GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2273

1990 ICE ISLAND REFRACTION SURVEY, ELLEF RIGNES AND MEIGHEN ISLANDS REGION, CANADIAN ARCTIC

1990

Geological Survey of Canada
Open File No. 2273

1990 Ice Island Refraction Survey
Phase 1 Report

by

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ABSTRACT

The 1990 Ice Island refraction survey consisted of three reversed, 120 km-long profiles shot at offset distances up to 203 km. The profiles, parallel and perpendicular to the polar margin in the unsurveyed area between Ellef Ringnes and Meighen islands (Fig. 1), are the first continuous detailed refraction surveys from the hydrocarbon-rich Sverdrup Basin to the continental shelf.

Several significant improvements to both the shooting and recording tasks have made the refraction operation faster, safer and cheaper than the 1986 operation, yet resulted in a major increase in data-gathering capability. Using 60 portable refraction seismographs in three deployments, and a total of 19 shots, 1032 seismograms were recorded with a nominal spacing of 2 km.

Both the SYLEDIS radio positioning system (Dearnley-Davison and Forsyth, 1989) and the Global Positioning System (GPS) were used to navigate to planned positions with a precision of 50 meters or less. In a few instances where SYLEDIS reception from a limited shore-based network was poor and GPS was unobtainable, water-wave arrival times relative to adjacent receivers with good navigational fixes were used to refine positions. We are confident that positions are generally precise to within 50 meters.

Processing of the raw data and plotting seismic sections on the Ice Island after each deployment enabled preliminary velocity modelling and optimization of survey plans in the field.

This report summarizes survey parameters and includes data logs and plots of water wave and crustal wave coda.

1- INTRODUCTION

The Ice Island seismic refraction surveys (Fig.1) began in 1985 as part of the Frontier Geoscience Program to determine the configuration and structure of sedimentary basins beneath the Canadian Polar margin. The April 1985 and 1986 refraction surveys are described in Geological Survey of Canada Open File Reports 1196 and 1511 respectively (Asudeh et al., 1985; Asudeh et al., 1986).

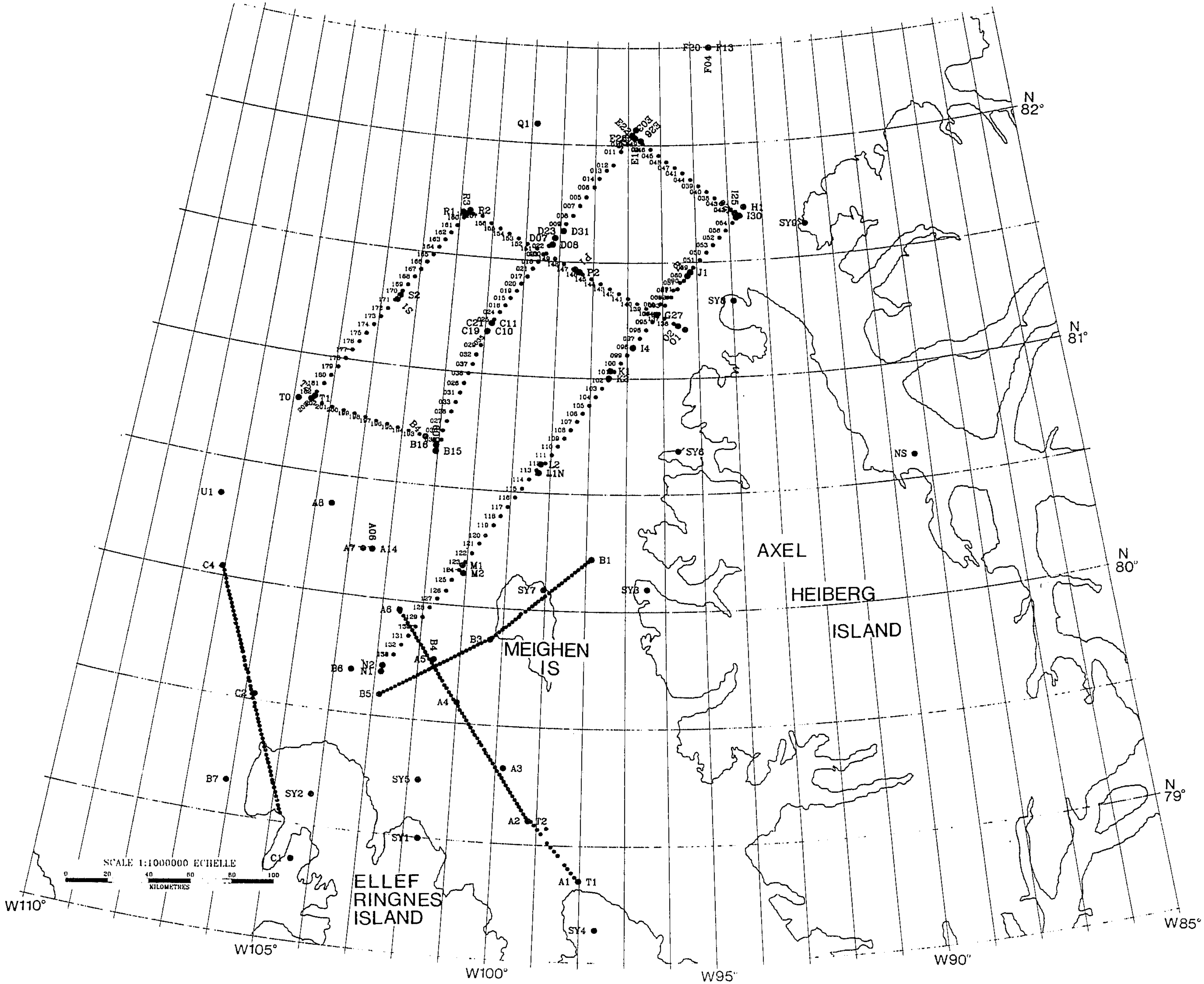
From March 22 to April 13, 1990, personnel from the Continental Geoscience Division (Ottawa), the Atlantic Geoscience Centre (Dartmouth), the Geophysics Division (Ottawa), the Department of Fisheries and Oceans (Dartmouth), the University of Waterloo (Ontario) and VRIJE University (Amsterdam), conducted a third major Arctic seismic refraction experiment using the Canadian Ice Island as a base (Fig.2).

The Canadian Ice Island is a floating fragment of the Ward Hunt Ice Shelf, 7 km by 4 km in areal extent, and approximately 42 m thick. Since breaking from the Ward-Hunt ice shelf on northern Ellesmere Island in 1983, the island has drifted with the winds and currents to 79°14'51'', N 101° 45'36'' W, its position off the north-east coast of Ellef Ringnes Island during the 1990 refraction operation. The Polar Continental Shelf Project of Energy Mines and Resources has occupied the island seasonally since 1984 and has maintained a base to support research on and from the island. This camp was used as field headquarters for the 1990 seismic project.

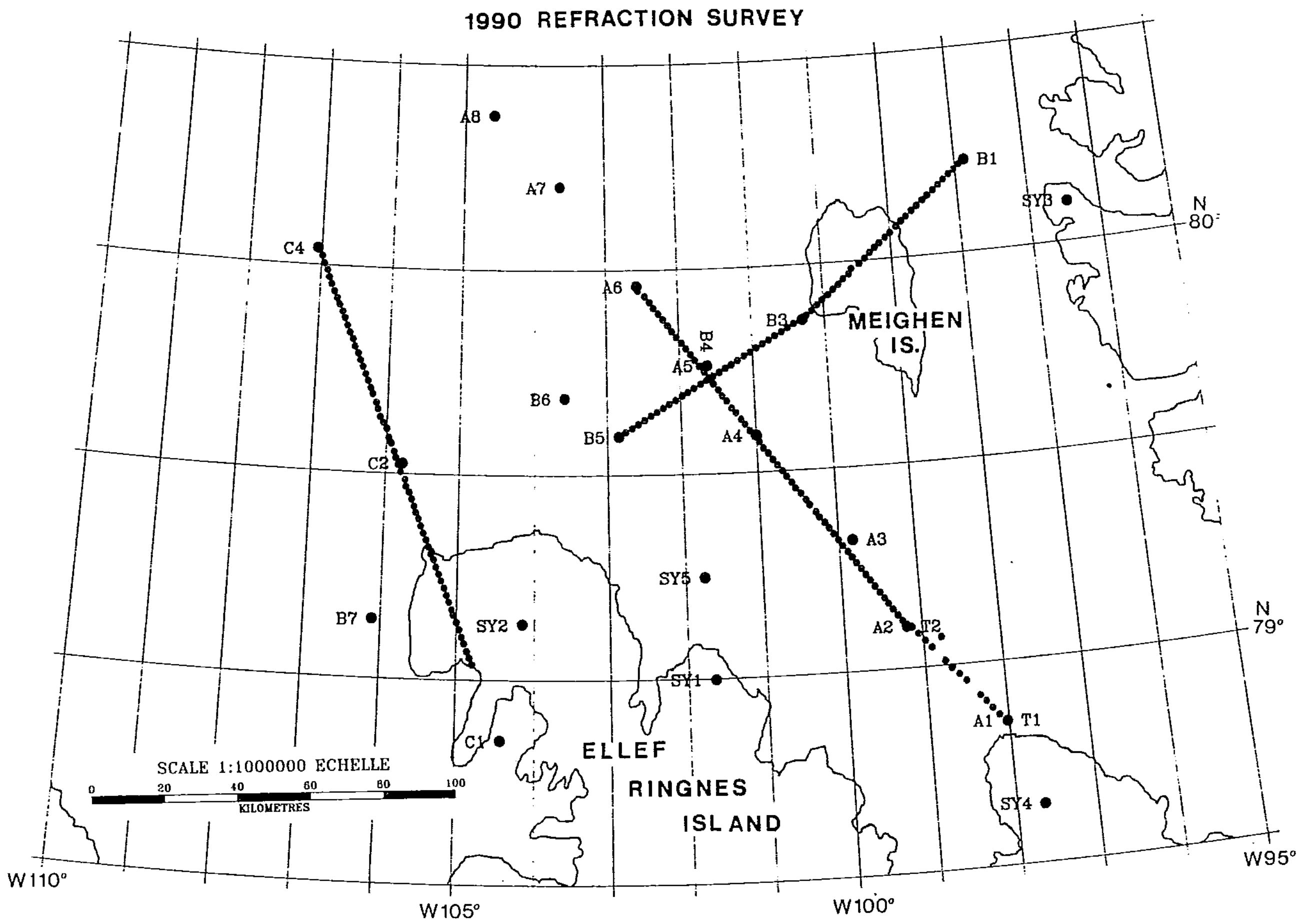
Despite weather conditions more adverse than the 25 year average and some logistic delays, three main refraction profiles of 5 originally planned, and a test line were completed in 1990. Each of the main lines consisted of a 120 km reversed profile, made up of four 30 km-long sections. Sixty GSC-developed, EDA*-produced "Lunchbox" portable refraction seismographs (PRS-1's) were deployed along these lines at a receiver spacing of 2 km. Offset shots at 30 km increments from the ends of the main profiles were recorded to distances of 200 km to provide information to the depth of the crust-mantle boundary.

Charges were made from units of 27.2 kg Geogel 60%, each suspended at a depth of 100 m below sea level. A maximum of 218 kg was loaded in any one hole. Detonation was accomplished using reinforced primacord and GSC-developed, commercially produced, electronic blasting boxes.

*Technology transferred from EMR to EDA: now under Scintrex Ltd., 222 Snidercroft Rd, Concord, Ontario L4K 1B5



REFRACTION SURVEYS 85,86,90


1990 REFRACTION SURVEY
A8
A7
B1
SY3
N
80°
C4
A6
B3
MEIGHEN
IS.
B4
A5
B6
B5
A4
C2
A3
SY5
N
79°
B7
SY2
A2
T2
SY1
A1
T1
C1
ELLEF
RINGNES
ISLAND
SCALE 1:1000000 ECHELLE
0
20
40
60
80
100
KILOMETRES
SY4
W110°
W105°
W100°
W95°

Despite some project curtailment, the volume of recorded data exceeded the very successful 1986 survey by 28%. Seventeen shots were fired into 60 deployed recorders in the three main deployments, and two shots were fired into 15 recorders in the test line, producing a total of 1032 usable seismograms.

Due to the expansion of the survey grid on the northeast polar margin since 1985, a new naming convention was developed for this survey, which can be continued for future surveys. Line or deployment names consist of a single sequential letter; shot names consist of the appropriate deployment name followed by a single digit sequential number; site names consist of the appropriate deployment name followed by a three digit sequential number. Using this convention, survey, deployment, shots and recorder sites are readily distinguished and the uniqueness of sites is maintained.

The success of the 1990 mission was made possible by significant improvements in both the shooting and recording facets of the operation over the 1986 program. Several of these advances were first tested during the Mackenzie Delta program in 1987 (Stephenson et al., 1989).

Proving the operational GPS capability, operating essentially with only basket-equipped 206L helicopters, a reliable and much more portable shooting system and the aluminium versions of the auger systems, have been major advances in 1990. From the 1990 experience, it is clear that straightforward modifications to the blasting system, improvements to the PRS-1 seismographs, and further development of the auger systems would probably enable 30% more data to be acquired with no increase in the number of aircraft and a minimal increase in the flying time on future surveys.

Environmental permission was obtained after assessment by agencies of the Government of the Northwest Territories, the Department of Fisheries and Oceans and the Department of Energy Mines and resources. This report summarizes the survey parameters and data logs, and presents plots of water wave and crustal wave coda.

2- FIELD PROCEDURES

2.1 LOGISTICS

Using the Ice Island as a base camp, transportation to and from the margin area was provided by a Twin Otter fixed wing aircraft and three Bell 206L helicopters. The Polar Continental Shelf Project arranged aircraft contracts for the project with support from the Frontier Geoscience Project.

2.2 RECORDING

Several major improvements have been realized since the 1985 and 1986 Ice Island operations. In the 1990 project, sixty, PRS-1's were deployed with pre-warmed gel packs in thermally insulated bags, and performed extremely well in temperatures as low as -42° C. The PRS-1's were deployed with a VHF beacon (within the frequency range of 131.50 to 133.75 mhz) and flags to facilitate retrieval. Baskets secured to the helicopter skids were used to carry flags and seismometers, leaving the valuable heated interior space for PRS-1's and beacons. The experience of using 20 recording systems per helicopter, where the main limitation is space, not weight, has shown that future surveys could record some 30% more data with a version of the PRS-1 similar in size to the prototype developed by the GSC.

