

SERIS

SEISMIC EXPERIMENT ROSS ICE SHELF

Prepared by
Uri ten Brink

February, 1993

PASSCAL Data Report 93-002



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Seismic investigation of the boundary between East and West Antarctica

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Background. The Transantarctic mountain front constitutes the boundary between East and West Antarctica. The continental crust of East Antarctica (on which the Transantarctic Mountains are located) is probably thick and tectonically stable (e.g., Stern and ten Brink, 1989). The adjacent West Antarctica is, on the other hand, underlain by a thin continental crust resulting from episodic extension (rifting) in the past ~70 million years (Cooper et al., 1987). The rise of the Transantarctic Mountain range was accompanied by extension and a gentle asymmetric tilt of strata toward the polar plateau. Thrusting and folding, which characterize mountain ranges of similar size, such as the Andes and the Rocky Mountains, are not observed in the Transantarctic Mountains. Thus, the Transantarctic Mountains are probably the most striking global example of a different category of mountains, the rift-shoulder mountains (e.g. Stern and ten Brink, 1989).

The Seismic Experiment Ross Ice Shelf (SERIS), was carried out by Stanford University and the Geology and Geophysics Division, DSIR, New Zealand, during the austral summer of 1990-91 across the Transantarctic Mountain

Seismic reflection. The seismic sources for the reflection experiment were 5 and 7.5 kilograms explosive charges placed at 200 meter intervals at the bottom of 17-18 meter deep holes in the ice. Shot holes were drilled in the ice by a hose ejecting hot (80° C) water at high pressure. An improved nozzle design saved physical labor, but the drilling rate, 3-5 holes per hour was slower than the rate of acquisition. Several test shots of blasting cord were also fired. Using blasting cord as a potential sound source may save fuel and manpower for drilling, eliminate shot preparation, and increase acquisition rate. Preliminary comparison with down hole shots indicates comparable levels of energy returns at least, from shallow (2-3 seconds) depth.

Two receiving systems were compared during the experiment. A conventional seismic cable with 48 groups of geophone strings and phones located at 50 meters intervals, was used over the glaciers and some of the ice shelf. The remainder of the profile on the ice shelf was recorded using an experimental snow streamer borrowed from Norsk-Hydro. Two shots, located 0.2 and 1.8 kilometers ahead of the streamer were shot into each streamer location to achieve an effective 3 kilometer long receiving array of 120 groups of geophone strings at 25 meters group intervals. The streamer was towed by an over-snow vehicle which also housed the seismic recording unit.

Seismic field records from the two systems were found to have similar noise levels despite the fact that the geophones connected to the conventional cable were buried whereas the geophones dragged by the streamer lay on the surface. However some streamer-geophone groups became considerably noisier above wind speeds of 5-6 knots (2.5-3 meters/second). In all other respects the streamer proved superior to a conventional cable - the rate of acquisition was doubled, manpower was cut by half, and there was a considerable reduction in the usage of vehicles, sleds, and fuel.

Wide angle reflection/refraction. The wide-angle reflection/refraction experiment consisted of 4 deployments of a 23-25 kilometers long receiving array, with 162 channels and a geophone group interval of 100-300 meters. Two of the

deployments were situated mostly over the glaciers of the Transantarctic Mountains whereas the other two were on the Ross Ice Shelf. Independent recording units, cables and geophones all borrowed from IRIS, comprised most of the receiving array.

Shots for each array deployment were detonated at each end of the receiving array and farther away from the array with a maximum shot-receiver offset of 90 kilometers on the ice shelf and 51 kilometers on the glacier. Shot sizes ranged (with offset) between 100-400 kilograms and the charges were placed at the bottom of 20 meter deep holes. Data were recorded on the internal RAM of each unit and were transferred to portable hard disk immediately following shooting. Preliminary processing was carried out in the field on a workstation.

Preliminary results. Preliminary stack section from the ice shelf (see Fig. 1 for location) shows sub-seafloor sedimentary layers which dip east and away from the mountains (Fig. 2). Similar east-dipping sedimentary strata are seen in marine seismic sections from the Ross Sea close to the mountain front. The dipping strata in the Ross Sea were interpreted to be the result of the uplift of the mountains (Cooper et al., 1987). Wide angle reflection shot records from the Robb and Lowery glaciers indicate that the glaciers are grounded and are directly underlain by crystalline basement (e.g., Fig. 3). The shot records further show a westward-dipping band of high reflectivity at travel times of 6.5-8 seconds (e.g., Fig. 3) under the Transantarctic mountain front (see Fig. 1 for location). The zone of high reflectivity may be analogous to the highly reflective lower crust observed in the Basin and Range (Allmendinger et al., 1987) and may suggest crustal thickness of at least, 21-26 kilometers. It should be emphasized that these results are tentative. Analysis of the seismic data is currently underway at both Stanford University and the DSIR, New Zealand.

