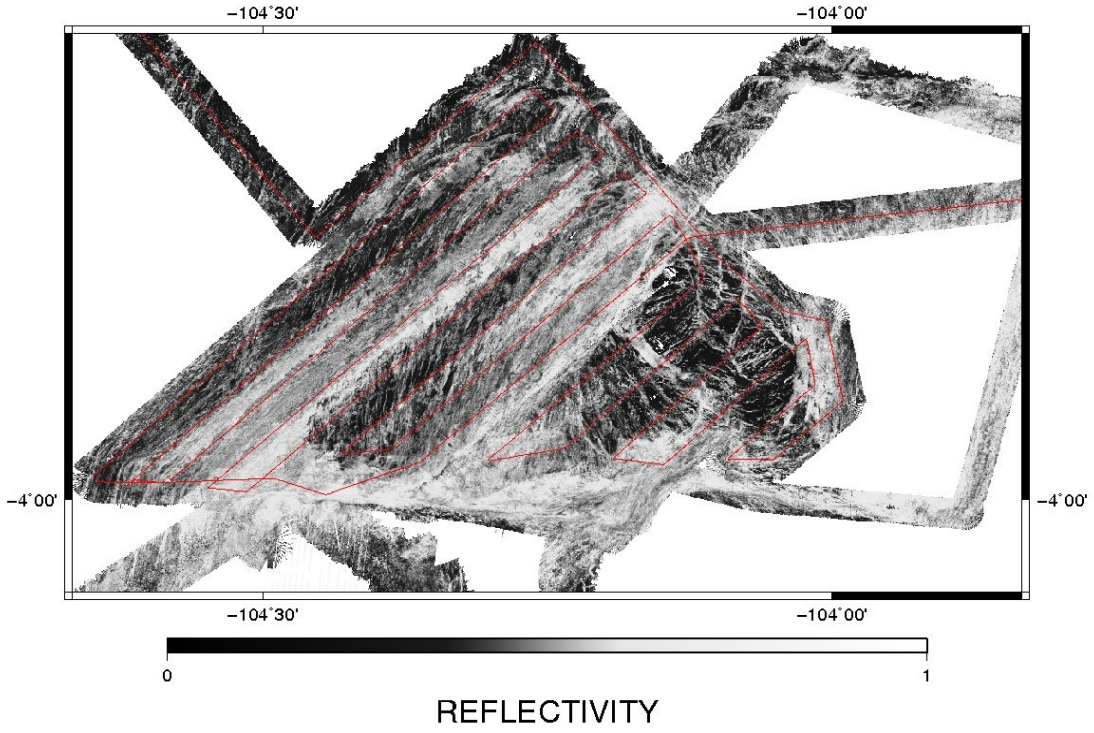

Figure 12. Backscatter for the region in figure 11.

Log:

12/15/2007

08:00 Depart San Diego

12/16/2007

Transit South

12/17/2007

08:30 On-deck 8242 Release test started.
08:40 Release S/N 13653 had typo in enable code; correct value is 470246
-Note the response pings are 2 sec apart before releasing anchor and 1 sec apart after release.
09:20 Acoustic Release Rosette in water. Lat 22 57.5614' Lon 114 17.78', Water depth 3886
09:20-11:00 Rosette lowered into water at ~60 m/min. Comms worked at shallow depth.
-Hull xducer acoustics is fine at 2000 m depth; not fine at 2700 m;
11:00 Rosette test completed with over the side xducer, all working.
-Had to turn DP off
-clearest replies are 14748, 14165, 14160, 14150, 14125, 14143;
-weakest replies are 13653, 14148; Decision is to not use 14148;
11:00-1:00 Tried ship xducers again, more success with the main Knudsen xducer
1:00 Started pulling up the rosette.

12/18/2007

Transit South

12/19/2007

Transit South

12/20/2007

Transit South

12/21/2007

Transit South

12/22/2007

Transit South

12/23/2007

20:01 UTC	On Station OBS1 (S73, G01) In DP at -4 26.996, -106 15.601
20:06:11	Release OBS
20:16:06	Range 431 m
20:21:33	Range 668 m
20:35:15	Range 1278 m
21:22:00	On bottom Fall Rate ~45 m/min
21:27:58	Start Survey at 4 knots
22:38:25	End Survey and Disable OBS
22:43:06	Depart Station

23:39 UTC	On Station OBS2 (S72, G02) In DP at -4 32.76, -106 11.88
23:52:01	Release OB
23:13:17	Range 965 m
23:14:17	Range 1101 m
23:37:28	Range 2056 m
01:00:50	On bottom Fall Rate ~40 m/min
01:06:35	Start Survey at 4 knots