Three Compaq model 286 and 386 personal computers were used for downloading pre-planned shot windows to the PRS-1's and uploading recorded data after each deployment. A fourth 386 was used for merging, manipulating and archiving data.

2.3 SHOOTING

Improvements recommended from experience in 1985 and 1986, and from collaboration with Defense Research Establishment Pacific, have been realized and were used on the 1990 field program. These included a new folding powerhead frame for the ice augers to make them lighter and portable in the 206L aircraft, redesigned aluminium drill bits and extensions for the auger systems and a new, lighter blasting system. The redesigned drill bits are 62% lighter and can be transported in a basket outside of the helicopter, enabling much more efficient use of the interior space. The shooting operation may now be run mainly with helicopters, involves minimal or no slinging, requires less manhandling and is thus quicker and safer. A major gain has been the ability to record more data with only one shot at profile ends. Operationally this means less explosive, less environmental impact, less flying, and with a shotpoint every 30 km, better resolution of upper crustal velocity structure.

2.4 NAVIGATION

Three navigation systems were employed in the 1990 refraction survey. Dynamic navigation was accomplished mainly using a Sercel UHF SYLEDIS system, with five transmitter stations located on the Ice Island, Meighen Island, Ellef Ringnes Island, Amund Ringnes Island and on Axel Heiberg Island (SY sites in Fig.2). Three mobile units were mounted in the helicopters for navigation to pre-planned shot and recording sites. Global Positioning System (GPS) receivers were used extensively to accurately position the SYLEDIS transmitting stations, some shotpoints, fuel caches and the recorders when

SYLEDIS reception was poor. In addition, the aircraft's resident Onboard Navigation System (ONS) was used to complement the other, more accurate systems.
A new arrangement of the SYLEDIS display in the cockpit enables the pilot to immediately monitor his position relative to the planned track and fly accordingly. Final fixes were recorded on take off following deployment. For areas where SYLEDIS reception was poor, water wave data was used to arrive at final positions.

3- DATA PROCESSING IN THE FIELD

Compaq 386 and 286 portable microcomputers, using LithoSEIS, a GSC-developed seismic data acquisition and processing package, were used to download shot windows to the PRS-1's and to upload the recorded data. The Lunchbox data were stored in LITHOSEIS internal format on floppy diskettes and on DC-1000 and DC-2000 cartridges. Subsequently data were transferred to a single 386 hard disc in SEGY format for plotting and analysis. In-field plotting of water wave and crustal data was done on a Zeta-8 model, pen plotter.

3.1 TIMING CORRECTIONS

Each personal computer was linked to a clock receiving information from the Geocentric Orbiting Earth Satellite (GOES) to provide a time base accurate to within 1 ms. The Lunchboxes and shooter boxes were all synchronized to satellite time before each deployment and the drift of their internal clocks was rated on return to base. These corrections were then applied to the data using LithoSEIS. A 16 millisecond correction has been applied as part of the shot time correction to take into account the delay caused by primacord detonation to the shot.

Lines B and C have several sites on Meighen Island and Ellef Ringnes Island respectively. Static corrections will have to be applied to these sites in order to compensate for the elevation differences from the other sites (ie. sea level). Table 3 lists the topograhic elevations relative to sea level for the refraction sites as determined from hydrographic charts and 1:50,000 topographic maps of the islands. The static corrections are not included the section plots of this report but will be required in the interpretation of the data.

3.2 INSTRUMENT MALFUNCTIONS

The 1990 survey was extremely successful in terms of hardware performance. The new shooting boxes worked perfectly, all shots being detonated electronically on the minute marks. Shot T1 may have only partially detonated due to explosive quality, but all other shots were successful. The Lunchboxes performed excellently with only two out of 60 failing to produce data. The overall recording performance was excellent, providing 1032 usable traces out of 1050 possible traces; a success rate of 98%, unmatched to date for high Arctic surveys.

4- DATA ANALYSIS IN THE FIELD

Picking of first events was accomplished using VISTA, a seismic analysis package within LithoSEIS. These picks were then modelled using RAYAMP, a ray tracing program adapted for personal computers. Preliminary velocity-depth models were obtained in the field and decisions as to the length of recording line to use to gather data from a given crustal depth were based on analysis rather than estimates as in 1986. This was the first time modelling had been accomplished during field operations in any large scale refraction experiment, let alone under Arctic conditions.

5- DATA ANALYSIS IN OTTAWA

5.1 WATER WAVE DATA

To check positions obtained from the SYLEDIS system, several seconds of water wave data were recorded for each shot. Since the velocity of the water wave is uniform at about 1440 m/s, and the impulsive water wave arrivals can usually be picked to better than 50 ms, it was possible to identify and correct errors in position on the order of 75 m by using the reversed water wave arrival times. This verification was only required for 6 sites north of Ellef Ringnes Island on the final deployment when SYLEDIS reception was often weak.

Observation of the apparent velocity of the water wave on the various sections showed a small difference in velocity between portions of the survey. The offshore areas covered by lines B and C, and the north end of line A, indicated a water wave velocity of 1.441 km/s, while the area within the islands north of Amundsen Island indicated a velocity of 1.442 km/s. This was confirmed by independent measurements made by R. Perkin, Institute of Ocean Sciences, Sidney, British Columbia during a survey conducted immediately following the refraction operation (R. Perkin, personal communication, 1990). These velocities have been used as reduction velocities on the respective water wave sections.

SUMMARY

Despite extremely poor weather, a successful refraction program was carried out in March and April of 1990, on the polar margin between Ellef Ringnes and Meighen islands. Innovations and improvements in methodology, hardware and software, developed on the basis of previous Ice Island surveys, have resulted in a much more efficient refraction operation than previous surveys. 390 km of high quality reversed refraction profile have been added to the northeast margin database and the refraction grid established in the 1985 and 1986 projects has been extended to a previously unknown area. The 1990 survey provides the first continuous link between the structure of the hydrocarbon-rich Sverdrup Basin and the offshore area of the continental shelf, including ties through known industry wells drilled on Ellef Ringnes and Meighen islands.

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Asudeh, I., D.A. Forsyth, H.R. Jackson, R. Stephenson and D. White, 1985. 1985 Ice Island Refraction Survey, Phase I Report: Earth Physics Branch, Open File No. 85-23; Geological Survey of Canada, Open File No. 1196, 25 p.

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Stephenson, R.A., B.C. Zelt, I. Asudeh, D.A. Forsyth, C. Spencer and R.M. Ellis, 1989. Acquisition of regional seismic refraction data in the Mackenzie Delta - southern Beaufort Sea - northern Yukon area, 1987: Geological Survey of Canada, Open File 2058, 65p.

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TABLE 1

SHOT DATA SUMMARY

Dep Code	Shot ID	Shot Site	Shot Depth (m)	Shot Weight (kg)	Shot Time (jjj:hh:mm:ss)	Time Correction (s)
DEPT	01T1	T1	95	136.0	087:19:40:00	0.016
DEPT	02T2	T2	100	136.0	087:19:30:00	0.010
DEPA	03A1	A1	80	435.2	089:19:00:00	0.018
DEPA	04A2	A2	100	326.4	089:18:30:00	0.018
DEPA	05A3	A3	100	136.0	089:18:00:00	0.017
DEPA	06A4	A4	100	217.6	089:18:03:00	0.018
DEPA	07A5	A5	100	136.0	089:18:33:00	0.019
DEPA	08A6	A6	100	326.4	089:18:06:00	0.014
DEPA	09A7	A7	100	244.8	089:19:06:00	0.014
DEPA	10A8	A8	100	652.8	089:20:06:00	0.013
DEPB	11B1	B1	100	516.8	092:23:00:00	-0.008
DEPB	12B3	B3	100	136.0	092:19:36:00	0.020
DEPB	13B4	B4	100	217.6	092:20:06:00	0.020
DEPB	14B5	B5	100	136.0	092:20:00:00	0.013
DEPB	15B6	B6	100	571.2	092:19:00:00	0.014
DEPB	16B7	B7	100	761.6	092:21:33:00	-0.003
DEPC	17C1	C1	100	761.6	104:01:00:00	0.019
DEPC	18C2	C2	100	163.2	104:01:03:00	-0.005
DEPC	20C4	C4	100	380.8	104:00:06:00	0.028

TABLE 2

RECORDING AND NAVIGATION SITES SUMMARY

Site ID	Line ID	Latitude	Longitude	Site Elev.	Northing	Easting	UTM Zone
A001	A	079:06:03.50N	099:11:52.80W	0.0	8781116	495820	14
A002	A	079:06:57.50N	099:14:57.00W	0.0	8782794	494748	14
A003	A	079:07:50.00N	099:18:12.10W	0.0	8784427	493614	14
A004	A	079:08:45.70N	099:21:36.80W	0.0	8786161	492427	14
A005	A	079:09:38.50N	099:24:42.20W	0.0	8787805	491356	14
A006	A	079:10:27.90N	099:27:32.30W	0.0	8789344	490376	14
A007	A	079:11:23.10N	099:30:57.30W	0.0	8791065	489197	14
A008	A	079:12:17.60N	099:34:24.20W	0.0	8792766	488011	14
A009	A	079:13:13.70N	099:37:40.10W	0.0	8794517	486891	14
A010	A	079:14:04.10N	099:40:45.90W	0.0	8796092	485832	14
A011	A	079:14:59.10N	099:44:04.90W	0.0	8797811	484701	14
A012	A	079:15:51.70N	099:47:23.20W	0.0	8799456	483576	14
A013	A	079:16:45.70N	099:50:25.70W	0.0	8801145	482546	14
A014	A	079:17:36.30N	099:53:38.30W	0.0	8802730	481459	14
A015	A	079:18:31.10N	099:57:10.10W	0.0	8804449	480267	14
A016	A	079:19:22.80N	100:00:23.70W	0.0	8806070	479181	14
A017	A	079:20:19.60N	100:03:48.20W	0.0	8807852	478038	14
A018	A	079:21:14.70N	100:07:13.10W	0.0	8809582	476896	14
A019	A	079:22:05.80N	100:10:19.30W	0.0	8811187	475861	14
A020	A	079:22:54.30N	100:14:12.80W	0.0	8812718	474557	14
A021	A	079:23:42.83N	100:16:37.76W	0.0	8814240	473762	14
A022	A	079:24:47.07N	100:21:01.45W	0.0	8816265	472303	14
A023	A	079:25:35.79N	100:23:54.65W	0.0	8817798	471353	14
A024	A	079:26:31.05N	100:27:16.76W	0.0	8819539	470246	14
A025	A	079:27:21.26N	100:31:15.62W	0.0	8821130	468930	14
A026	A	079:28:14.93N	100:34:06.70W	0.0	8822819	468004	14
A027	A	079:29:08.35N	100:37:44.10W	0.0	8824509	466819	14
A028	A	079:30:00.75N	100:40:52.02W	0.0	8826163	465803	14
A029	A	079:30:52.41N	100:44:21.09W	0.0	8827799	464669	14
A030	A	079:31:44.62N	100:47:43.50W	0.0	8829451	463577	14
A031	A	079:32:39.22N	100:51:12.33W	0.0	8831180	462455	14
A032	A	079:33:28.07N	100:54:55.00W	0.0	8832734	461252	14
A033	A	079:34:26.10N	100:57:54.69W	0.0	8834566	460303	14
A034	A	079:35:17.73N	101:01:05.54W	0.0	8836203	459288	14
A035	A	079:36:04.16N	101:05:07.28W	0.0	8837689	457986	14
A036	A	079:37:01.97N	101:08:48.54W	0.0	8839525	456814	14
A037	A	079:37:50.37N	101:11:59.28W	0.0	8841065	455806	14
A038	A	079:38:47.91N	101:15:43.06W	0.0	8842895	454627	14
A039	A	079:39:32.16N	101:19:21.72W	0.0	8844314	453464	14
A040	A	079:40:34.35N	101:22:54.14W	0.0	8846288	452361	14
A041	A	079:41:18.92N	101:26:26.38W	0.0	8847718	451240	14
A042	A	079:42:14.99N	101:29:26.00W	0.0	8849497	450318	14
A043	A	079:43:09.08N	101:33:11.43W	0.0	8851227	449143	14
A044	A	079:44:03.35N	101:36:39.52W	0.0	8852959	448068	14

Site ID	Line ID	Latitude	Longitude	Site Elev.	Northing	Easting	UTM Zone
A045	A	079:44:55.46N	101:40:04.31W	0.0	8854624	447011	14
A046	A	079:45:46.98N	101:44:03.70W	0.0	8856281	445767	14
A047	A	079:46:40.79N	101:47:45.04W	0.0	8858006	444628	14
A048	A	079:47:29.44N	101:50:58.14W	0.0	8859564	443640	14
A049	A	079:48:23.64N	101:54:30.35W	0.0	8861300	442559	14
A050	A	079:49:13.70N	101:57:58.93W	0.0	8862908	441495	14
A051	A	079:50:05.93N	102:02:07.08W	0.0	8864523	558390	13
A052	A	079:50:57.60N	102:05:42.93W	0.0	8866064	557130	13
A053	A	079:51:50.77N	102:09:04.91W	0.0	8867656	555946	13
A054	A	079:52:42.91N	102:12:46.78W	0.0	8869212	554660	13
A055	A	079:53:33.58N	102:16:31.18W	0.0	8870724	553364	13
A056	A	079:54:25.19N	102:20:31.54W	0.0	8872262	551985	13
A057	A	079:55:17.70N	102:23:47.36W	0.0	8873840	550849	13
A058	A	079:56:09.28N	102:27:41.01W	0.0	8875382	549512	13
A059	A	079:57:00.11N	102:33:15.80W	0.0	8876879	547633	13
A060	A	079:57:53.92N	102:35:09.76W	0.0	8878520	546948	13
A1	A	078:51:05.70N	098:01:29.30W	0.0	8753449	521049	14
A2	A	079:06:03.46N	099:11:53.30W	0.0	8781114	495817	14
A3	A	079:19:18.90N	099:49:18.50W	0.0	8805889	483001	14
A4	A	079:35:23.50N	101:00:01.70W	0.0	8836369	459652	14
A5	A	079:45:49.50N	101:37:45.80W	0.0	8856263	447851	14
A6	A	079:57:37.29N	102:34:09.73W	0.0	8878019	547293	13
A7	A	080:12:13.62N	103:38:47.88W	0.0	8904501	525706	13
A8	A	080:22:38.08N	104:35:25.20W	0.0	8923591	507645	13
B001	B	080:13:28.03N	097:51:50.88W	0.0	8906720	521530	14
B002	B	080:12:47.01N	097:56:42.83W	0.0	8905419	520016	14
B003	B	080:12:07.24N	098:01:32.51W	0.0	8904159	518510	14
B004	B	080:11:29.78N	098:06:21.03W	0.0	8902973	517005	14
B005	B	080:10:45.96N	098:11:20.37W	0.0	8901592	515443	14
B006	B	080:10:06.31N	098:16:05.25W	0.0	8900342	513952	14
B007	B	080:09:24.08N	098:20:47.47W	0.0	8899015	512472	14
B008	B	080:08:41.32N	098:25:59.58W	0.0	8897672	510830	14
B009	B	080:08:02.37N	098:30:31.73W	0.0	8896451	509396	14
B010	B	080:07:17.01N	098:35:31.74W	0.0	8895033	507812	14
B011	B	080:06:38.03N	098:40:07.99W	0.0	8893815	506349	14
B012	B	080:05:52.85N	098:45:27.29W	0.0	8892406	504654	14
B013	B	080:05:15.37N	098:50:06.50W	0.0	8891238	503168	14
B014	B	080:04:31.58N	098:54:26.02W	3.0	8889877	501785	14
B015	B	080:03:42.99N	099:00:00.58W	29.0	8888370	499997	14
B016	B	080:03:03.66N	099:04:29.90W	55.0	8887151	498554	14
B017	B	080:02:21.85N	099:09:54.21W	89.0	8885858	496813	14
B018	B	080:01:41.89N	099:14:06.97W	96.0	8884624	495452	14
B019	B	080:01:01.53N	099:18:27.32W	100.0	8883379	494047	14
B020	B	080:00:17.34N	099:23:04.49W	100.0	8882018	492548	14
B021	B	079:59:32.63N	099:28:10.61W	58.0	8880644	490889	14

