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M E M O R A N D U M

TO: Dr. Arthur E. Maxwell  
FROM: Yosio Nakamura *YN*  
SUBJECT: Cruise Report, Coriolis EVA-XIII

Three members of the Institute for Geophysics participated in the N/O *Coriolis* cruise EVA-XIII, which took place on August 20 through September 26, 1986, in the south Pacific, a cruise organized by Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) of France. The purpose of the cruise was to acquire both passive (microearthquake) and active (large-offset air-gun) seismic data using ocean-bottom seismographs (OBS) at selected areas in the New Hebrides island arc. Although our primary and official purpose of participating in the cruise was to field-test our digital OBS's for detecting and recording real earthquake signals, we were also very heavily involved in all phases of the cruise including the active seismic experiment.

The passive part of the experiment was conducted to study in detail the occurrence of microearthquakes in the subducting slab east of the South New Hebrides trench, Fig. 1. During the cruise, we first deployed 13 OBS's (6 analog and 7 digital, of which 6 digital OBS's were UT instrument) for a period of 30 days, recovered and examined all but one of them, and redeployed 12 OBS's (6 analog and 6 digital, of which 5 digitals were UT's) for another 22 days. (The latter 12 OBS's were recovered last week from N/O *Vauban*.)

The two overlapping arrays covered an area approximately 60 km in diameter, Fig. 1 and Table 1, and were located over a suspected seismic asperity. More than 1000 earthquakes were detected and recorded by the first array, see Table 2. Figure 2 shows a sample seismogram from our digital OBS in a compressed time scale.

The active part of the experiment covered three areas in the back-arc region, Fig. 1: (A) *Vot Tande* trough in the northern New Hebrides: Three 111-km lines (Lines 1, 2 and 3) were shot in the area with 5 OBS's on each line. This area was chosen to represent an area in the northern New Hebrides comparable in bathymetry to the *Coriolis* trough, below. (B) *North Aoba* basin in the central New Hebrides: Two 60-km lines (Lines 4 and 5) were shot within the basin with 4 OBS's on Line 4 and a single OBS on Line 5 (additional data being available for this line from an earlier experiment). This basin is located on the eastern extension of

the d'Entrecasteau ridge, which collides with the New Hebrides arc. (C) Coriolis trough in the southern New Hebrides: Three 111-km lines (Lines 6, 7 and 8) were shot in the area with 4 to 5 OBS's on each line. This area is directly behind the asperity over which the earthquake arrays were set up and represents a rather complicated structure involving old and new volcanic chains and a trough.

We used only digital OBS's for the active experiment in essentially the same way as our past experiments in the Gulf of Mexico. Either one 1000-in<sup>3</sup> air gun fired at 50-second intervals or two 1000-in<sup>3</sup> guns fired at 100-second intervals served as sound sources. Of 35 OBS's deployed during this part of the experiment, 22 were ORSTOM's and remaining 13 were ours. Table 3 gives the locations of the OBS's and summarizes their performance.

The cruise was generally successful, although we have noted several areas where improvements are need. I list below some observations, first positive ones, and then some negative ones:

- (1) This was the first time UT's digital OBS's worked for detecting and recording earthquake signals in a real field experiment.
- (2) The presence of UT personnel on board was very helpful, and probably was essential, to conducting the large-offset active seismic experiment, although our participation in this part of the cruise was not official. Our past experience in this area greatly helped the French, who had no prior experience with digital OBS's.
- (3) We received tremendous support from ORSTOM, including all the expenses on board N/O Coriolis and free lodging on the ORSTOM campus. Both ORSTOM personnel and the crew of N/O Coriolis were extremely helpful to us in all occasions.
- (4) The cruise schedule was very tight, but everyone worked hard to accomplish what we planned, with time to spare for occasional champagne toasts. The personnel in charge of OBS preparation, deployment and recovery (McPherson, Hello and Pontoise) worked especially hard, often with very little sleep.
- (5) The living accommodation on board was excellent, but the lab space where we prepared OBS's was not. It was a wet lab, and it really was too wet for OBS preparation. This condition seems to have contributed to deterioration of some of our most reliable OBS's.
- (6) There was no general-purpose computer on board. Practically all processing of acquired OBS data was done on a Macintosh. It was very slow, but did generate some usable record sections during the cruise.
- (7) Although the earthquake detection algorithm generally worked very well, the detection sensitivity was reduced when there was a finite dc offset on the signal. This problem can be avoided with a software revision.
- (8) The most serious problem with our earthquake OBS's is their tendency not to pull the tape when equipped with fresh batteries and after being dormant for an extended time in cold temperature. Many

detected events were not recorded on tape because of this problem. We have not yet found a satisfactory solution to this problem.