This work was supported by National Science Foundation grant DPP-8917634 and the New Zealand Science Foundation contract 90/188. We thank IRIS (NSF funded) for lending us recording instruments and other related equipment and for sending a field technician, Norsk-Hydro of Norway and Y. Kristoffersen for lending us the snow streamer, Grant-Norpac, for lending us two DFS-V boards, the personnel of DSIR-Department of Survey and Land Information, New Zealand, for surveying the seismic line, and Polar Ice Coring Office personnel for drilling the shot holes. Logistical support by DPP-Operations and DSIR-Antarctic Division, New Zealand, is gratefully acknowledged. Finally, special thanks to our field participants, R. Busby, B. Harris, and N. Lord (U.S.A.) and S. Heaphy, T. Hefford, C. Hobbs, D. Lously, and B. Staite (N.Z.) for their invaluable help and good spirits.

References

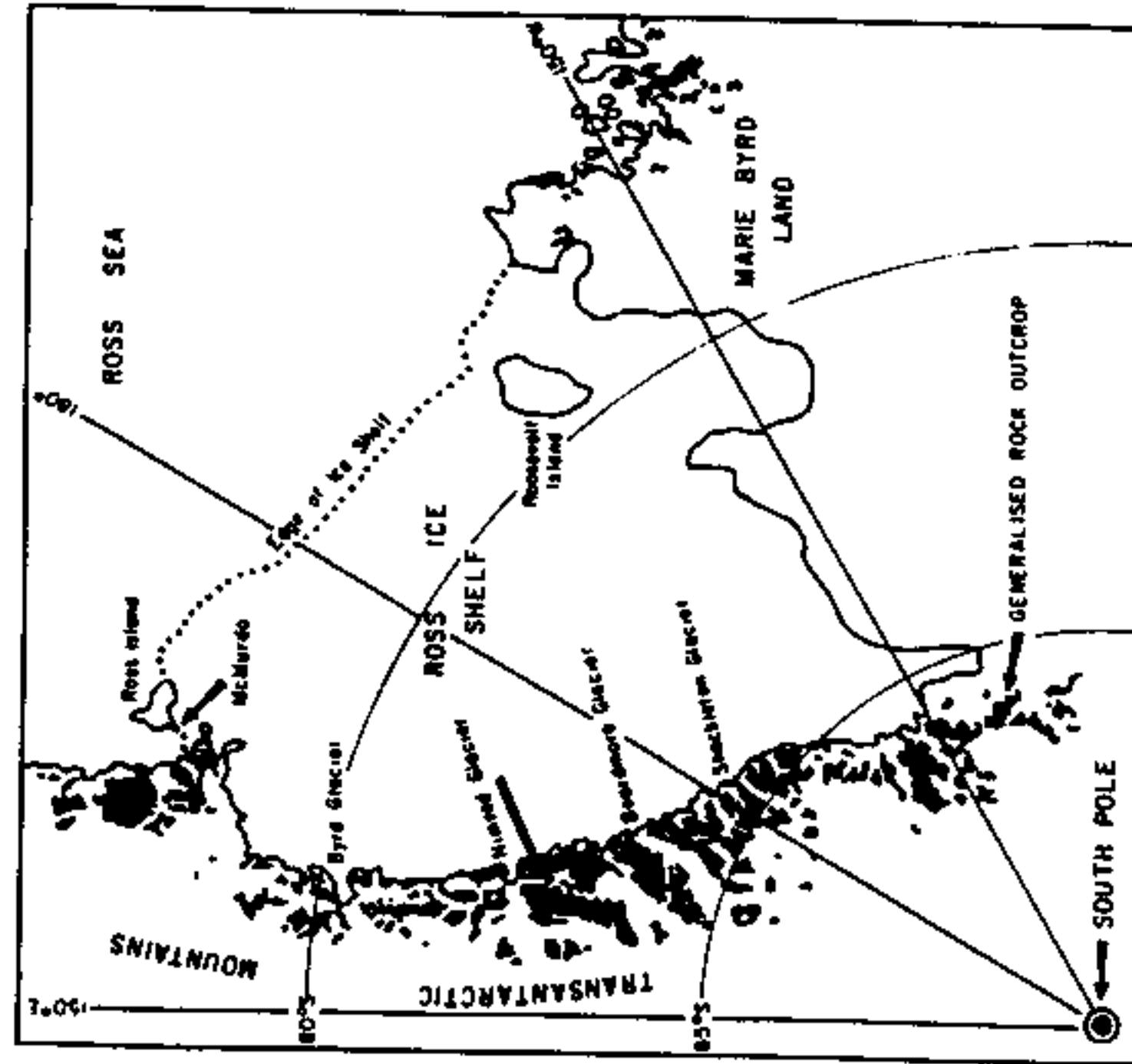
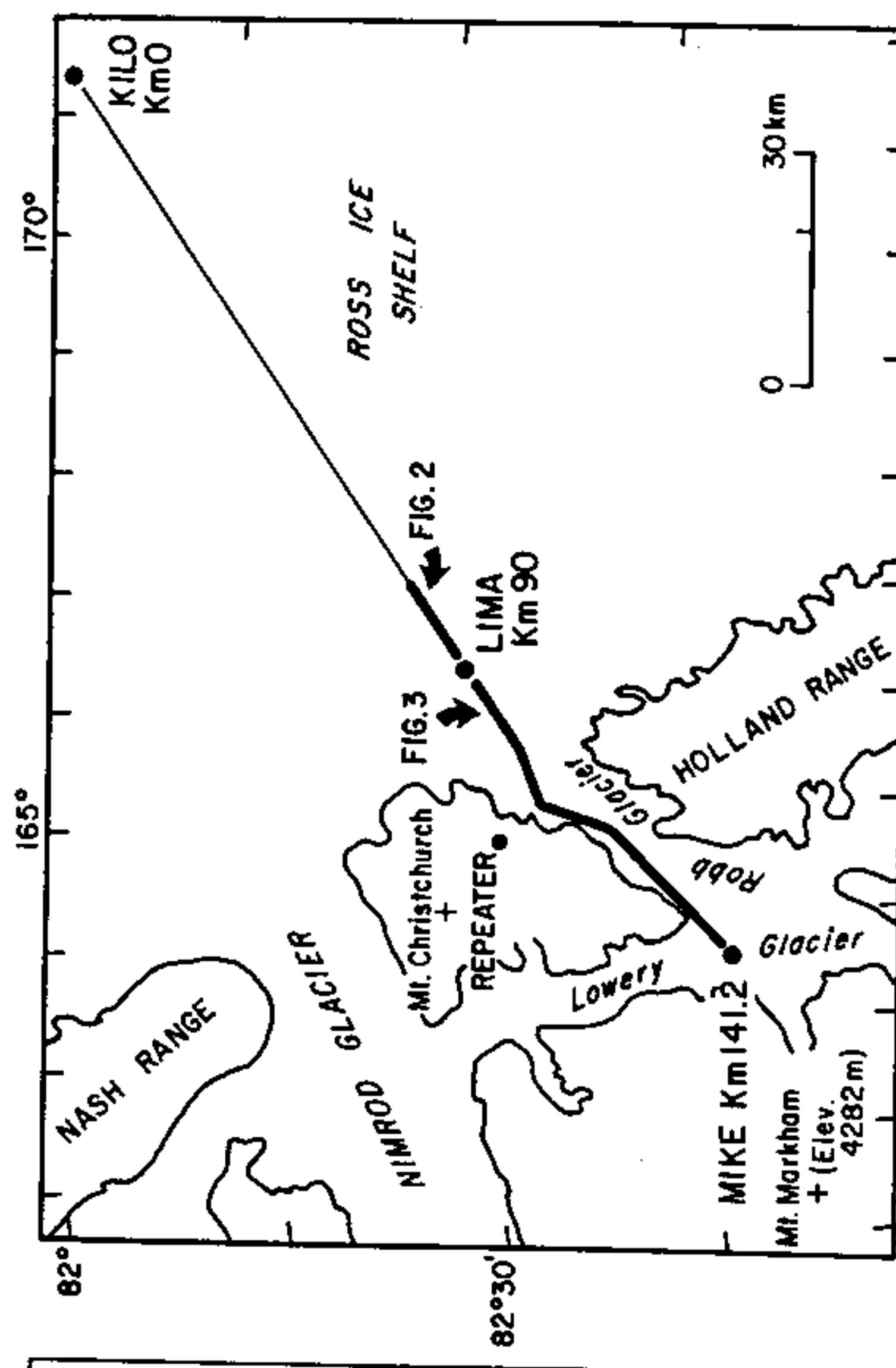