12/24/2007

03:07 UTC	On Station OBS3 (S70,G03) In DP at -4 36.98 S, -106 09.00 W
03:08:47	Release OB
03:18:20	Range 431 m
03:20:05	Range 507 m
03:24:55	Range 723 m
03:47:11	Range 1717 m
04:21:00	On Bottom, Fall Rate ~ 44 m/min

04:25:00 Begin Survey
05:05:00 UPGRADED SURVEY SPEED to 5 knots, worked fine.
05:35:00 End Survey TOTAL ON STATION TIME 2.5 HOURS
05:39:00 Depart to Station OBS4

06:13:00 On Station OBS4 (S82,G04) In DP at -4 33.332 S, -106 7.5695 W
06:23:21 Release FIRST KECK OBS
06:37:13 Range 532 m
07:14:05 Range 1094 m
07:47:37 On Bottom, Fall Rate ~ 38 m/min
07:51:24 Begin Survey
08:58:00 End Survey TOTAL ON STATION TIME 2:45

09:00:00-15:52:00 Multibeam Survey of the Gofar fracture zone
15:30:00 Approximate time of 4th XBT launch by Tony

15:52:00 On site for OBS5 (2nd Keck).
16:15:00 Trouble with 12.5 kHz reply frequency at the beginning of the drop, much noisier than previous obs reply frequency.
18:42:00 Finished Survey TOTAL ON STATION TIME 3 HOURS

19:27:00 On Station for OBS6 (3rd Keck, S85, G06) In DP at -4 34.0952, -106 02.2290
19:32:50 Release OBS
19:37:37 Range 186 m
19:39:22 Range 246 m
19:40:52 Range 321 m
19:43:23 Range 412 m
21:06:48 On Bottom, Fall Rate ~ 40 m/min
21:10:30 Begin Survey – Through waypoints, 4-5 knots
22:15:00 End Survey
22:18:04 Disengage Instruments, Depart Station G06
22:20:00 done with obs6 TOTAL ON STATION TIME 3 HOURS

23:18:00 On Station for OBS7 (4th Keck, S86, G07) in DP at -04 39.5305, -105 58.0266
23:23:55 Release OBS
23:06:94 Range 726
23:44:02 Range 763
23:46:47 Range 867
00:48:16 On Bottom, Fall Rate ~ 40 m/min
00:53:50 Begin Survey – Through waypoints, 4-5 knots
01:57:00 End Survey

02:00:01 Disengage Instruments, Depart Station G07
02:10:00 done with obs7 TOTAL ON STATION TIME 3 HOURS

12/25/2007

02:42:42 On Station for OBS8 (5th Keck, S88, G08) in DP at 04 35.8065 S, 105 56.8765 W
02:45:29 Release OBS
03:01:27 Range 638 m
04:10:26 On Bottom, Fall Rate ~ 40m/min
04:13:00 Begin Survey – through waypoints, 4.5-5 knots
05:25:00 End Survey
05:25:00 Disengage Instruments, Depart Station G08
05:26:00 Done with OBS8 TOTAL STATION TIME 2:45
06:16:10 On Station for OBS9 (6th Keck, S84, G09) in DP at 04 30.2323 S, 105 54.5827 W
06:17:56 Release OBS
06:40:30 Range 873 m
07:21:32 Range 2486 m
07:42:43 On Bottom, Fall Rate ~ 39 m/min
07:45:52 Begin Survey; through waypoints, 4.5-5 knots
08:52:36 End Survey
08:53:00 Disengage Instruments, Depart Station G09
08:53:00 Done with OBS9 TOTAL STATION TIME 2:38
08:54:00 Multibeam mapping leg #2, ETA OBS10 12/25/2007 16:00 UTC

15:05:00 On Station for OBS10 (7th Keck, S83, G10) at -04 35.6178, -105 52.0138
15:08:26 Release OBS
15:13:36 Range 179
15:17:03 Range 314
15:30:34 Range 850
16:37:07 On Bottom , Fall Rate~38m/min
16:38:00 Begin Survey, through waypoints, 4.5-5 knots
17:47:47 Disengage Instrument, Depart Station G10
17:47:47 Done with OBS10 TOTAL STATION TIME 2:47

18:35:05 On Station for OBS11(4th NSF, S46, G11) at -04 37.1987 -105 47.5602
18:37:28 Release OBS
18:41:05 Range 164
18:42:50 Range 239
18:46:21 Range 386
19:55:38 On Bottom, Fall Rate ~