- (9) We lost two digital OBS's: one ORSTOM unit early in the active seismic experiment, and one UT unit in the first earthquake array. For each of them, a brand new sphere was used. Are there any convenient way to test new spheres before we use them in the field?

The scientific party consisted of the following:

ORSTOM:

Rémy Louat	Chief Scientist
Bernard Pontoise	Geophysicist
Philippe Charvis	Geophysicist - Navigation
Yann Hello	Electronics Technician
Yvon Penneau	Air-gun/Compressor Engineer
Pascal Michaux	Air-gun/Compressor Technician
Alain Grzesczyk	Geologist - Navigation (leg 1 only)
Patrick Rigolot	Geologist - Navigation (leg 2 only)
Roger Foy	Field Technician - Navigation (leg 1 only)

UTIG:

Yosio Nakamura	Co-Chief Scientist
Cliff Frohlich	Seismologist - Navigation (leg 2 only)
Paul McPherson	Electronics Technician

A chronological narrative follows (all times are local):

12 August

12:45 McPherson and Nakamura arrived at Noumea, New Caledonia

13-18 August - OBS testing and preparation

19 August

10:15-11:15 Started earthquake OBS clocks

20 August

14:15 Sailed from Noumea

21 August

10:15 Started earthquake OBS array 1 deployment

22 August

15:01 Completed earthquake OBS array 1 deployment

23 August -

Bathymetric and magnetic profiling

24 August

11:55 Array 1 OBS's activated (day 236, 00:55 GMT)

13:32-23:07 10 air-gun shots to locate and calibrate earthquake OBS's

25 August -

Transit

26 August -

Bathymetric and magnetic profiling while waiting to repair EPROM programmer

27 August

22:33-05:16 Line 1 OBS deployment

28 August

09:00-00:00 Line 1 shooting

29 August

01:56-09:33 Line 1 OBS recovery

22:32-04:31 Line 2 OBS deployment

30 August

09:00-00:00 Line 2 shooting

31 August  
 01:49-09:02 Line 2 OBS recovery  
1 September  
 22:32-04:34 Line 3 OBS deployment (delayed because of bad weather)  
2 September  
 09:00-00:00 Line 3 shooting  
3 September  
 01:05-09:10 Line 3 OBS recovery  
4 September  
 16:00 Arrived at Luganville, Santo, Vanuatu  
5 September - in Luganville port  
6 September  
 08:00 Frohlich flew in from Austin  
7 September  
 15:45 Sailed out of Luganville  
 20:36-01:05 Line 4 OBS deployment  
8 September  
 03:30-20:00 Line 4 shooting  
 21:05-02:47 Line 4 OBS recovery  
9 September  
 06:56 Line 5 OBS deployment  
 09:30-~~17:30~~<sup>02:00</sup> Line 5 shooting  
10 September  
 03:38 Line 5 OBS recovery  
11 September  
 11:30-17:00 Anchored at Aniwa for OBS preparation  
 20:42-01:55 Line 6 OBS deployment  
12 September  
 05:00-20:00 Line 6 shooting  
 21:37-04:03 Line 6 OBS recovery  
13 September  
 06:00-17:00 Anchored at Anatom for OBS preparation  
 20:32-01:48 Line 7 OBS deployment  
14 September  
 05:00-20:00 Line 7 shooting  
 22:07-04:17 Line 7 OBS recovery  
15 September  
 06:00-16:00 Anchored at Futuna for OBS preparation  
 21:20-01:13 Line 6 reshoot OBS deployment  
16 September  
 05:00-20:00 Line 6 reshoot  
 21:40-02:47 Line 6 reshoot OBS recovery  
17 September  
 06:00-16:00 Anchored at Futuna for OBS preparation  
 20:15-02:15 Line 8 OBS deployment  
18 September  
 05:30-20:00 Line 8 shooting  
 21:29-04:34 Line 8 OBS recovery  
19 September  
 18:21 Started earthquake OBS array 1 recovery  
20 September  
 19:50 Completed earthquake OBS array 1 recovery  
21-22 September - Anchored at Tanna for OBS preparation