Site ID	Line ID	Latitude	Longitude	Site Elev.	Northing	Easting	UTM Zone
B022	B	079:58:53.56N	099:34:53.56W	60.0	8879452	488705	14
B023	B	079:58:08.17N	099:37:20.25W	72.0	8878053	487899	14
B024	B	079:57:27.16N	099:42:17.74W	48.0	8876800	486277	14
B025	B	079:56:44.32N	099:46:48.66W	43.0	8875490	484794	14
B026	B	079:56:02.72N	099:51:34.60W	60.0	8874222	483227	14
B027	B	079:55:20.24N	099:56:01.61W	49.0	8872928	481759	14
B028	B	079:54:37.07N	100:00:54.42W	40.0	8871616	480147	14
B029	B	079:53:55.54N	100:05:22.19W	25.0	8870355	478668	14
B030	B	079:53:09.36N	100:10:01.84W	0.0	8868953	477118	14
B031	B	079:52:29.53N	100:14:34.96W	0.0	8867749	475605	14
B032	B	079:51:24.99N	100:25:14.88W	0.0	8865828	472068	14
B033	B	079:50:52.88N	100:30:29.00W	0.0	8864876	470327	14
B034	B	079:50:20.50N	100:35:40.33W	0.0	8863918	468599	14
B035	B	079:49:47.00N	100:41:03.27W	0.0	8862929	466803	14
B036	B	079:49:14.28N	100:46:17.41W	0.0	8861967	465052	14
B037	B	079:48:41.85N	100:51:34.04W	0.0	8861016	463286	14
B038	B	079:48:08.98N	100:56:50.54W	0.0	8860054	461516	14
B039	B	079:47:35.95N	101:02:01.74W	0.0	8859089	459773	14
B040	B	079:47:02.82N	101:07:17.51W	0.0	8858124	458001	14
B041	B	079:46:27.40N	101:12:40.50W	0.0	8857093	456184	14
B042	B	079:45:50.90N	101:18:02.70W	0.0	8856031	454367	14
B043	B	079:45:21.70N	101:22:56.70W	0.0	8855191	452711	14
B044	B	079:44:48.20N	101:28:12.20W	0.0	8854226	450928	14
B045	B	079:44:16.50N	101:33:20.70W	0.0	8853317	449184	14
B046	B	079:43:43.60N	101:38:46.30W	0.0	8852379	447340	14
B047	B	079:43:12.30N	101:43:28.00W	0.0	8851481	445739	14
B048	B	079:42:35.80N	101:49:00.70W	0.0	8850438	443845	14
B049	B	079:42:00.70N	101:54:08.10W	0.0	8849435	442090	14
B050	B	079:41:31.50N	101:58:43.90W	0.0	8848608	440516	14
B051	B	079:40:54.20N	102:04:01.70W	0.0	8847406	558624	13
B052	B	079:40:20.10N	102:09:22.30W	0.0	8846262	556897	13
B053	B	079:39:47.30N	102:14:19.50W	0.0	8845166	555295	13
B054	B	079:39:12.10N	102:19:25.30W	0.0	8843997	553645	13
B055	B	079:38:40.50N	102:24:21.60W	0.0	8842943	552040	13
B056	B	079:38:03.40N	102:29:40.10W	0.0	8841716	550316	13
B057	B	079:37:28.30N	102:34:46.70W	0.0	8840557	548652	13
B058	B	079:36:53.40N	102:39:58.60W	0.0	8839404	546954	13
B059	B	079:36:20.40N	102:45:17.90W	0.0	8838312	545210	13
B060	B	079:35:43.30N	102:50:18.70W	0.0	8837099	543571	13
B1	B	080:13:25.00N	097:51:52.00W	0.0	8906625	521526	14
B3	B	079:51:56.40N	100:18:04.42W	0.0	8866747	474440	14
B4	B	079:45:49.50N	101:37:45.80W	0.0	8856263	447851	14
B5	B	079:35:38.50N	102:51:01.30W	0.0	8836941	543338	13
B6	B	079:41:16.60N	103:35:15.80W	0.0	8846966	528222	13
B7	B	079:08:42.00N	106:06:38.00W	0.0	8786245	476652	13

Site ID	Line ID	Latitude	Longitude	Site Elev.	Northing	Easting	UTM Zone
C001	C	079:02:14.90N	104:47:32.10W	5.0	8774029	504411	13
C002	C	079:03:16.30N	104:49:51.20W	30.0	8775930	503585	13
C003	C	079:04:11.40N	104:51:45.80W	80.0	8777637	502906	13
C004	C	079:05:19.60N	104:53:56.60W	110.0	8779749	502133	13
C005	C	079:06:17.80N	104:55:54.40W	135.0	8781553	501440	13
C006	C	079:07:21.10N	104:57:50.80W	250.0	8783515	500756	13
C007	C	079:08:26.10N	105:00:13.70W	250.0	8785530	499920	13
C008	C	079:09:29.70N	105:02:46.20W	200.0	8787502	499031	13
C009	C	079:10:15.40N	105:04:07.00W	170.0	8788919	498561	13
C010	C	079:11:22.80N	105:06:22.30W	145.0	8791010	497776	13
C011	C	079:12:21.10N	105:08:24.80W	115.0	8792819	497068	13
C012	C	079:13:25.10N	105:10:21.90W	85.0	8794805	496394	13
C013	C	079:14:26.80N	105:12:48.80W	60.0	8796721	495549	13
C014	C	079:15:23.90N	105:14:59.00W	30.0	8798494	494803	13
C015	C	079:16:26.30N	105:17:11.20W	15.0	8800433	494048	13
C016	C	079:17:32.80N	105:19:08.70W	10.0	8802498	493381	13
C017	C	079:18:22.20N	105:21:22.50W	5.0	8804034	492620	13
C018	C	079:19:23.00N	105:23:36.00W	0.0	8805924	491864	13
C019	C	079:20:22.90N	105:25:28.40W	0.0	8807785	491232	13
C020	C	079:21:23.10N	105:27:57.20W	0.0	8809658	490393	13
C021	C	079:22:25.48N	105:30:19.26W	0.0	8811599	489597	13
C022	C	079:23:28.90N	105:32:14.03W	0.0	8813571	488958	13
C023	C	079:24:22.56N	105:34:30.01W	0.0	8815242	488198	13
C024	C	079:25:15.01N	105:36:13.49W	0.0	8816874	487625	13
C025	C	079:26:16.84N	105:38:14.05W	0.0	8818799	486960	13
C026	C	079:27:19.01N	105:40:34.84W	0.0	8820735	486182	13
C027	C	079:28:09.89N	105:43:19.46W	0.0	8822324	485267	13
C028	C	079:29:09.35N	105:44:03.90W	0.0	8824170	485039	13
C029	C	079:30:16.11N	105:47:47.20W	0.0	8826256	483804	13
C030	C	079:31:18.17N	105:50:05.72W	0.0	8828191	483049	13
C031	C	079:32:19.36N	105:52:02.31W	0.0	8830098	482419	13
C032	C	079:33:11.76N	105:53:43.58W	0.0	8831731	481874	13
C033	C	079:34:23.70N	105:56:08.18W	0.0	8833974	481097	13
C034	C	079:35:11.65N	105:58:31.12W	0.0	8835474	480320	13
C035	C	079:36:30.87N	106:00:36.89W	0.0	8837942	479657	13
C036	C	079:37:20.72N	106:03:11.28W	0.0	8839502	478822	13
C037	C	079:38:11.80N	106:05:53.14W	0.0	8841102	477948	13
C038	C	079:39:19.38N	106:07:51.68W	0.0	8843210	477327	13
C039	C	079:40:13.04N	106:09:27.34W	0.0	8844884	476828	13
C040	C	079:41:31.58N	106:12:28.42W	0.0	8847339	475871	13
C041	C	079:42:22.90N	106:14:35.95W	0.0	8848945	475198	13
C042	C	079:43:23.06N	106:16:48.32W	0.0	8850825	474506	13
C043	C	079:44:21.92N	106:19:02.79W	0.0	8852666	473803	13
C044	C	079:45:23.74N	106:21:35.21W	0.0	8854602	473006	13
C045	C	079:46:21.62N	106:23:55.16W	0.0	8856414	472278	13

Site ID	Line ID	Latitude	Longitude	Site Elev.	Northing	Easting	UTM Zone
C046	C	079:47:21.04N	106:25:53.16W	0.0	8858272	471673	13
C047	C	079:48:18.94N	106:28:50.67W	0.0	8860091	470743	13
C048	C	079:49:23.71N	106:30:30.25W	0.0	8862113	470249	13
C049	C	079:50:19.26N	106:33:24.05W	0.0	8863859	469343	13
C050	C	079:51:20.41N	106:35:47.46W	0.0	8865776	468611	13
C051	C	079:52:24.15N	106:38:13.46W	0.0	8867774	467869	13
C052	C	079:53:20.38N	106:40:16.53W	0.0	8869535	467248	13
C053	C	079:54:21.20N	106:42:57.60W	0.0	8871446	466427	13
C054	C	079:55:16.50N	106:45:15.80W	0.0	8873182	465728	13
C055	C	079:56:13.00N	106:47:50.30W	0.0	8874959	464944	13
C056	C	079:57:16.80N	106:50:30.90W	0.0	8876963	464137	13
C057	C	079:58:14.00N	106:52:55.70W	0.0	8878761	463412	13
C058	C	079:59:17.20N	106:54:39.30W	0.0	8880738	462917	13
C059	C	080:00:14.10N	106:57:21.40W	0.0	8882530	462102	13
C060	C	080:01:17.10N	106:59:31.20W	0.0	8884506	461471	13
C1	C	078:51:09.50N	104:25:39.00W	0.0	8753452	512357	13
C2	C	079:31:32.79N	105:46:20.13W	0.0	8828627	484327	13
C4	C	080:02:26.50N	107:03:21.32W	0.0	8886699	460311	13
II	II	079:14:50.35N	101:45:35.67W	0.0	8798803	442535	14
S1		078:59:53.57N	101:39:36.59W	250.0	8770931	443343	14
S2		079:08:10.96N	104:09:20.98W	125.0	8785189	517762	13
S3		080:05:46.34N	096:27:27.50W	800.0	8893261	548803	14
S4		078:38:31.71N	097:39:19.68W	367.0	8730238	529558	14
S5		079:14:50.35N	101:45:35.67W	0.0	8798803	442535	14
T001	T	078:51:05.60N	098:01:29.40W	0.0	8753446	521049	14
T002	T	078:52:06.40N	098:06:54.30W	0.0	8755300	519072	14
T003	T	078:53:13.10N	098:11:42.50W	0.0	8757343	517319	14
T004	T	078:54:17.69N	098:16:07.36W	0.0	8759324	515711	14
T005	T	078:55:11.70N	098:20:16.70W	0.0	8760981	514204	14
T006	T	079:04:11.61N	098:46:19.31W	0.0	8777649	504826	14
T007	T	078:57:30.61N	098:29:42.42W	0.0	8765254	510795	14
T008	T	078:58:32.48N	098:34:42.46W	0.0	8767158	508999	14
T009	T	078:59:35.74N	098:39:46.93W	0.0	8769107	507182	14
T010	T	079:00:38.27N	098:44:42.90W	0.0	8771037	505422	14
T012	T	079:02:46.78N	098:53:57.49W	0.0	8775011	502136	14
T013	T	079:03:51.89N	098:58:43.44W	0.0	8777028	500450	14
T014	T	079:04:56.05N	099:03:25.61W	0.0	8779018	498792	14
T015	T	079:05:54.86N	099:07:36.36W	0.0	8780844	497324	14
T016	T	079:06:01.33N	099:12:02.34W	0.0	8781049	495764	14
T1	T	078:51:05.70N	098:01:29.30W	0.0	8753449	521049	14
T2	T	079:06:03.46N	099:11:53.30W	0.0	8781114	495817	14

TABLE 3

TOPOGRAPHY ALONG 1990 REFRACTION PROFILES
VALUES IN METRES BELOW SEA LEVEL

NOTE: A '+' INDICATES ELEVATION ABOVE SEA LEVEL

SITE	BATHYMETRY (m)	SITE	BATHYMETRY (m)	SITE	BATHYMETRY(m)
T001	150	A021	430	A059	460
T002	160	A022	450	A060	460
T003	180	A023	470		
T004	200	A024	495		
T005	280	A025	510	B001	195
T006	300	A026	515	B002	195
T007	360	A027	520	B003	190
T008	370	A028	530	B004	175
T009	370	A029	535	B005	170
T010	370	A030	540	B006	165
T011	no record	A031	540	B007	160
T012	380	A032	535	B008	140
T013	380	A033	530	B009	130
T014	375	A034	525	B010	100
T015	370	A035	520	B011	80
T016	370	A036	510	B012	60
		A037	505	B013	30
		A038	500	B014	+3
A001	370	A039	495	B015	+29
A002	360	A040	490	B016	+55
A003	360	A041	490	B017	+89
A004	350	A042	480	B018	+96
A005	350	A043	480	B019	+100
A006	340	A044	480	B020	+100
A007	330	A045	475	B021	+58
A008	320	A046	475	B022	+60
A009	320	A047	480	B023	+72
A010	330	A048	480	B024	+48
A011	335	A049	485	B025	+43
A012	340	A050	485	B026	+60
A013	350	A051	485	B027	+49
A014	360	A052	490	B028	+40
A015	370	A053	490	B029	+25
A016	380	A054	490	B030	20
A017	390	A055	480	B031	120
A018	410	A056	475	B032	230
A019	410	A057	475	B033	260
A020	430	A058	470	B034	300