19:56:52 Begin Survey, through waypoints, 4.5-5 knots
21:06:38 Disengage Instrument, Depart Station G11
21:06:38 Done with OBS11 TOTAL STATION TIME 2:30

21:53:11 On Station for OBS12 (5th NSF, S65, G12) at -04 40.6258 -105 47.9532
21:54:25 Release OBS
21:58:29 Range 179
21:58:49 Range 201
22:00:16 Range 272
22:01:16 Range 306
23:05:29 On Bottom, Fall Rate ~
23:11:09 Begin Survey, through waypoints, **This was done at 5.5 knots**, 1km max dist.
00:05:18 Disengage Instrument, Depart Station G12
00:05:18 Done with OBS12 TOTAL STATION TIME 2:15

12/26/2007

01:24:55 On Station for OBS13 (6th NSF, S14, G13) at -04 32.4005, -105 42.3052
01:28:37 Release OBS
01:37:58 Range 400
01:39:58 Range 485
01:41:48 Range 564
01:44:48 Range 691
02:51:06 On Bottom, Fall Rate ~38 m/min
02:53:48 Begin Survey, through waypoints, 4.5-5 knots, 1km max dist.
03:46:17 Disengage Instrument, Depart Station G13
03:48:20 Done with OBS13 TOTAL STATION TIME 2:24
04:28:23 On Station for OBS14 (7th NSF, S37, G14) at -04 36.3631 S, -104 42.1834 W
04:29:12 Release OBS
04:58:45 Range 1196 m
06:08:15 On Bottom, Fall Rate ~ 40 m/min
06:09:40 Begin Survey, through waypoints, 4.5-5 knots, 1 km dist.
07:11:00 Disengage Instrument, Depart Station G14
07:14:00 Done with OBS14 TOTAL STATION TIME 2:46
07:14:00 Multibeam leg, ETA OBS15 @ 15:00 UTC
14:58:50 On Station for OBS15 (S30, G15) at -04 39.4448, -105 36.00?
15:06:21 Release OBS
15:09:44 Range 146
15:10:19 Range 172

15:15:40 Range 396
15:20:01 Range 581
16:26:15 On Bottom, Fall Rate ~38 m/min
16:30:00 Begin Survey, through waypoints, 4.5-5 knots, 1km max dist.
17:35:00 Disengage Instrument, Depart Station G15
17:35:00 Done with OBS15 TOTAL STATION TIME 2:36

18:07:35 On Station for OBS16 (S74, G16) at -043.0213, -105 35.1046?
18:15:13 Release OBS
18:22:19 Range 318
18:22:59 Range 356
18:26:44 Range 521
18:44:38 Range 1328
19:21:50 On Bottom, Fall Rate ~35 m/min
19:25:05 Begin Survey, through waypoints, 4.5-5 knots, 1km max dist.
20:25:10 Disengage Instrument
20:31:52 Depart Station G16, Done with OBS16 TOTAL STATION TIME 2:25

20:31:52 Begin Transit to Geodesy Array -

12/27/2007

08:20:57 P5 Drop at 3 59.9133, 104 27.1143 3365 m water depth
09:22:00 P5 Disabled
09:38:00 P4 Drop at 3 59.6702, 104 26.6176 3576 m water depth
10:44:00 P4 Disabled
10:56:00 P2 Drop 3 59.7023 104 26.2827 3619m
12:00:00 P2 Disabled
12:00 C1 TURNED ON! FIRST PING AT 22:00 (2 am pacific).
12:00 TRIPOD DROP RATES ARE ONLY ABOUT 60 m/s this time compared with 80 m/s in Kilauea? All that's different is the bottom angle/spring piece and the fact that the anchor can't swivel.
12:17:28 P1 Drop at 03 59.3645, 104 26.0853 3613
13:00 C2 TURNED ON! First Ping at 23:00 (3 am Pacific).
13:18 P1 Disabled
13:37:34 P3 Drop at 3 59.2960 104 26.5156 3537m
14:37:20 P3 Disabled

14:54:05 C1 Dropped at 03 59.5598, 104 26.3703, 3620m
15:55:00 C1 Disabled
16:09:44 C2 Drop at 03 59.8188 104.268348 3430
17:10? C2 Disabled.