23 September  
 12:04 Started earthquake OBS array 2 deployment  
24 September  
 11:04 Completed earthquake OBS array 2 deployment  
25 September  
 00:01 Array 2 OBS's activated (day 267, 13:01 GMT)  
 00:28-16:22 9 air-gun shots to locate and calibrate earthquake OBS's  
26 September  
 13:00 N/O *Coriolis* returned to Noumea  
27 September - 1 October - Post-cruise data processing  
2 October  
 23:00 Nakamura left Noumea [Frohlich and McPherson remained in  
 Noumea for recovery of the second-array OBS's later]

Our next task will be to process and analyze these excellent data set. The following are some thoughts about how we approach this task:

- (1) Without Loran-C, the navigation was much more difficult than in the Gulf of Mexico. Rémy Louat of ORSTOM is now processing the satellite navigation data from a Magnavox, which will be available to us soon.
- (2) The first step in the processing of the digital OBS data, namely to transfer the data from digital cartridge tapes to 9-track computer tapes, has been completed using the PDP-11/34 on board R/V *Fred H. Moore* in Galveston.
- (3) The earthquake data can be processed and analyzed with relatively little computer cost. Cliff and I will work on these as quickly as we can.
- (4) The processing of the air-gun data requires more extensive use of a computer facility.
- (5) Currently, ORSTOM has no capability to properly process the digital OBS data. [They are trying to build up this capability, but it will take a while.] Jacques Recy of ORSTOM has asked us if he can send a scientist [most likely Philippe Charvis] early next year to work with us to process and analyze the air-gun seismic data on our VAX computer. Considering their excellent cooperation with us in the past and the big support they gave us during this cruise, can we give them a free access to our VAX for two to three months? I estimate it would require about \$10K of soft-money account.
- (6) Although the active (air-gun) part of the experiment was not on our original plan, our involvement in acquiring this data set was quite extensive. I believe that we should be fully involved in analyzing the data and publishing the results. I think we should try to get an NSF support to do this. We need to write a proposal addressing some very exciting aspects of the study. Kevin MacKenzie has expressed some interest.