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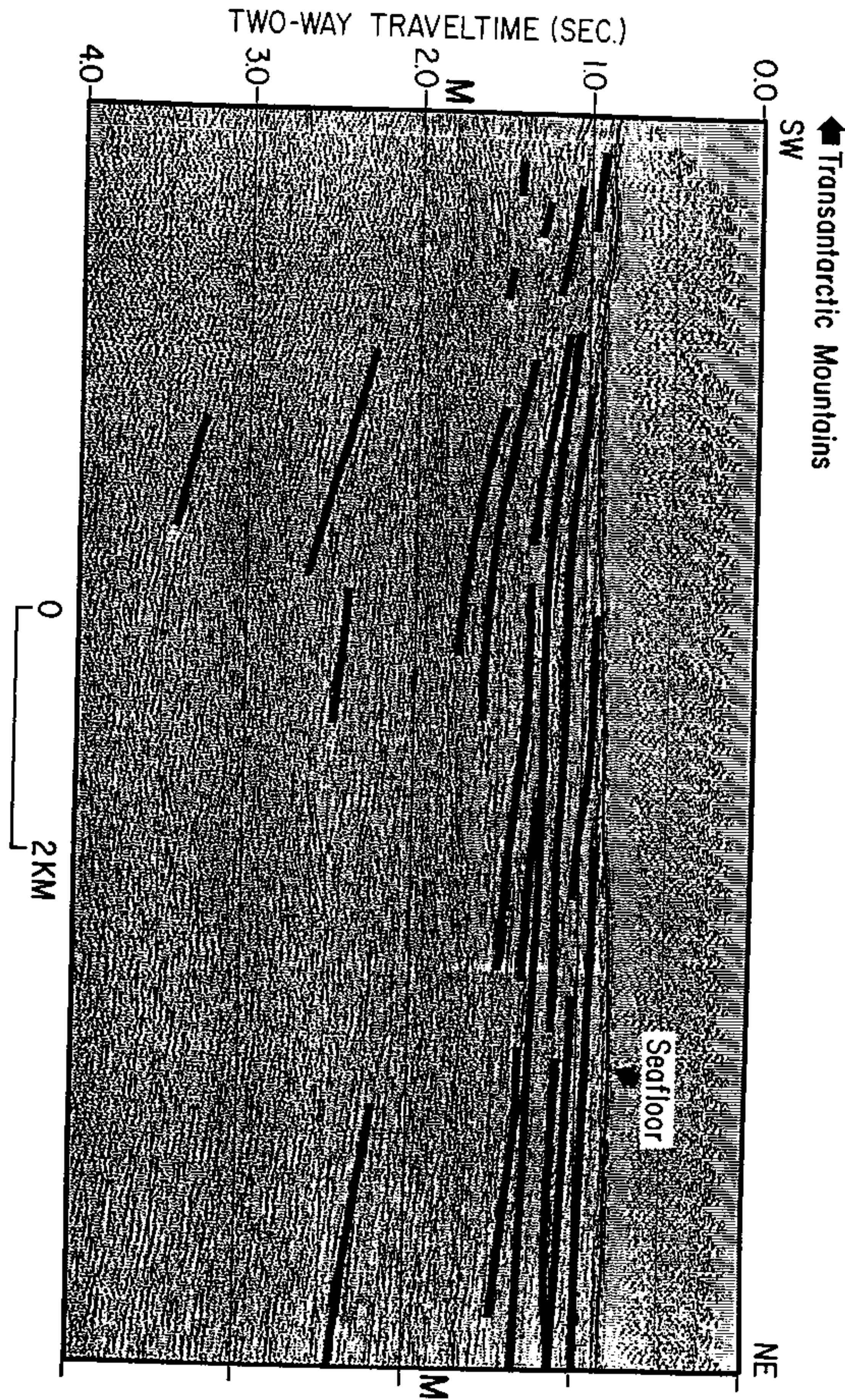
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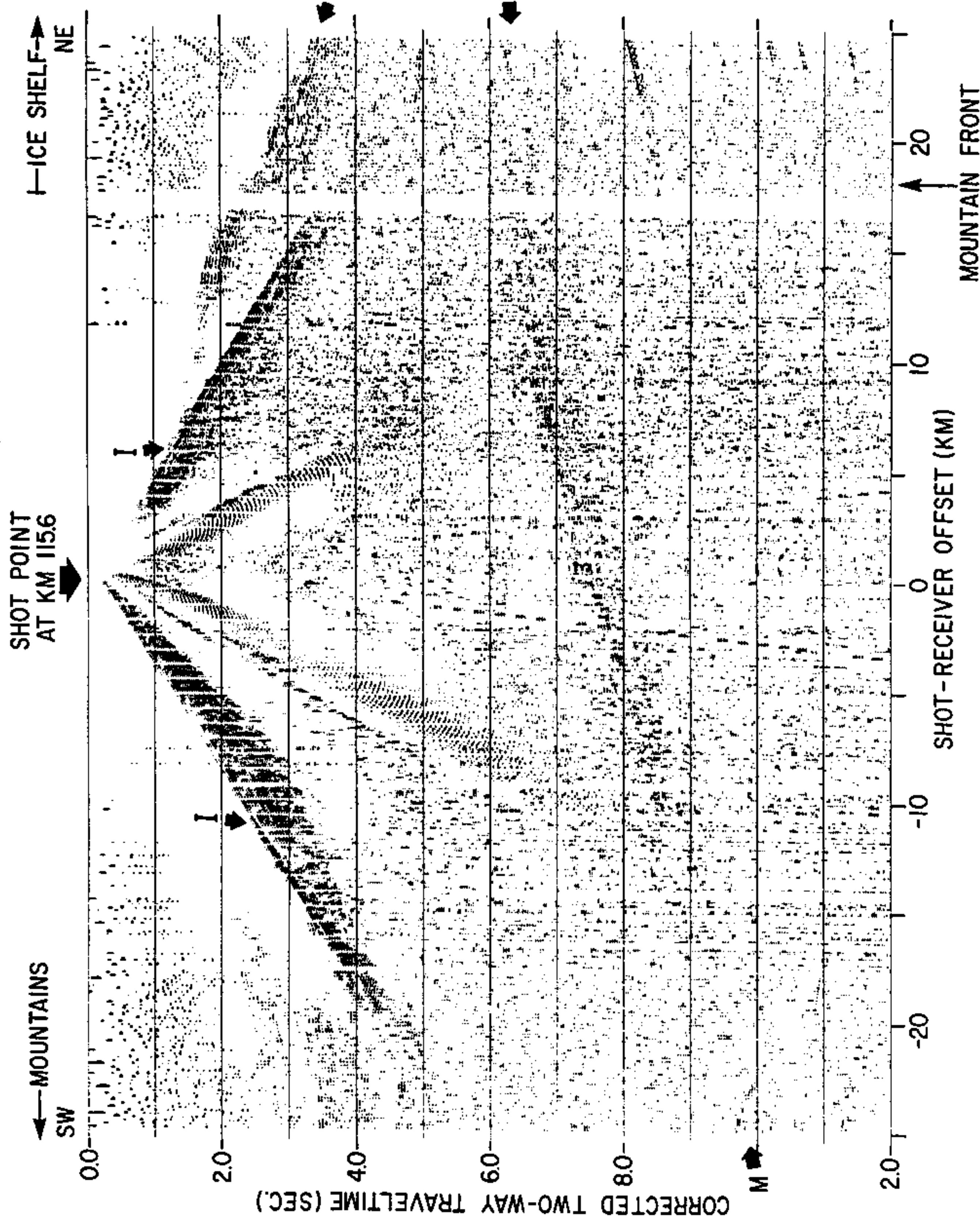
Figure 1. Location of the SERIS profile across the eastern edge of the Transantarctic Mountains and on the Ross Ice Shelf. Three logistical camps, Kilo, Lima, and Mike are marked.