17:35:00 On Station for OBS 24 (S87, D01) at -04 00.5064, -104 25.2064
17:38:22 Release OBS
17:39:00 Too tired for Recording Ranging
19:02:00 On Bottom
19:04:00 Begin Survey, through waypoints, 4.5-5 knots, 1km max dist.
20:02:10 Disengage Instrument
20:31:52 Depart Station D01, Done with OBS24 TOTAL STATION TIME 3:00

20:57:50 On Station for OBS17 (S81, D02) at -03 55.8003, -104 29.9952
21:00:05 Release OBS
21:03:37 Range 126
21:04:22 Range 156
21:05:53 Range 218
21:07:14 Range 268
On Bottom, Fall Rate ~35 m/min
Begin Survey, through waypoints, 4.5-5 knots, 1km max dist.
Disengage Instrument
Depart Station D02, Done with OBS17 TOTAL STATION TIME

12/28/2007

00:18:34 On Station for OBS23 (S89,D03) at -4 2.4000 S, -104 29.4137 W, 3042m
00:19:59 Release OBS
00:27:02 Range 271 m
00:32:13 Range 465 m
01:39:17 On Bottom, Fall Rate ~ 38 m/min
01:43:00 Begin Survey, through waypoints, 4.5-5 knots, 1km dist
02:34:00 Disengage instrument
02:34:00 End Survey, Depart Station D03 TOTAL STATION TIME 2:19
03:53:50 On Station for OBS22 (S71,D04) at -4 3.5995 S, 0104 20.9970 W, 3128 m
03:54:53 Release OBS
04:17:00 Range 998 m
04:38:00 Range 1999 m

05:03:00 On Bottom, 3147 m, Fall Rate ~ 46 m/min
05:07:00 Begin Survey, through waypoints, 4.5-5 knots, 1km dist
06:03:00 End Survey
06:04:00 Disengage instrument
06:04:00 End Survey, Depart Station D04 TOTAL STATION TIME 2:10
06:04:00 Begin Multibeam leg, ETA @ OBS21 15:00 UTC (7AM local)

16:06:24 On Station for OBS21 (S67, D05) at -4 05.4119, -104 13.6248 W, 3107 m
16:17:42 Release OBS
16:11:16 Range 160 m
16:15:06 Range 325 m
16:25:06 Range 761 m
16:38:47 Range 1350 m
17:18:30 On Bottom, 3147 m, Fall Rate ~ 43 m/min
17:20:00 Begin Survey, through waypoints, 4.5-5 knots, 1km dist
18:15:00 End Survey, Disengage instrument
18:18:50 Depart Station D05 TOTAL STATION TIME 2:12

19:32:00 On Station for OBS22 (S66, D06) at -03 55.7863, -104 12.0023 W, 3225 m
19:34:32 Release OBS
19:36:41 Range 110 m
19:39:01 Range 210 m
19:44:21 Range 440 m
19:51:22 Range 750 m
20:48:45 On Bottom, 3259 m, Fall Rate ~ 43 m/min
20:56:05 Begin Survey, through waypoints, 4.5-5 knots, 1km dist
21:50:07 End Survey, Disengage instrument
21:52:45 Depart Station D06 TOTAL STATION TIME 2:20

22:40:45 On Station for OBS21 (S68, D07) at -04 00.2970, -104 16.6896 W, 3246 m
22:42:29 Release OBS
22:43:53 Range 112 m
22:45:38 Range 142 m
22:47:48 Range 214 m
22:48:50 Range 274 m
23:56:44 On Bottom, 3255 m, Fall Rate ~ 45 m/min
23:59;14 Begin Survey, through waypoints, 4.5-5 knots, 1km dist
End Survey, Disengage instrument
Depart Station D07 TOTAL STATION TIME

12/29/2007

10:30:00	On Station C1 to upload Data files
10:50:00	Started Data upload; MODEM ADDRESSES ARE SWITCHED!!
	C1 HAS BOTTEM MODEM ADDRESS 2 and C2 HAS BOTTEM MODEM 1
	C1 can see P1, P3, and P4; C1 cannot see P2; P3 linked up 12 hours after initial try.
12:45:00	Started Suvery of C1 because we had time to kill until after C2's next measurement cycle
14:00	Modem to C2, no data files written yet. Can't see P4 or P5.
16:04:00	Starting Survey of P4
17:07:00	Survey of P4 finished; both disable commands sent;
17:18:40	C2 Release Command Successful
17:46:56	Rise rate ~32 m/min.
19:08:26	C2 Sited on surface: SURFACED ON ITS SIDE? mast submerged horizontally
19:18:00	C2 On board
19:30:00	P5 Release Command Sent Succesfully
20:48:56	P5 On Surface, all 3 legs in air.
20:59:40	P5 on Deck
21:24:15	P2 Release Command successful
22:58:00	P2 On Deck, surfaced with all 3 legs up out of water.
23:00:00	C2 TURNED BACK ON, 1st Range Expected at 09:00:00 UTC on 12/30 = 1 a.m.