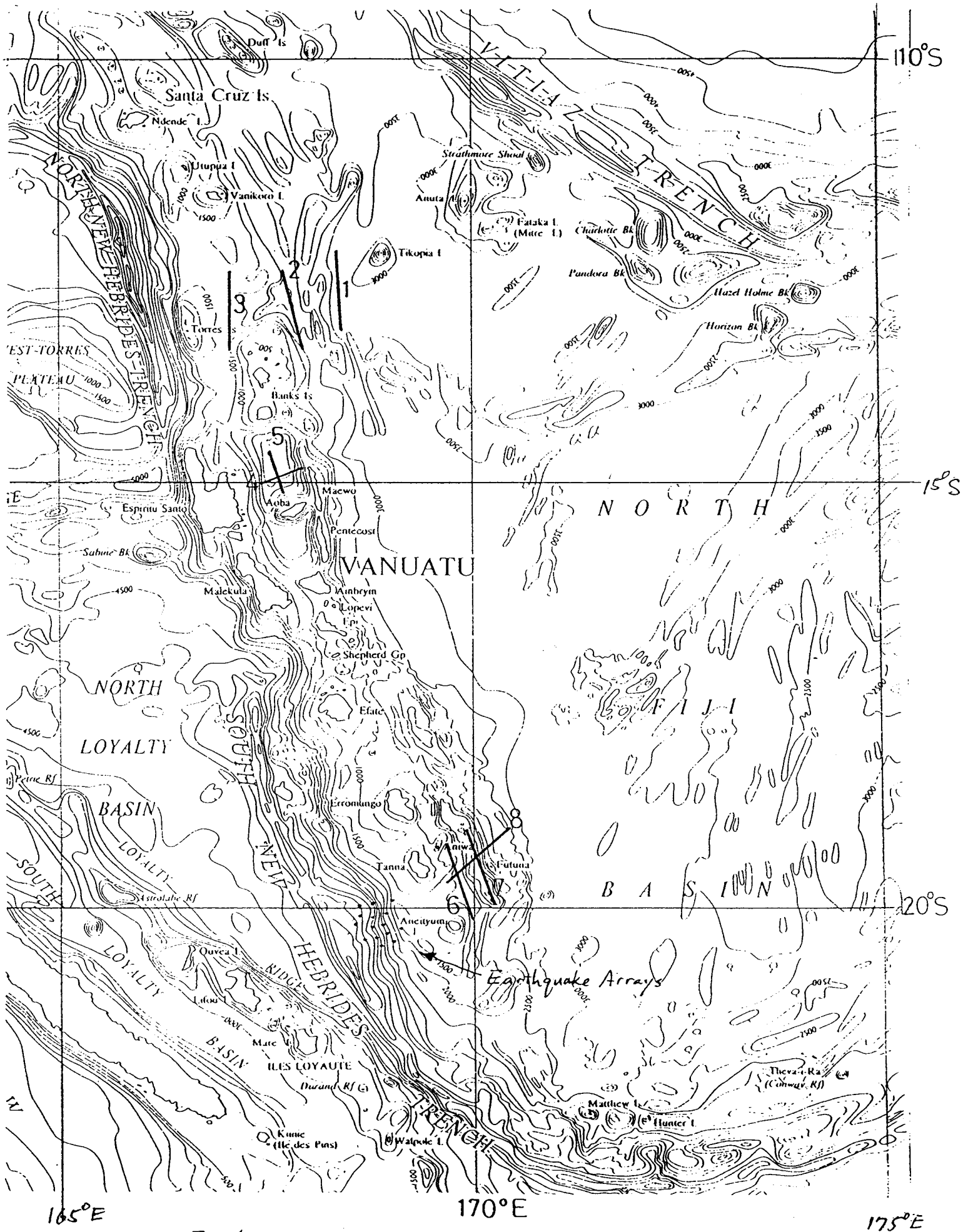


Fig. 1.

Table 1. Earthquake OBS array stations

Sta.	Unit*	Latitude,S	Longitude,E	Depth,m	Remarks
<u>Array 1</u>					
1	OA	19°58.91'	168°37.71'	5370	tape full in 27 hours
2	OA	19°57.67'	168°45.97'	5110	tape full in 20 hours
3	U-83.1	20°07.06'	168°37.32'	5400	did not return
4	OA	20°08.33'	168°46.52'	4850	not yet processed
5	U-81.4	20°08.33'	168°46.52'	4850	skipped 12 days
6	U-83.4	20°05.00'	168°56.51'	2750	no data
7	OA	20°11.85'	168°33.86'	6400	no data
8	U-81.2	20°14.62'	168°45.61'	5020	skipped recording 6 days
9	OD-3	20°11.07'	168°52.10'	4500	tape full in 13 days
10	U-81.6	20°23.01'	168°39.98'	5850	no data
11	U-84.1	20°20.21'	168°48.52'	5150	27 days of recording
12	OA	20°18.44'	168°56.01'	3800	no data
13	OA	20°27.55'	168°51.00'	5050	tape full in 30 hours
<u>Array 2</u>					
14	U-84.1	19°59.57'	168°37.76'	5450	
15	OA-22	19°58.70'	168°47.21'	5050	
16	U-81.4	19°57.26'	169°00.78'	1500	
17	U-81.3	20°07.33'	168°45.01'	4920	
18	U-81.2	20°05.65'	168°56.52'	2590	
19	OA-F7	20°15.16'	168°45.05'	5110	
20	U-81.6	20°11.67'	168°51.05'	4520	
21	OA-11	20°19.56'	168°47.62'	5130	
22	OA-31	20°18.86'	168°56.60'	3630	
23	OA-30	20°16.45'	169°07.00'	1820	
24	OA-42	20°27.27'	168°50.89'	5030	
25	OD-3	20°25.60'	168°58.51'	3720	

\*OA=ORSTOM analog; OD=ORSTOM digital; U=UTIG digital

Table 2. Number of events detected by earthquake OBS's\*

Station	Total	Single-Station Events	2-Station Events	3-5 Station Events
1	107	41	41	25
2	131	58	50	23
4	not yet processed			
5	274	182	88	4
8	325	152	122	51
9	337	154	115	68
11	242	21	158	63
13	103	64	18	21
Array 1	1048	672	296	80