Figure 2. Short stack section of the seismic reflection data collected with the snow streamer (120 geophone groups, 25 meters group interval). See Figure 1 for location. The section shows dipping reflectors away from the Transantarctic Mountains. SF - Sea floor, i.e., water bottom under the floating ice shelf. M - Multiple reflection from the sea floor. The processing sequence included f-k filtering to remove ground roll and spiking deconvolution before stack.

Figure 3. Wide-angle reflection shot gather on Robb Glacier in the Transantarctic Mountain front (See Figure 1 for location). Horizontal scale represents shot-receiver offset. The wide-angle shot gather was recorded by an array of 25 Reftek instruments at ~100 m group interval using 100 kilograms of ammonium-nitrate as a sound source. I - Direct wave within the ice layer. B - Diving wave from the crystalline basement. G - Ground roll. C - Crustal reflections. The dip of the reflective lower crustal layer, which generated the crustal reflections is close to the observed dip of these reflections.









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11/16/1992

Dr. James C. Fowler
Program manager/ PASSCAL - IRIS
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Arlington, VA 22209

Dear Jim,

Enclosed please find tapes of the raw Reftek data and the final wide-angle data from our seismic experiment in Antarctica (December 1990-January 1991). Also enclosed is a publication which provides background information on the scientific problem and the acquisition scheme.

The following table lists the shot and receiver location and the shot size. (All locations refer to distances along the profile as marked in Figure 1 of the publication). Shot and receiver locations and offsets are included in the trace header.

Shot #	shot location (km)	size (kg)	# traces	Reftek Array location (km)
1	115.6	100	156	133.7-115.7
2	90.0	250	156	133.7-115.7
3	141.2	100	156	133.7-115.7
4	141.2	260	150	115.5-98.2
5	115.6	100	150	115.5-98.2
6	102.8	57.5	150	115.5-98.2
7	90.0	100	150	115.5-98.2
8	0.0	400	162	89.9-68.6
9	90.0	100	162	89.9-68.6
10	67.6	100	162	89.9-68.6
11	67.6	100	162	68.3-46.7
12	0.0	300	162	68.3-46.7
13	44.6	100	162	68.3-46.7
14	90.0	300	162	68.3-46.7
15	22.4	200	162	68.3-46.7

Sincerely yours,

Uri ten Brink

The geometry is fairly simple. We always started interrogating the instruments from the east end of the array and finished at the west end, so the data order represents their relative location. For deployment 1 and 2 (shots 1-7), 6 vertical geophones were spaced at 100 m interval and connected to a 6-channel Reftek with 200 m between geophone groups. For deployment 3 and 4 (shots 8-15), geophones were spaced at 100 m interval with 300 m between geophone groups. The only exception: in deployment 4 instrument 150 (last 6 channels) was located between km 67.8-68.3

Order of instruments:

Deployment 1 (shots 1-3) starting from km 115.7:

84,101,107,115,145,151,153,197,227,231,358,261,338,345,346,348,369,372,373,375
,378,380,390,395,396,418

Deployment 1 (shots 4-7) starting from km 98.2:

101,107,115,145,151,153,197,227,231,358,261,338,345,346,348,369,403,373,375,378
,380,390,242,396,418. (The 1st instrument, #84, failed to record)

Deployment 1 (shots 8-10) starting from km 68.6:

150,101,107,115,145,151,153,197,227,231,358,261,338,345,346,348,369,403,373,375
,378,380,390, 395,396,418,242

Deployment 1 (shots 11-15) starting from km 46.7:

115,145,151,153,197,227,231,358,261,338,345,346,348,369,403,373,375,152,380,390
,395,396,418,242,372,107,150

Please, let me know if you need additional information

Sincerely yours,



Uri ten Brink



United States Department of the Interior



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1/22/1993

Dr. James C. Fowler
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1616 N.Ft. Myer Dr., Suite 1440
Arlington, VA 22209

Dear Jim,

In response to your comments from Jan. 5, 1993, please find a tape of the corrected final wide-angle data from our seismic experiment in Antarctica (December 1990-January 1991) which includes 60 sec. trace length, padded to 162 traces and corrected for the time shifts. In shots 4-7, traces 1-6 are dead because the Reftek didn't record. In shots 1-7, traces 157-162 are padded. Shots 1-7 also needed time shifts. The "air blast" arrival on shot 2 is an ice quake. (there are many of those in Antarctica particularly near fast flowing ice but were also triggered sometimes by our shots which can be scary).

I am sorry for the inconvenience, and hope these data are o.k.

Sincerely,

Uri ten Brink

A handwritten signature in black ink, appearing to read "Uri ten Brink".

REEL HEADER
 C 1 DEPARTMENT ON JOB ANTARCTI
 C 2 LINE C SUBLINE
 C 3 REEL DATE WRITTEN: 21-JAN-1993 TIME WRITTEN: 15:24:51
 C 4 INSTRUMENT INFO:
 C 5 DATA TRACES PER RECORD: 162 CDP MAX FOLD: 0
 C 6 SAMPLE INTERVAL: 0.0050 DATA SAMPLES PER TRACE 12001
 C 7 RECORDING FORMAT
 C 8 SAMPLE FORMAT: IBM FLOATING
 C 9 GAIN
 C10
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aux traces/record = 0

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18

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