12/30/2007

23:56:46	C2 SECOND Drop at 03 59.7503 104 26.6817, 3533m
00:50:44	On Bottom 3512m
00:53:15	C2 Survey started
01:56:55	Disabled
02:49:00	P5 Second Drop at 03 59.4275, 104 26.8576 3450m
03:49:49	P5 on bottom. Acoustics deteriorated once instrument hit ~3421m.
03:52:30	P5 Disabled

04:38:00 Back at C2 to do modem work;
did mmt_wint to force synch with both P4 and P5; Both Completed Successfully;
P4 Time delay .250600; P5 Time delay 0.9662; DID NOT WRITE DATA1.DAT
File to harddrive after successfully completing the mmt_wint command like the linkquest documentation says it should.

05:27:00 P2 Second Drop at 03 59.7180, 104 26.535, 3580m
06:29:00 P2 Disabled 15-two second beeps.

06:44:00 Start survey P3
07:40:00 End Survey P3; Both disable Commands sent

08:00:00-16:00 Multibeam/Transit between Discovery and Quebrada Faults

16:00:00 On site at OBS25-Q1

19:05:00 On Site at OBS26-Q2

12/31/2007

02:35:27 On Station for OBS28 (D58,Q04) at -3 46.2026 S, -104 36.4883 W, 3326 m
02:38:30 Release OBS
02:51:33 Range 768 m
02:50:47 Range 1173 m
03:35:50 On Bottom, 3331 m, Fall Rate ~56 m/min
OBS only replied to ~50% pings on its way down
03:39:00 Begin Survey, through waypoints, 4.5-5 knots, 1.25 km distance
04:50:00 End Survey, disable instrument
First disable attempt poorly communicated with ~12 messy beeps
After stopping ship, 2nd disable attempt produced 15 clear two-second beeps
04:57:00 Depart Station Q04 TOTAL STATION TIME 2:22
05:59:00 On Station for OBS30 (D56,Q05) at -3 41.9981 S, -103 31.0086 W, 3616 m
06:05:0 Release OBS
06:10:41 Range 325 m
06:21:48 Range 1007 m
06:40:00 Range 2083 m
07:06:00 On Bottom, 3645 m, Fall Rate ~ 60 m/min
07:07:00 Begin Survey, through waypoints, 4.5-5 knots, 1.25 km distance
08:16:00 End Survey, disable instrument

	15 clear two-second beeps
08:17:00	Depart Station Q05 TOTAL STATION TIME 2:18
08:17:00	Multibeam/Travel to Geodesy Station C1, ETA ~ 8:30 AM local, 16:30 UTC

Geodesy Surveys already done
-P3; C2 drop 2 (new Geo8); C1 (original drop); P4 original drop;

Geodesy SURVEYS LEFT TO BE DONE?
-New P2 WAYPOINT NEWGEO10
-New P5 WAYPOINT New Geo9
-Original P1 WAYPOINT NewGeo4

16:38:00	On site for C1 Comm Channel Good Data1.dat 537kb written at 12-30-07 12:04 pm Data2.dat 311 kb written at 12-31-07 04:10 pm
16:45	started data2.dat upload but didn't work
16:45-18:27	Pretty much wasted this entire time trying to get the acoustics for the modem to work well enough for the hpmgs_ld command to upload a data file. But the reason it wasn't working was actually not the acoustics but a wrong command in the linkquest manual. Unlike other commands, the hpmgs_ld command works when the transceiver is in LQC mode. So quitting procomm directly from LQC prompt (as opposed to doing gocom1) fixed this problem.
18:27	Started to upload data file
18:50	Talking to C1 from C2 waypoint, comms good.
18:52-19:07	Upload data2.dat 311kb/15 min = 20 kb/min in 3700m water.
19:08-19:37	Upload data1.dat 537kb/19 min = 28 kb/min in 3700 m water.
19:40:00	All Transceiver-Transponder links appear to be working. Nominal Separations are: C2-P5 708m C2-P4 172m C1-P2 304m C1-P1 642m C1-P3 518m C1-P4 316m C1 and C2 left in data collection mode. We are happy with the geometry, best guess from the bathymetry is that the ridge is actually the fault and that the array covers the fault. All that is left is to Survey P2, P5, P1.
20:0?	Started Survey of P2

21:20	Start survey of P5. Very difficult acoustics, got only minimal # of good ranges when making the 1.25 km diamond around the station. So we did a bunch of drifting and repositioning until we had good azimuthal coverage.
23:40	P5 release disabled, heard 11 of 15 pings (2 second spacing). No response when ranging.