\*Do not include air-gun events for calibration

Table 3. Line/OBS coordinates (preliminary)

Sta.	OBS*	Comp.**	Latitude,S	Longitude,E	Depth,m	Remarks
<u>Line 1</u>						
End of Line			13°19.8'	168°28.0'		
1	U-81.1	1	13°08.82'	168°27.26'	3190	track 1 early rewind
2	O-4	3	12°59.39'	168°26.91'	3220	water in sphere
3	O-2	1	12°48.98'	168°26.03'	3240	missed many shots
4	O-5	3	12°37.76'	168°24.91'	3400	wrong shot table
5	U-81.3	1	12°28.49'	168°25.06'	?	no H2 data
End of Line			12°18.1'	168°23.2'		
<u>Line 2</u>						
End of Line			13°24.5'	168°01.0'		
1	U-81.1	1	13°15.93'	167°58.67'	2420	
2	O-1	3	13°05.27'	167°55.47'	2920	Did not return
3	O-2	1	12°56.87'	167°52.52'	3280	missed many shots
4	O-5	3	12°47.55'	167°50.22'	3050	
5	U-81.3	1	12°37.44'	167°47.82'	2470	no H2 data
End of Line			12°26.7'	167°43.5'		
<u>Line 3</u>						
End of Line			13°28.9'	167°07.0'		
1	U-81.1	1	13°17.70'	167°08.63'	1685	
2	O-4	3	13°07.50'	167°09.33'	1910	
3	O-2	1	12°59.31'	167°09.49'	1880	missed many shots
4	O-5	3	12°48.47'	167°10.46'	2000	
5	U-81.3	1	12°38.96'	167°11.39'	1980	
End of Line			12°28.7'	167°11.9'		
<u>Line 4</u>						
End of Line			15°07.4'	167°27.3'		
1	U-81.1	1	15°06.42'	167°29.06'	2080	
2	O-4	1	15°02.00'	167°37.01'	3120	writing over track 1
3	O-5	3	14°57.24'	167°45.55'	3150	
4	U-81.3	1	14°52.46'	167°53.62'	2500	
End of Line			14°51.5'	167°55.6'		
<u>Line 5</u>						
End of Line			15°08.4'	167°44.8'		
1	O-5	1	15°06.82'	167°45.14'	3040?	
End of Line			14°39.0'	167°30.1'		
<u>Line 6</u>						
End of Line			19°15.0'	169°43.0'		
1	U-81.1	1	19°24.70'	169°48.46'	1630?	UART leakage to Z
2	O-2	1	19°37.17'	169°53.13'	1900?	
3	O-5	3	19°48.11'	169°58.11'	1640	
4	U-81.3	1	20°01.17'	170°03.44'	1910	track 1 only
End of Line			20°10.6'	170°07.4'		
<u>Line 6 Reshoot</u>						
End of Line			19°15.0'	169°43.0'		
1	O-2	1	19°23.84'	169°46.96'	1610	
4	O-5	1	20°01.34'	170°03.58'	1880	no data
End of Line			20°10.6'	170°07.4'		
<u>Line 7</u>						
End of Line			20°03.5'	170°19.5'		
1	U-81.1	1	19°54.28'	170°15.81'	3200	
2	O-2	1	19°41.37'	170°09.40'	3330?	
3	O-5	3	19°29.09'	170°04.09'	3270	
4	O-4	1	19°16.50'	169°58.07'	2450	writing over track 1
End of Line			19°07.7'	169°53.4'		

Line 8

End of Line			19°08.5'	170°28.1'		
1	U-81.1	1	19°14.81'	170°20.51'	2180	1 shot table only
2	O-4	3	19°22.93'	170°10.92'	1380	
3	O-2	1	19°32.09'	170°01.05'	3220	
4	O-5	3	19°35.85'	169°57.21'	2450	
5	U-81.3	1	19°42.97'	169°46.95'	1830	
End of Line			19°47.3'	169°42.2'		

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\*U=UTIG unit; O=ORSTOM unit

\*\*1=primarily single component with 3 component used at close ranges;

3=3 component