01/01/2007

	Survey of P1 - Not in site log?
04:00?-23:00	Multibeamed south of Quebrada to catch seamounts
23:21:20	On Station for OBS29 (NSF, S19, Q06) at 03 50.3725 S; 103 33.0205 W; ~2970 m
23:22:25	Deploy OBS

01/02/2007

00:32:36	OBS29 on bottom, 2984 m. Fall rate ~42 m/min
00:35:29	Start Survey, through waypoints, 4.5-5 knots, radius 1 km
01:33:00	OBS29 Disabled
01:34:00	Depart site Q06 – TOTAL STATION TIME 2:13
04:57:00	On Station for OBS32 (S28,Q07) at 103 0.0041 W, 3 46.1933 S, ~3890 m
04:58:00	Deploy OBS
05:22:00	Range 998 m
05:46:00	Range 2015 m
06:32:00	On Bottom, 3925 m, Fall rate ~ 42m/min
06:35:00	Begin survey, through waypoints, 4.5-5 knots, radius 1 km
07:32:00	OBS32/S28 disabled, 7 clear two-second beeps; end survey
07:34:00	Depart Station Q07 – TOTAL STATION TIME 3:37 Survey/Multibeam western Quebrada, ETA OBS? site G08 7 AM
14:57:08	On Station for OBS?? (S01,G08) at 104 1.1987 W, 3 39.2379 S, 3053 m
15:18:35	Deploy OBS
16:01:46	Range 1829 m
16:15:02	Range 2386 m
16:30:48	On Bottom, 3052 m, Fall rate ~ 42 m/min
16:33:50	Begin Survey, through waypoints, 4.5-5 knots, 1 km radius
17:35:35	OBS??/S01 Disabled, 7 two-second beeps; end survey

17:37:18	Depart Station G08 – TOTAL STATION TIME 2:40
19:05:00	On Station for OBS?? (S20, G09) at 102 51.3055 W, 3 41.0377 S, ~3300 m
19:06:19	Deploy OBS
20:27:16	On bottom, 3325 m, fall rate ~ 41 m/min
20:31:52	Begin survey, through waypoints, 4.5-5 knots, 1 km radius
21:28:07	OBS??/S20 disabled, 7 two-second beeps; end survey
21:30:38	Depart Station Q09 – TOTAL STATION TIME 2:25
22:44:33	On Station for OBS40 (S33,Q10) at 102 42.9038 W, 3 42.7226 S, ~3400 m
22:46:00	Deploy OBS
00:08:05	On Bottom, 3360 m, fall rate ~ 40 m/min
00:08:05	Begin survey, through waypoints, 4.5-5 knots, 1 km radius
01:00:18	OBS40/S33 disabled, 7 two-second beeps; end survey
01:08:24	Depart Station Q10 – TOTAL STATION TIME 2:24
01:51:53	On Station for OBS39 (S48,Q11) at 102 47.4068 w, 3 48.6000 S, ~3352 m
01:53:07	Deploy OBS
03:13:17	On Bottom, 3366 m, fall rate ~ 41.5 m /min
03:16:14	Begin survey, through waypoints, 4.5-5 knots, 1 km radius
04:12:00	OBS39/S48 disabled, 7 two-second beeps; end survey
04:24:00	Depart Station Q11 – TOTAL STATION TIME 2:32
	Survey/Multibeam eastern Quebrada fracture zone, ETA P12 @ 15:00 UTC (7 AM)

01/03/2008

More Quebrada OBS deplyments

01/04/2008

More Quebrada OBS deployments

01/05/2008

Multibeam survey of the Quebrada Transfrom Fault

01/06/2008

Multibeam Survey of the nanoplate north of Discovery Transform

01/07/2008

Multibeam Survey of the nanoplate north of Discovery Transform

01/08/2008

Headed for Home at 6:15 a.m. PST!

01/09/2008

transit

01/10/2008

transit

01/11/2008

transit

01/12/2008

transit

01/13/2008

transit

01/14/2008

transit

01/15/2008

transit

01/16/2008

arrive SD.

01/17/2008