TABLE 3 (cont'd)

TOPOGRAPHY ALONG 1990 REFRACTION PROFILES
VALUES IN METRES BELOW SEA LEVEL

NOTE: A '+' INDICATES ELEVATION ABOVE SEA LEVEL

SITE	BATHYMETRY (m)	SITE	BATHYMETRY (m)	SITE	BATHYMETRY (m)
B035	340	C011	+115	C049	410
B036	380	C012	+85	C050	420
B037	410	C013	+60	C051	430
B038	450	C014	+30	C052	440
B039	480	C015	+15	C053	445
B040	505	C016	+10	C054	450
B041	525	C017	+5	C055	450
B042	520	C018	0	C056	455
B043	510	C019	5	C057	460
B044	495	C020	5	C058	465
B045	480	C021	10	C059	465
B046	470	C022	30	C060	465
B047	470	C023	40		
B048	460	C024	50		
B049	450	C025	65		
B050	430	C026	80		
B051	420	C027	100		
B052	410	C028	120		
B053	405	C029	125		
B054	400	C030	130		
B055	400	C031	150		
B056	400	C032	160		
B057	400	C033	175		
B058	395	C034	190		
B059	390	C035	220		
B060	390	C036	240		
		C037	260		
		C038	280		
C001	+5	C039	300		
C002	+30	C040	320		
C003	+80	C041	340		
C004	+110	C042	360		
C005	+135	C043	370		
C006	+250	C044	370		
C007	+250	C045	380		
C008	+200	C046	390		
C009	+170	C047	400		
C010	+145	C048	405		

APPENDIX A - PARTICIPANTS LIST

Scientific

Malcolm Argyle	University of Waterloo
Tim Côté	Continental Geoscience Division
Jim Craven	Continental Geoscience Division
Dave Forsyth	Continental Geoscience Division
Ruth Jackson	Atlantic Geoscience Centre
Randell Stephenson	VRIJE University, Amsterdam

Navigation

Jack Davison	Fisheries & Oceans, Bedford Institute
Morely Wright	Fisheries & Oceans, Bedford Institute

Technical Support

Tim Cartwright	Geophysics Division
Larry Johnson	Atlantic Geoscience Centre
Robert Schieman	Geophysics Division

Aircrew

Rotary Wing	Canadian Helicopters, Edmonton
Brian Cleveland	Suru Pattel
Bruce Moore	Scott Dinsmore
Don Cleveland	James Mode
Fixed Wing	Kenn Borek Air, Edmonton
Duncan Grant	Jarek Matak
Bruce Alcorn	Jim Voss
Monty Stevenson	Marc Poppleton

APPENDIX B - WATER WAVE AND CRUSTAL SECTIONS

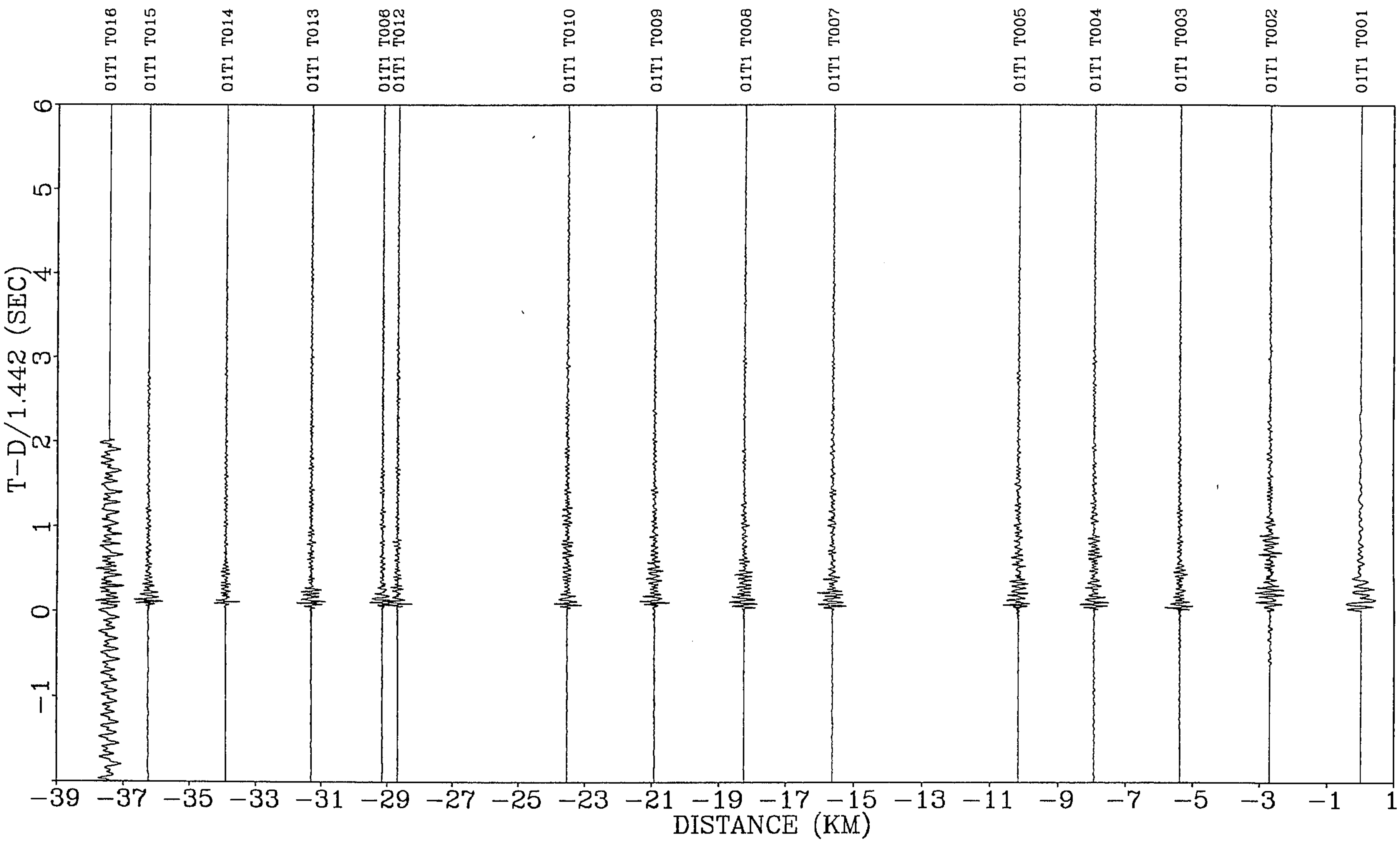
The seismic sections are arranged according to shot, with the water wave section (where applicable) presented first, followed by the crustal section. An water wave reduction velocity of 1.441 km/s was used for the majority of shots, but a slightly higher reduction velocity of 1.442 km/s was used for shots T1-A4 as explained in the report. All the crustal sections are reduced at 6.0 km/s.

Note that all traces are normalized with respect to the largest amplitude on the trace within the window of data plotted and thus do not reflect true amplitudes. Normally the large water wave amplitude would render the crustal amplitudes too small to be seen. For these seismograms, the water wave has been muted using a velocity of 1.441 km/s.

No static corrections for water depth or topography have been applied to the plotted data.

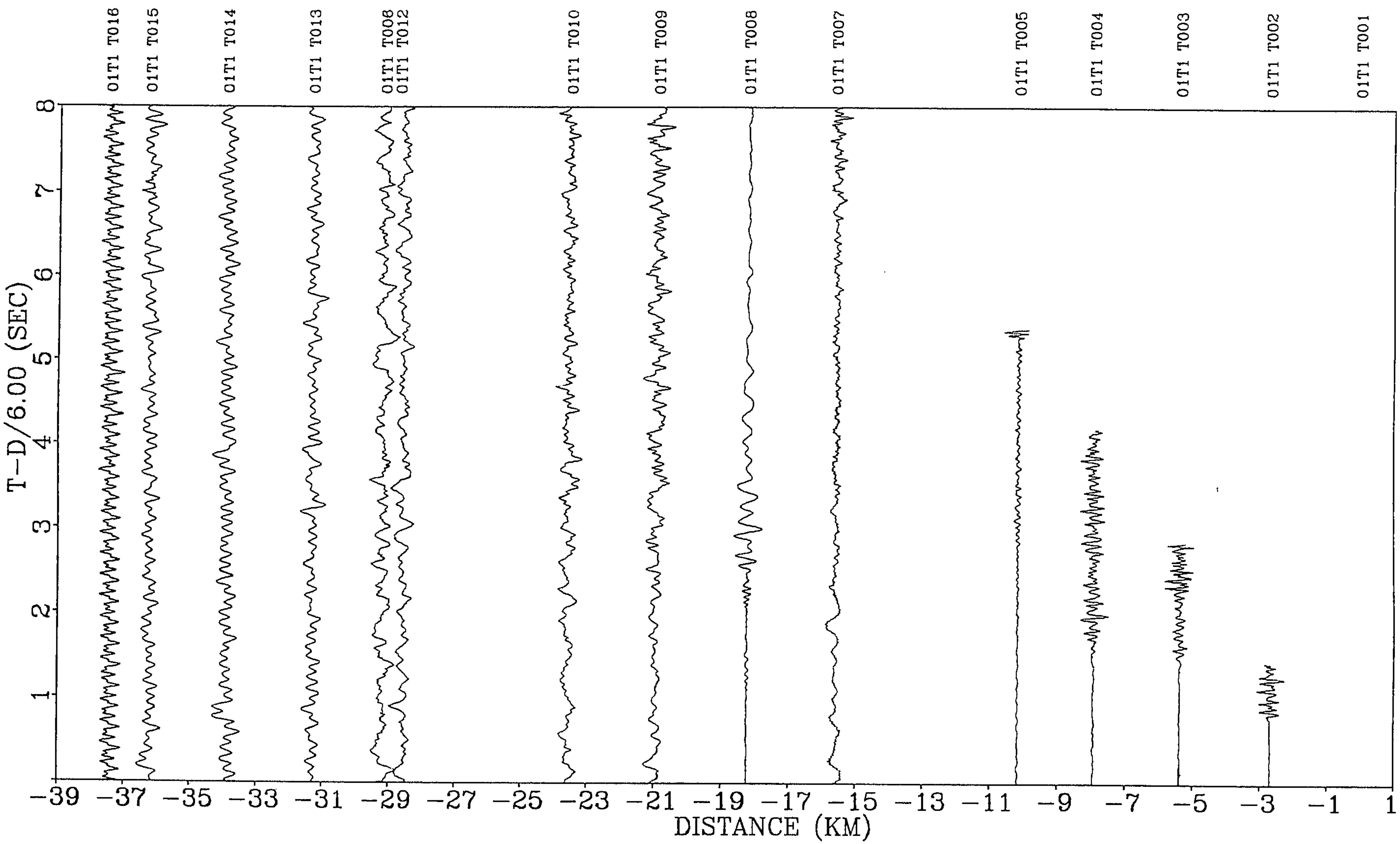
ICE ISLAND 1990:

Line T Shot T1, Water Wave Section



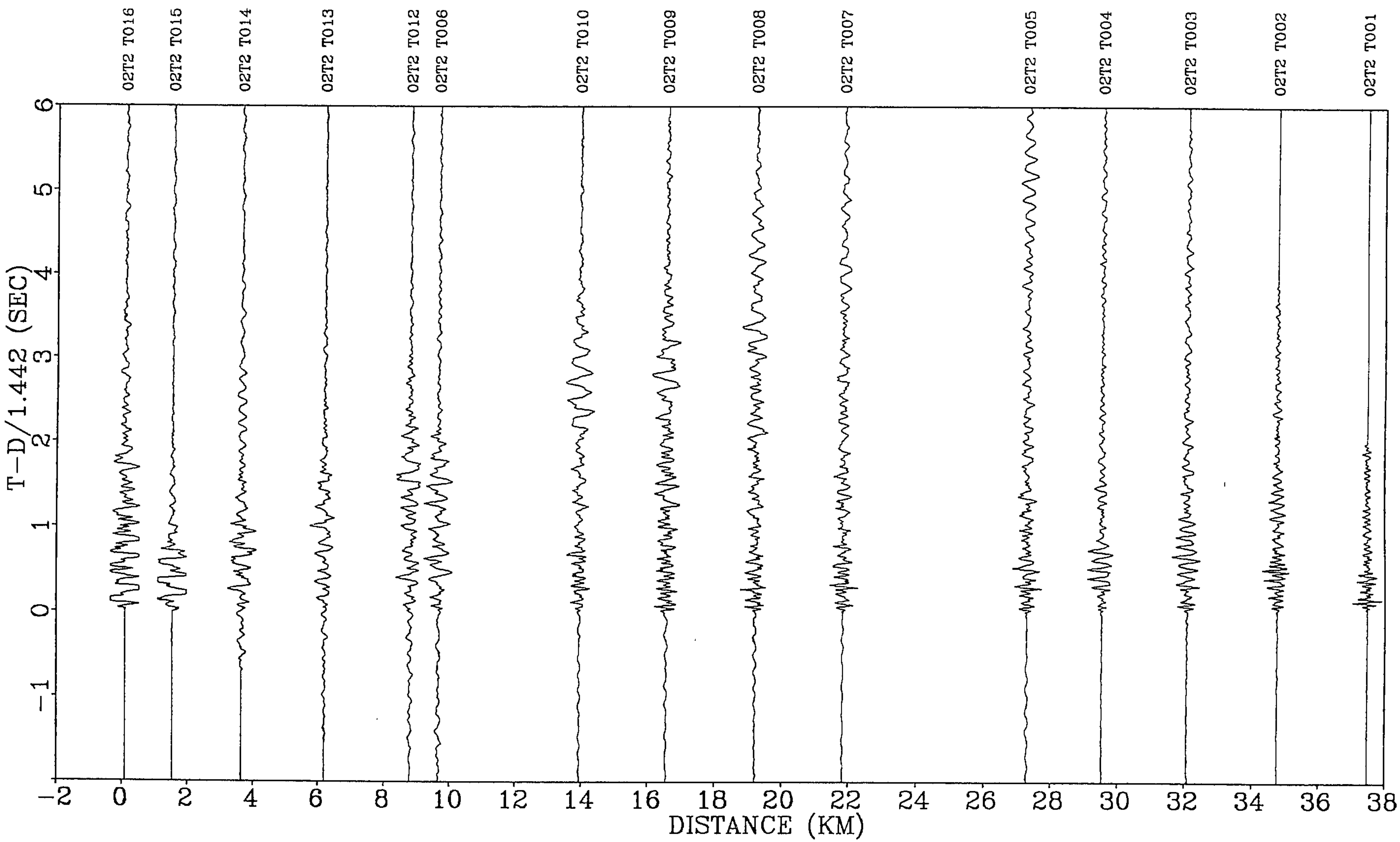
ICE ISLAND 1990:

Line T Shot T1, Crustal Section



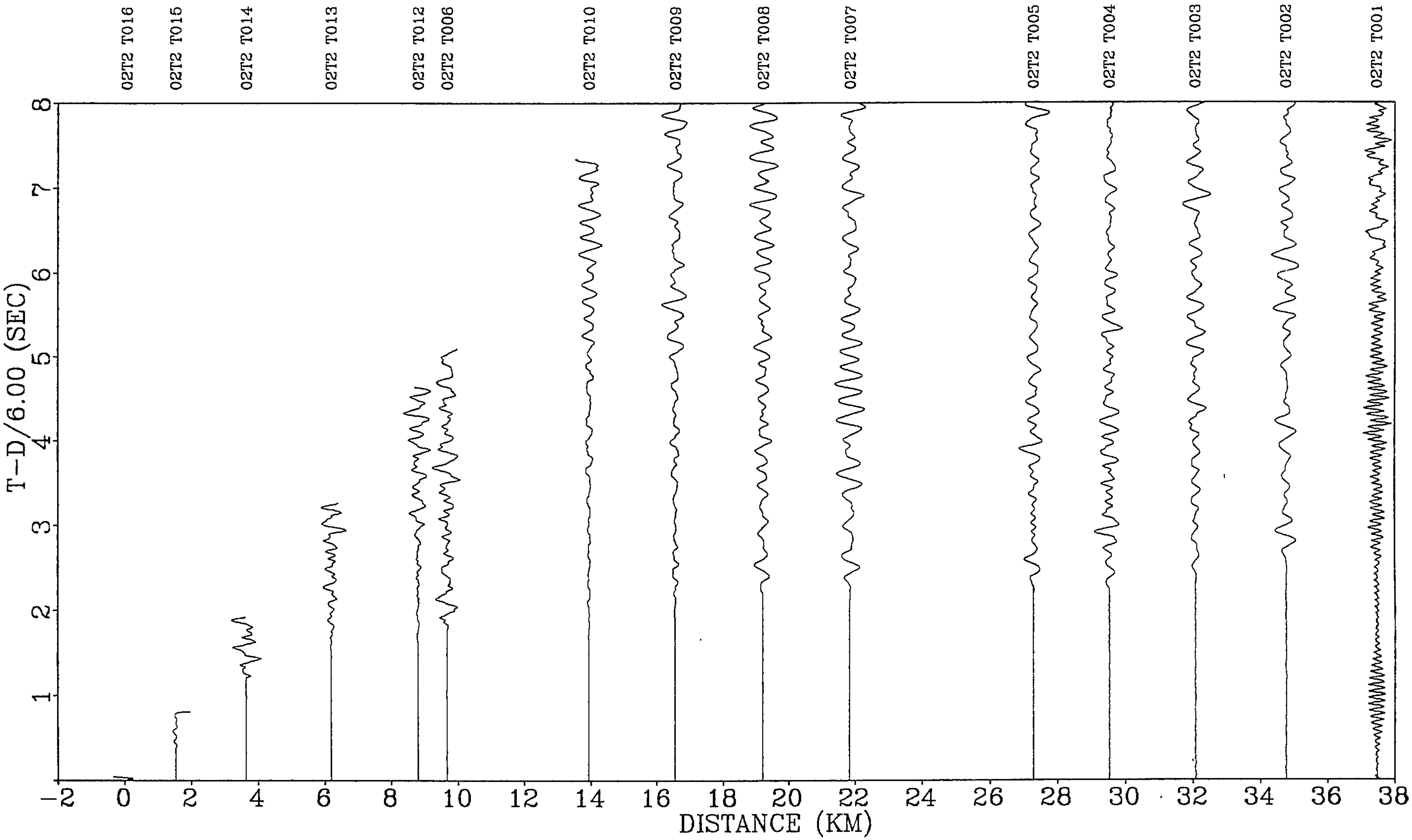
ICE ISLAND 1990:

Line T Shot T2, Water Wave Section



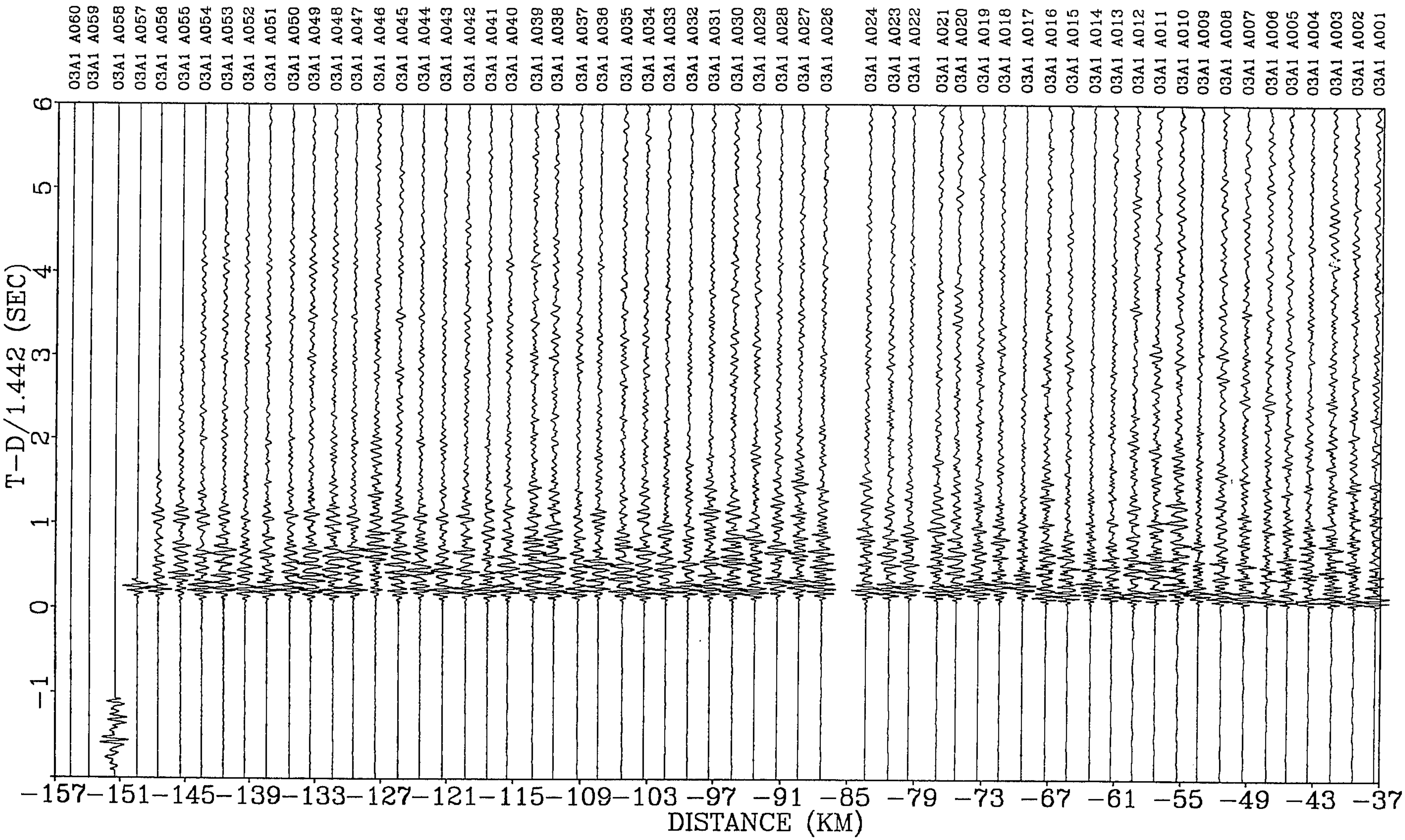
ICE ISLAND 1990:

Line T Shot T2, Crustal Section



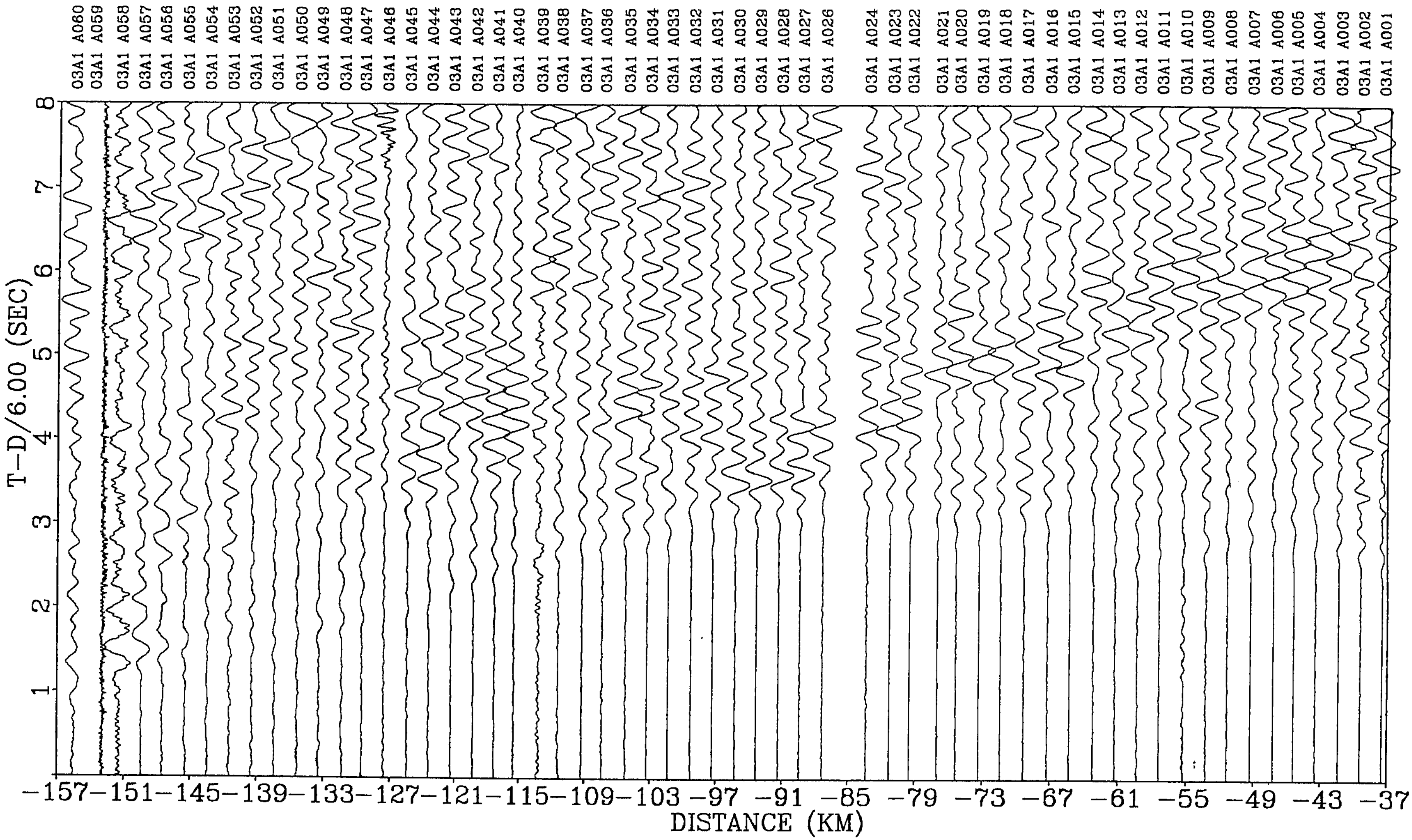
ICE ISLAND 1990:

Line A Shot A1, Water Wave Section



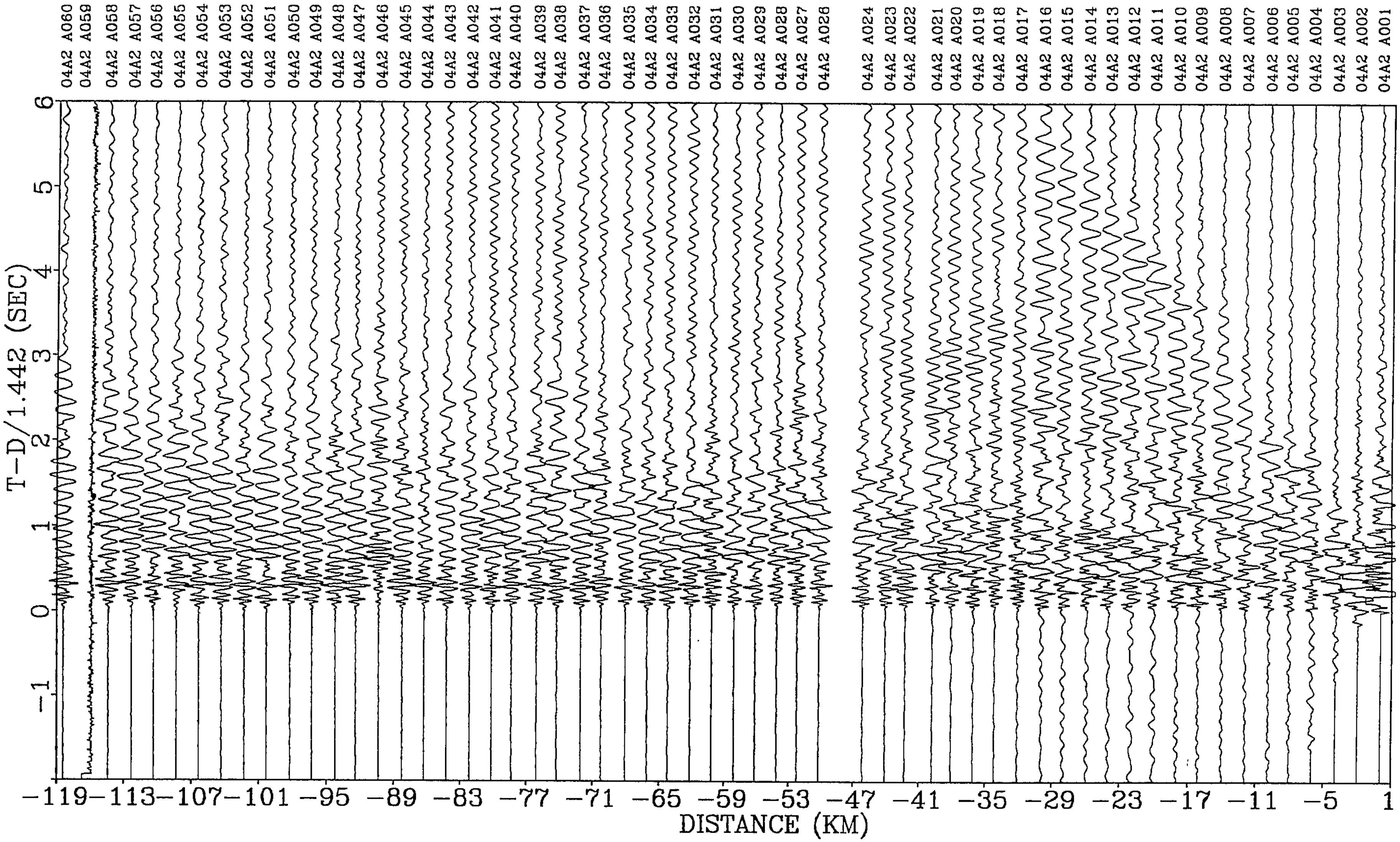
ICE ISLAND 1990:

Line A Shot A1, Crustal Section



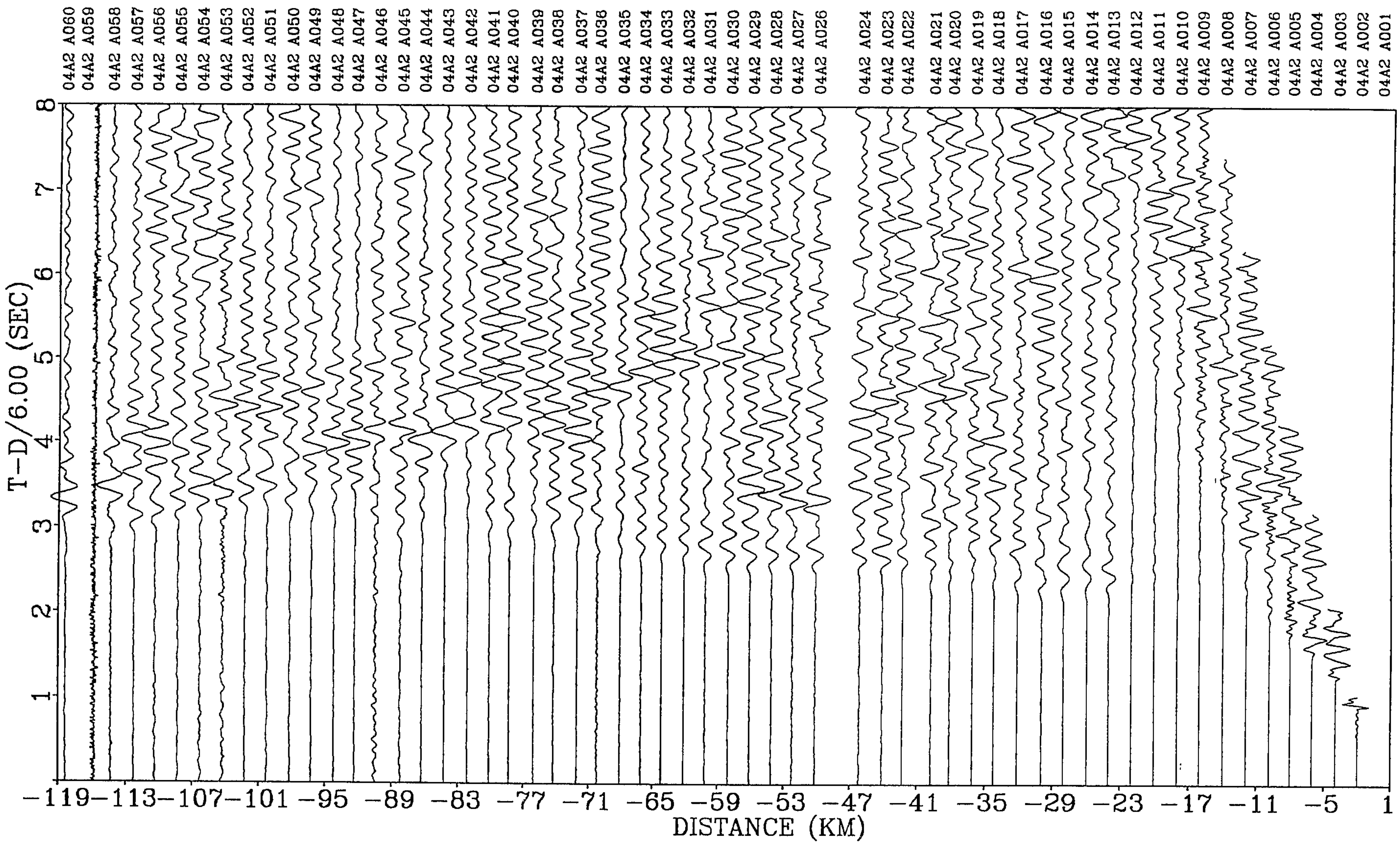
ICE ISLAND 1990:

Line A Shot A2, Water Wave Section



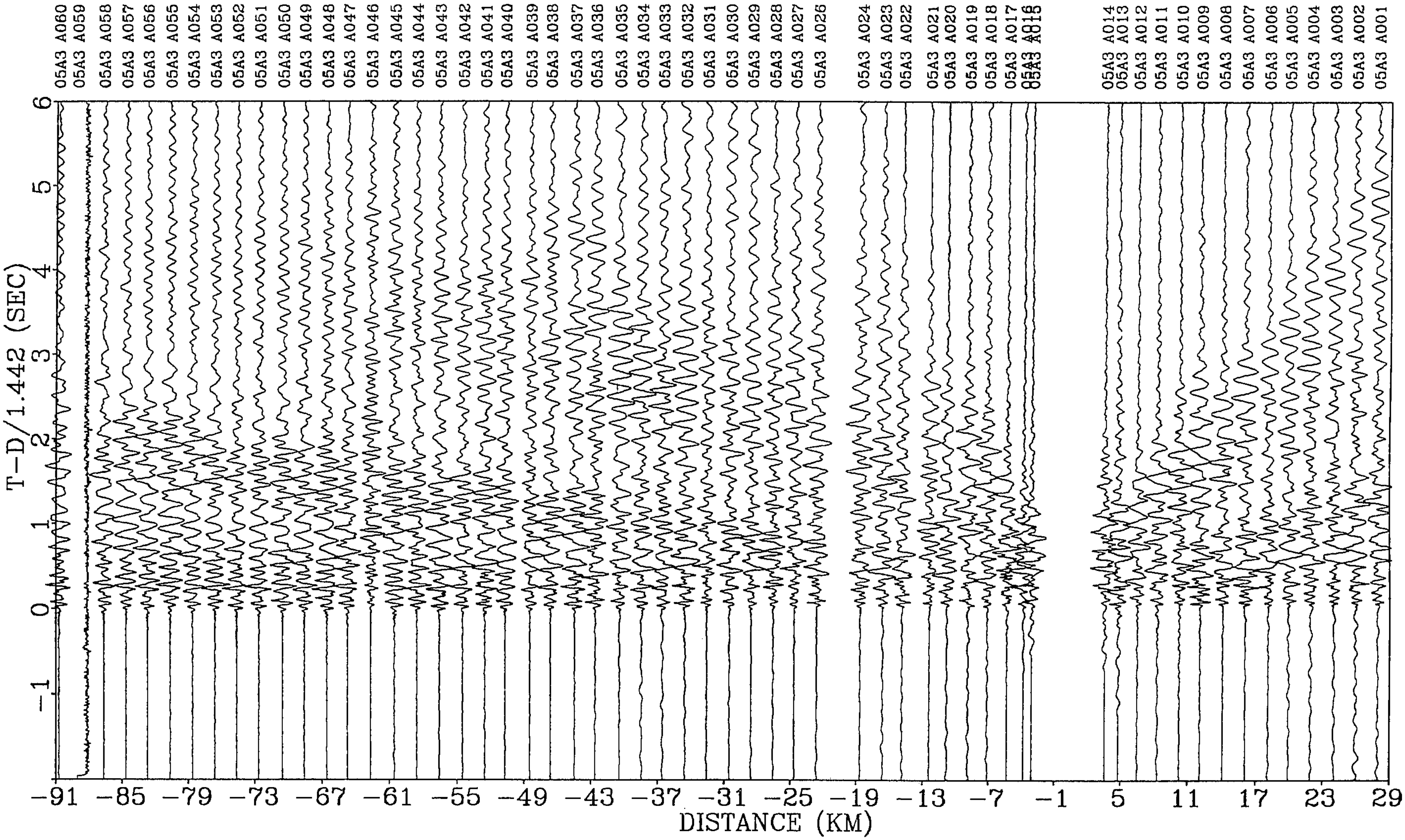
ICE ISLAND 1990:

Line A Shot A2, Crustal Section



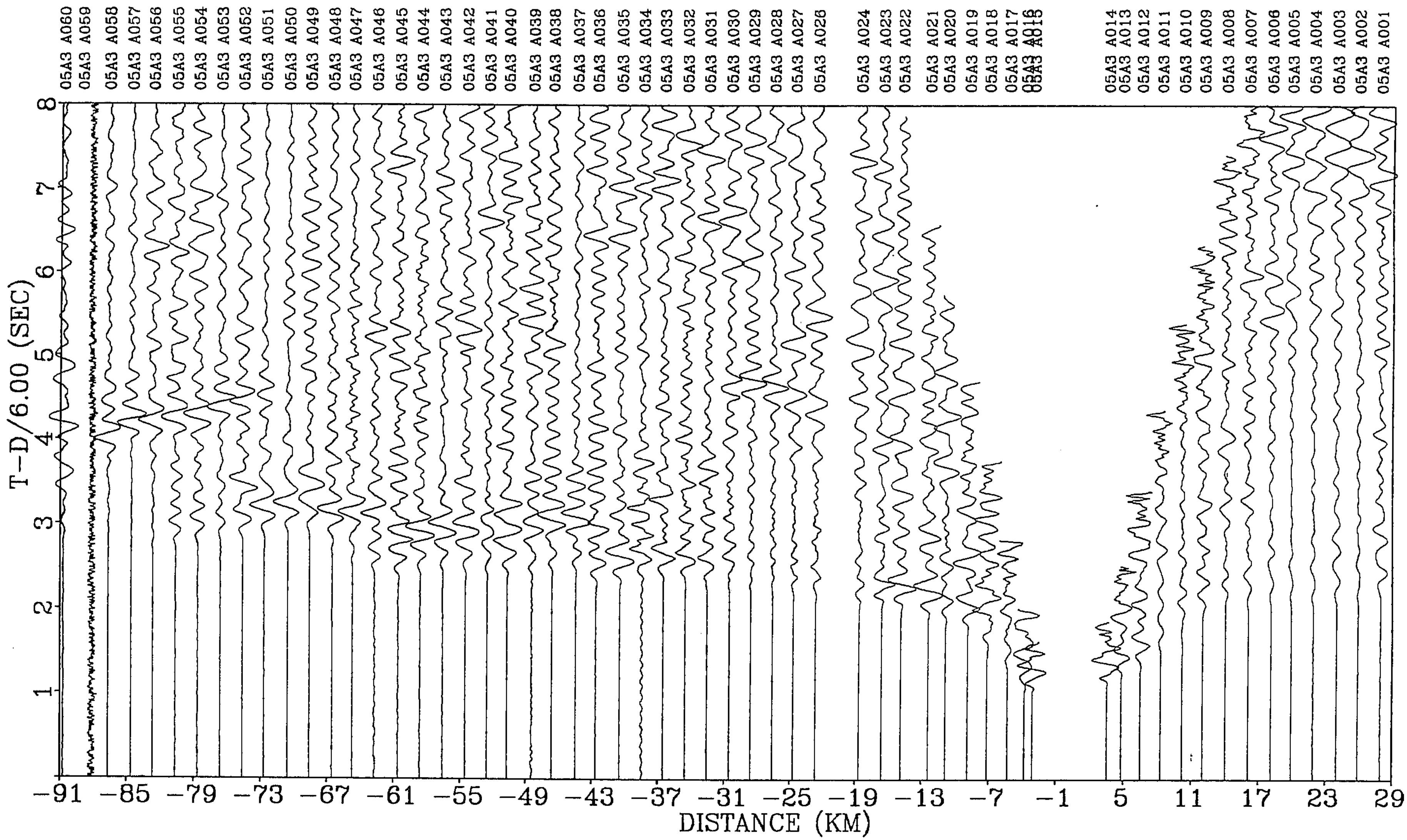
ICE ISLAND 1990:

Line A Shot A3, Water Wave Section



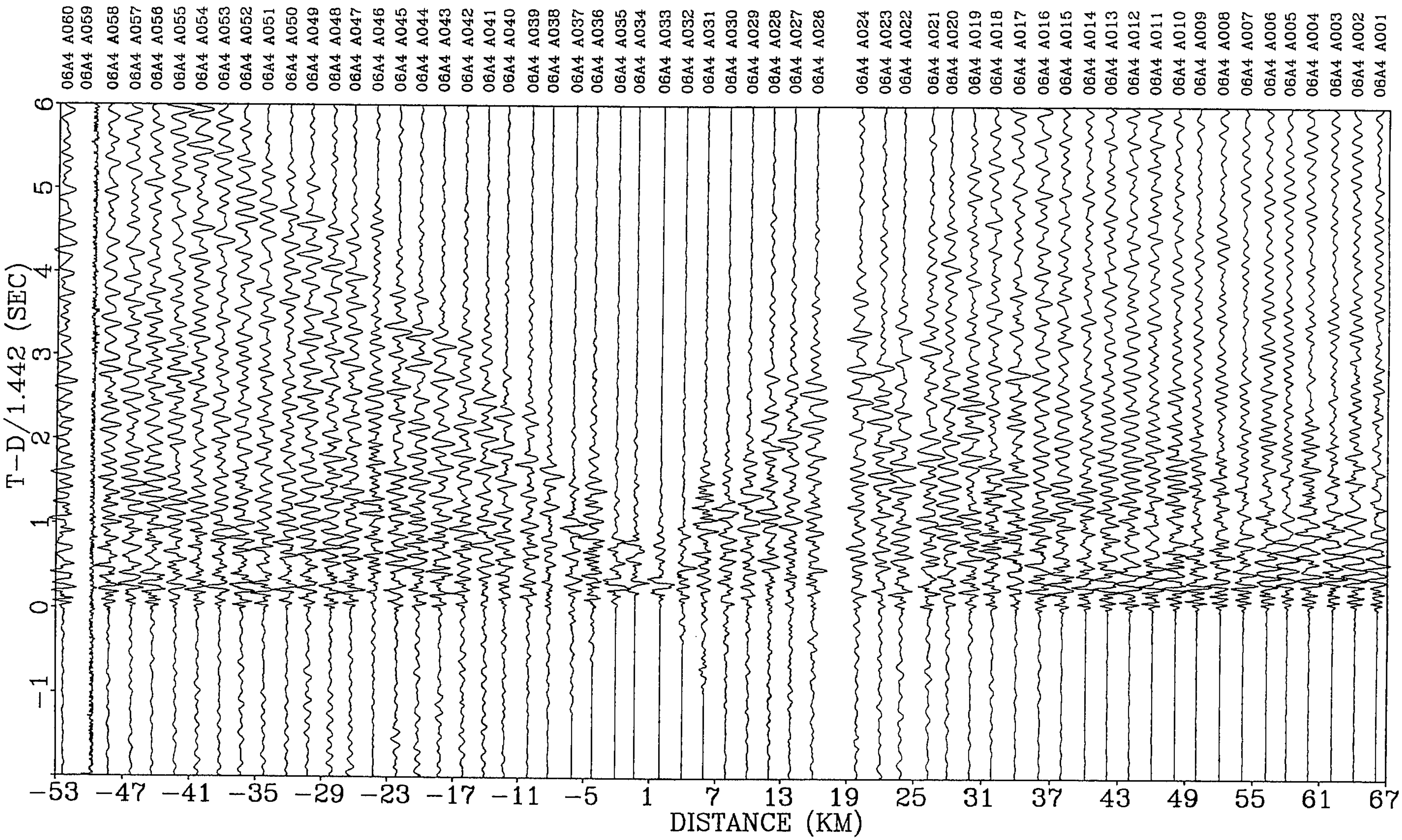
ICE ISLAND 1990:

Line A Shot A3, Crustal Section



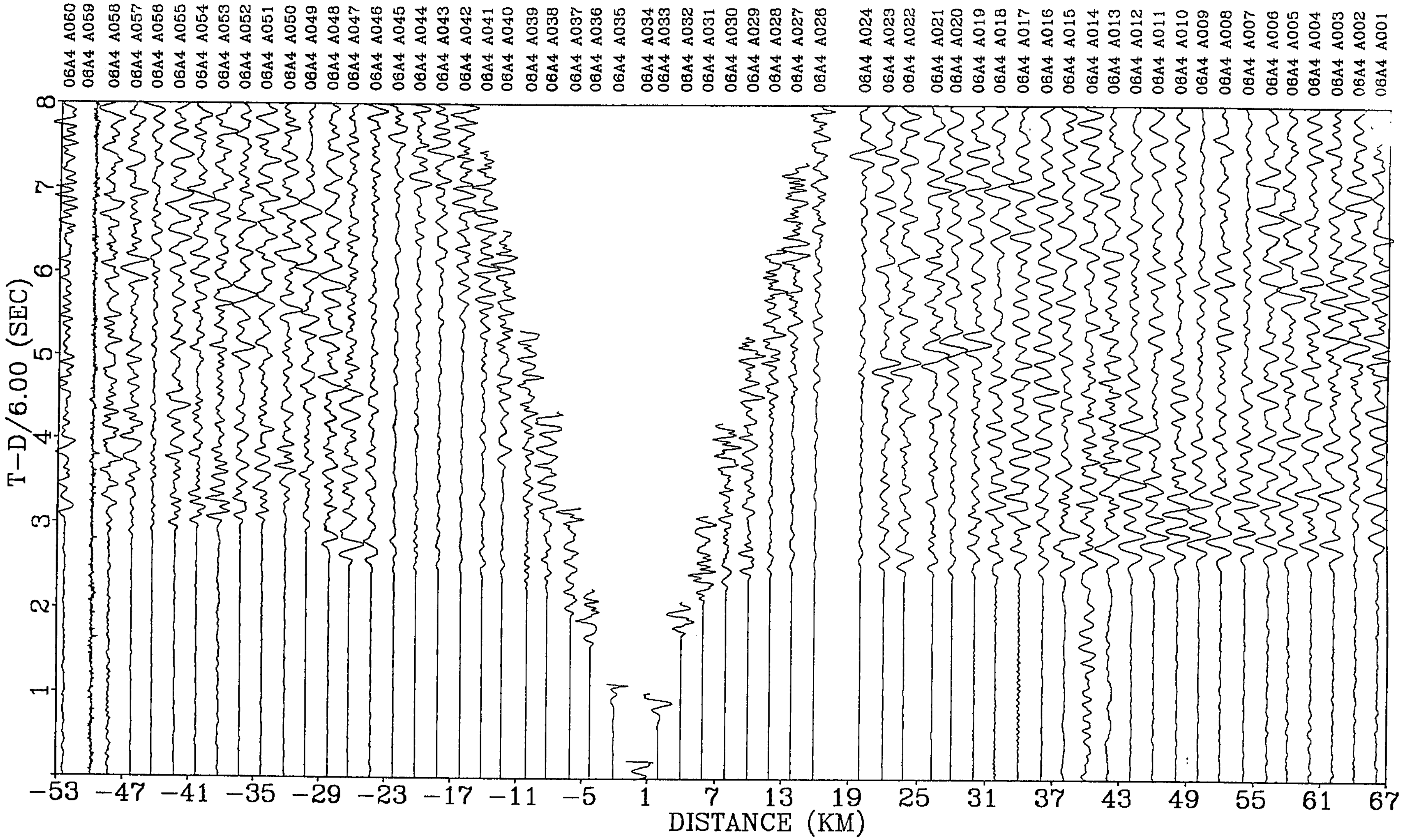
ICE ISLAND 1990:

Line A Shot A4, Water Wave Section



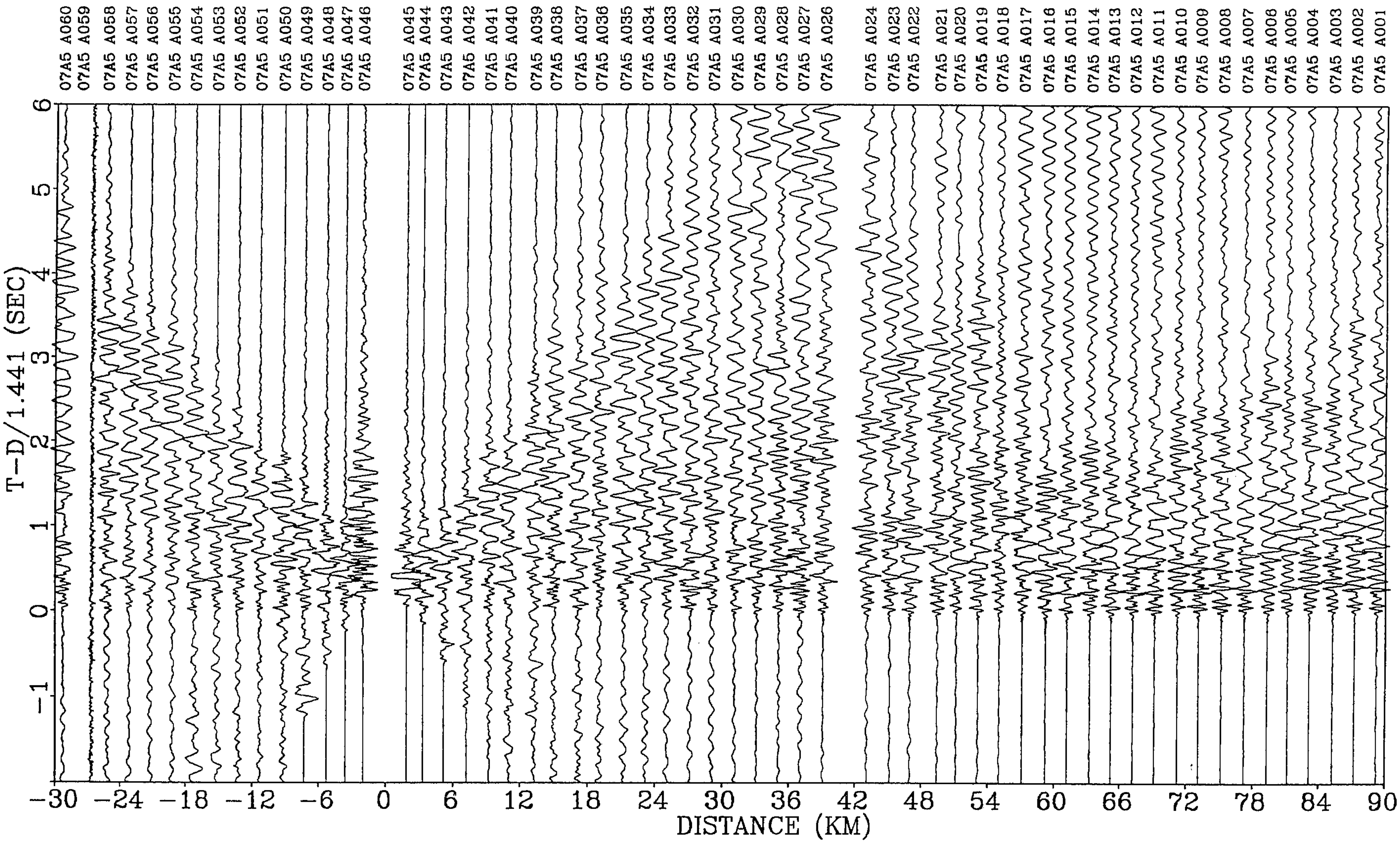
ICE ISLAND 1990:

Line A Shot A4, Crustal Section



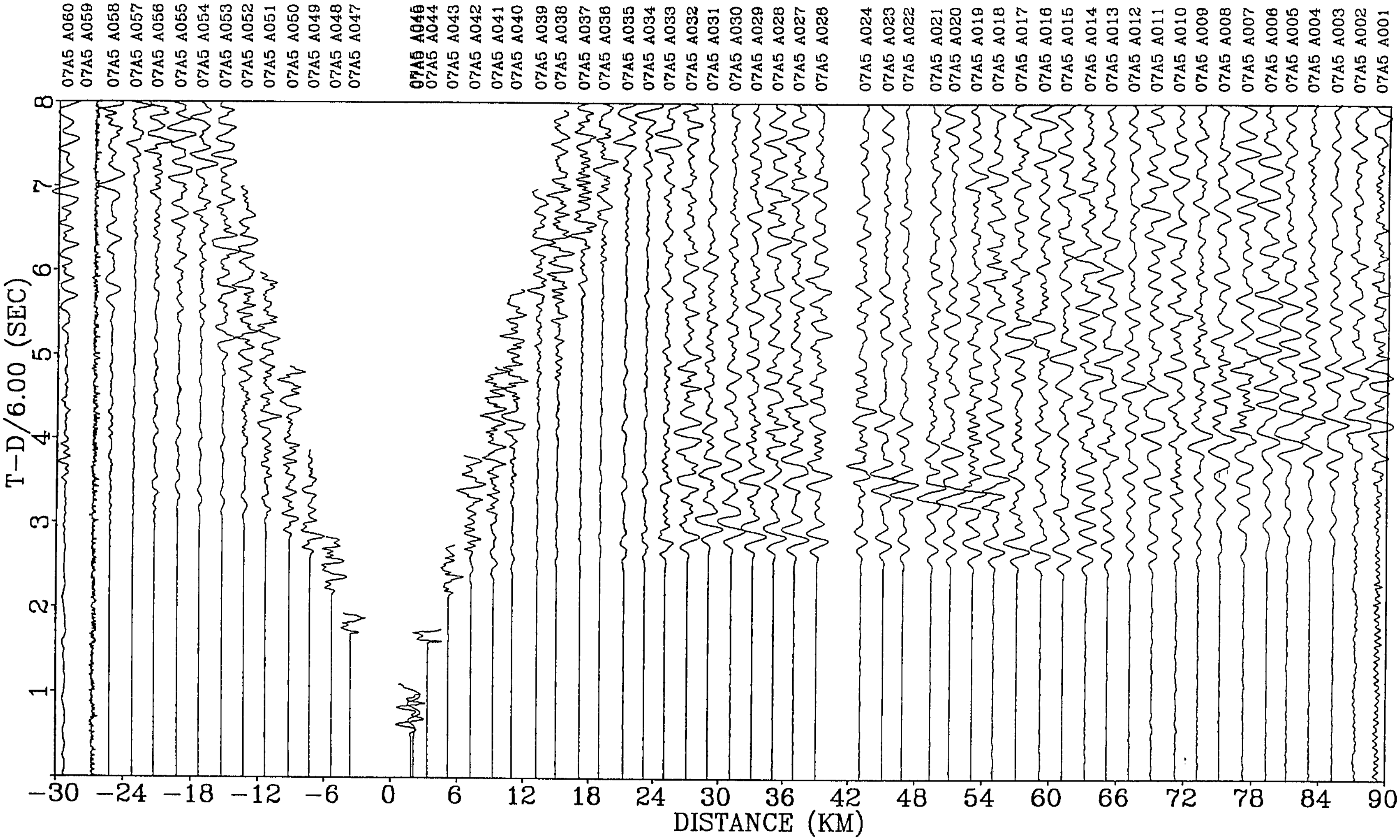
ICE ISLAND 1990:

Line A Shot A5, Water Wave Section



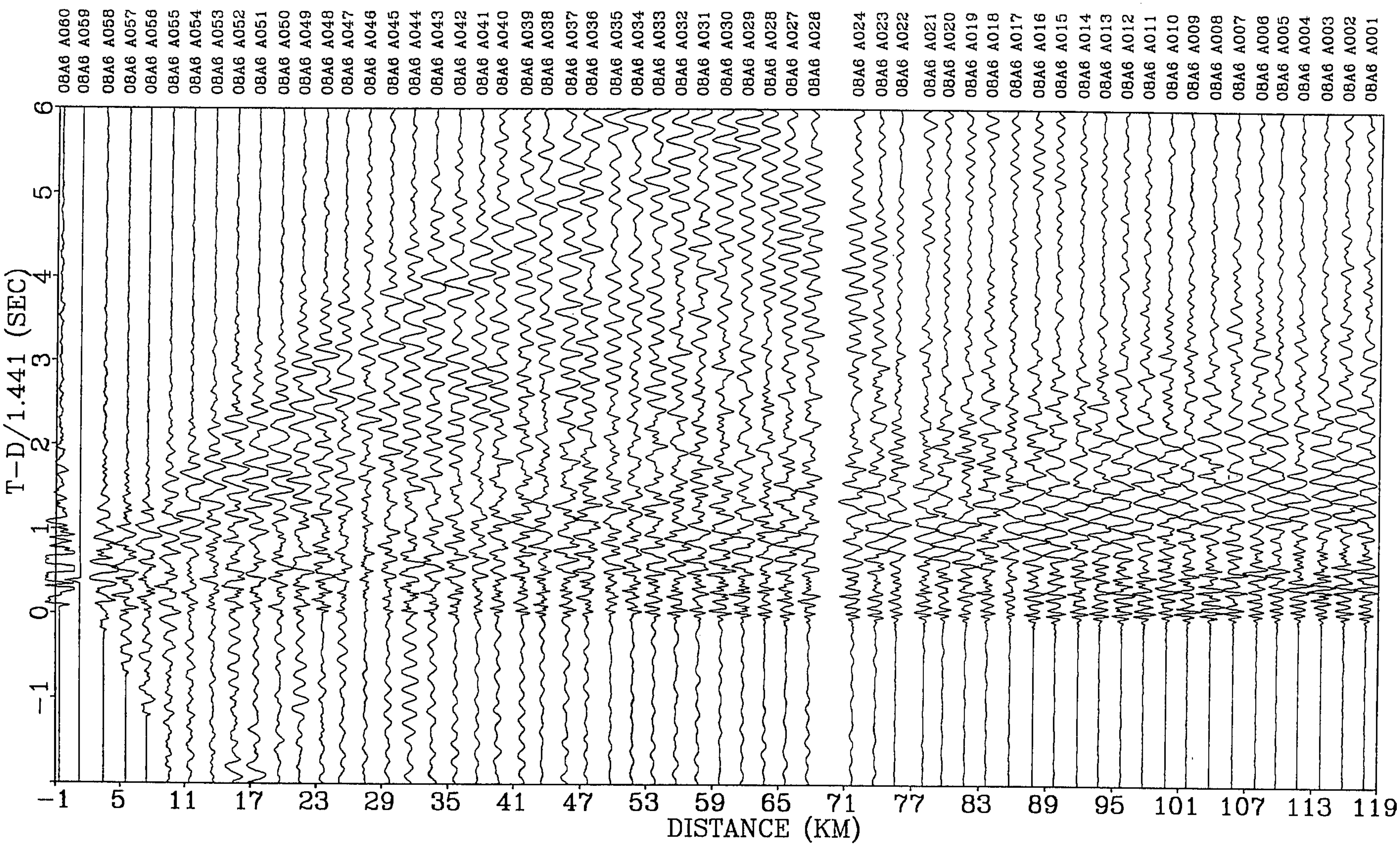
ICE ISLAND 1990:

Line A Shot A5, Crustal Section



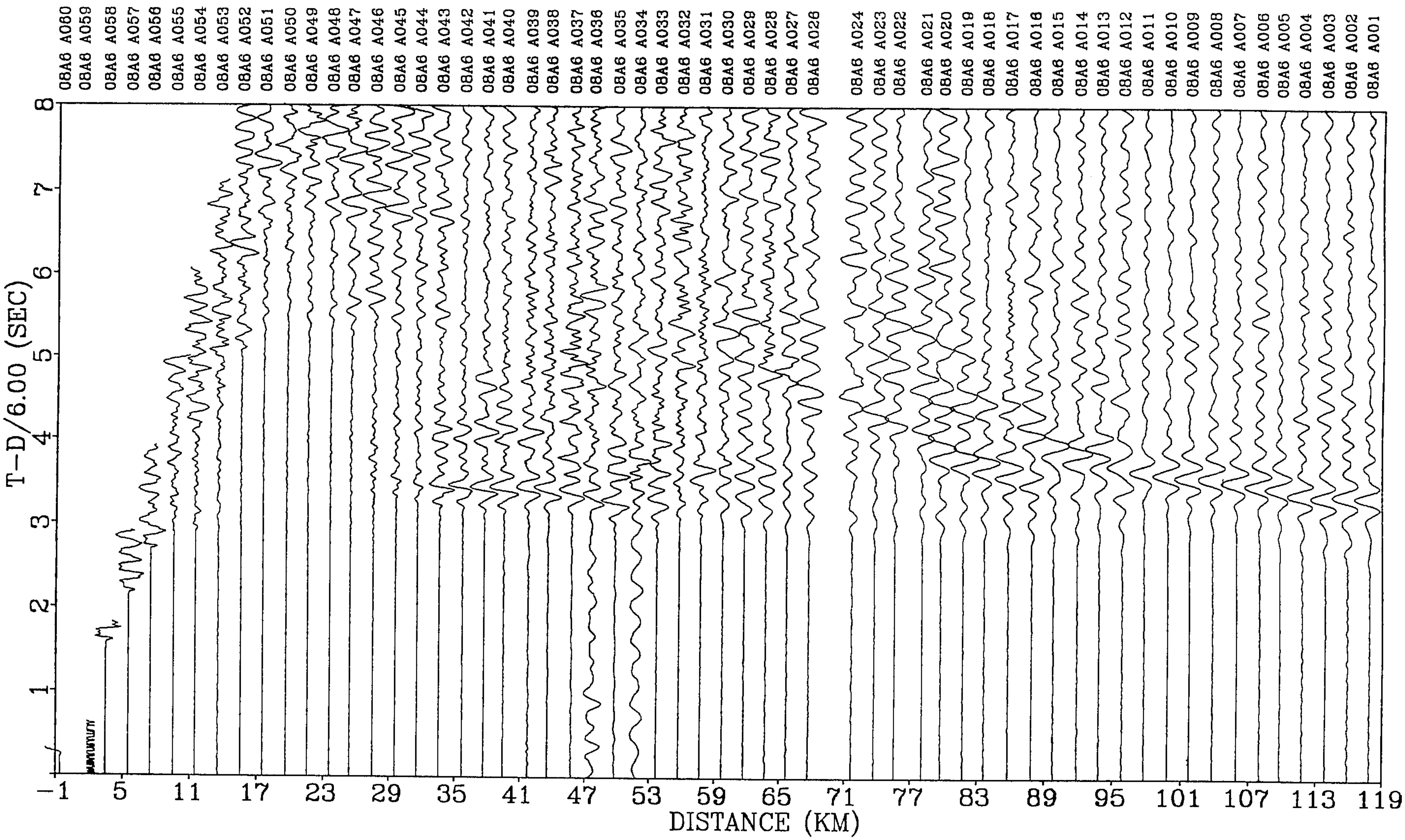
ICE ISLAND 1990:

Line A Shot A6, Water Wave Section



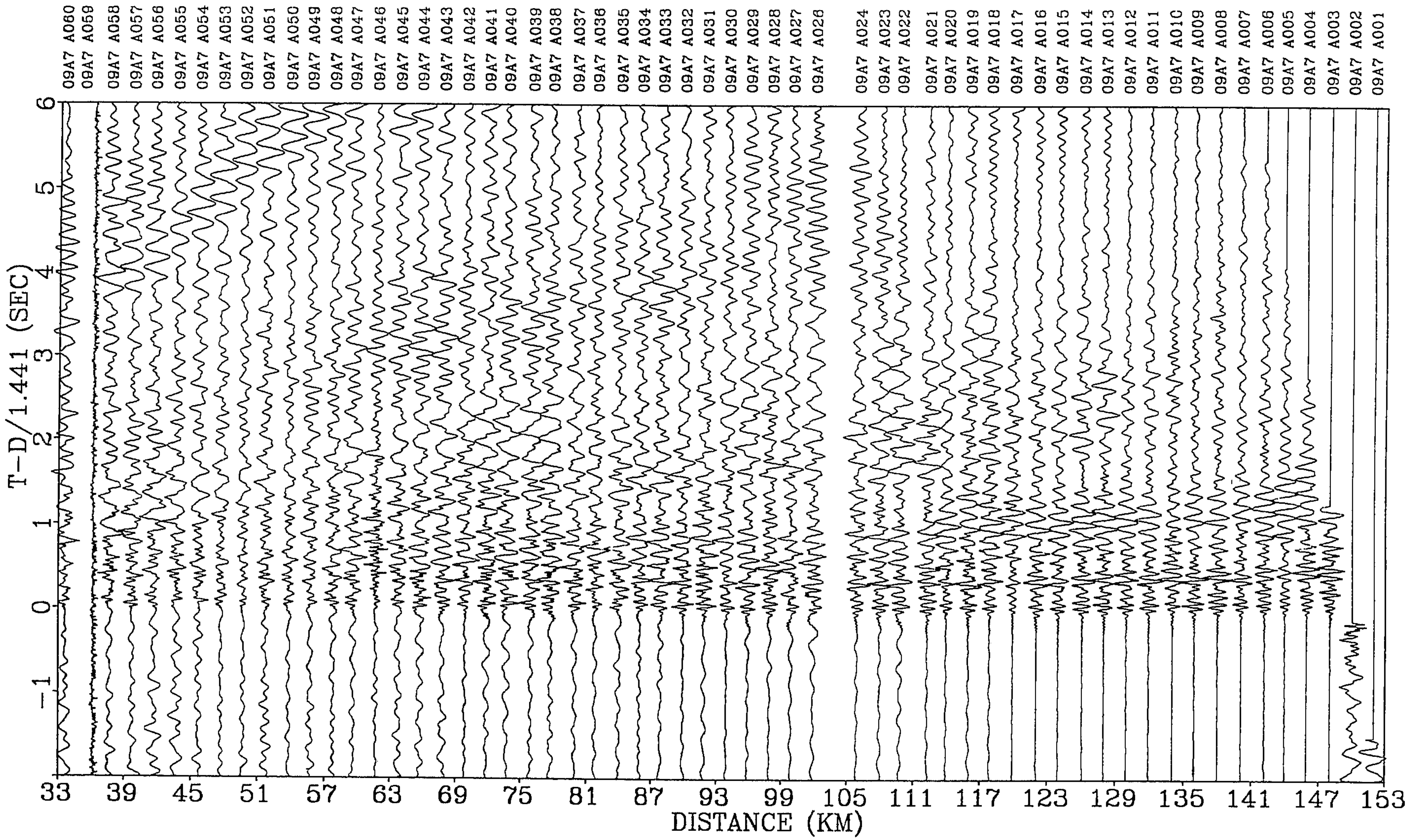
ICE ISLAND 1990:

Line A Shot A6, Crustal Section



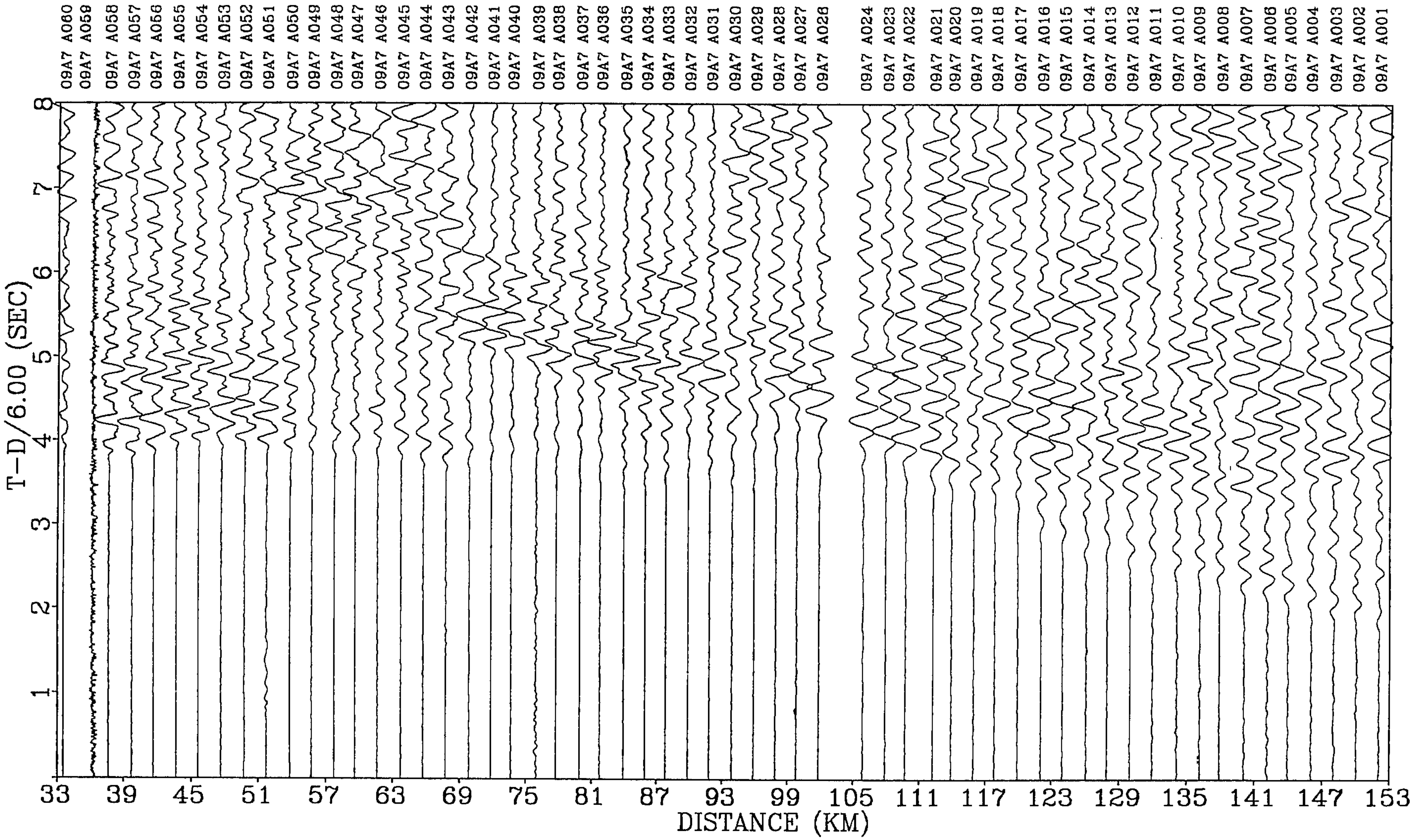
ICE ISLAND 1990:

Line A Shot A7, Water Wave Section



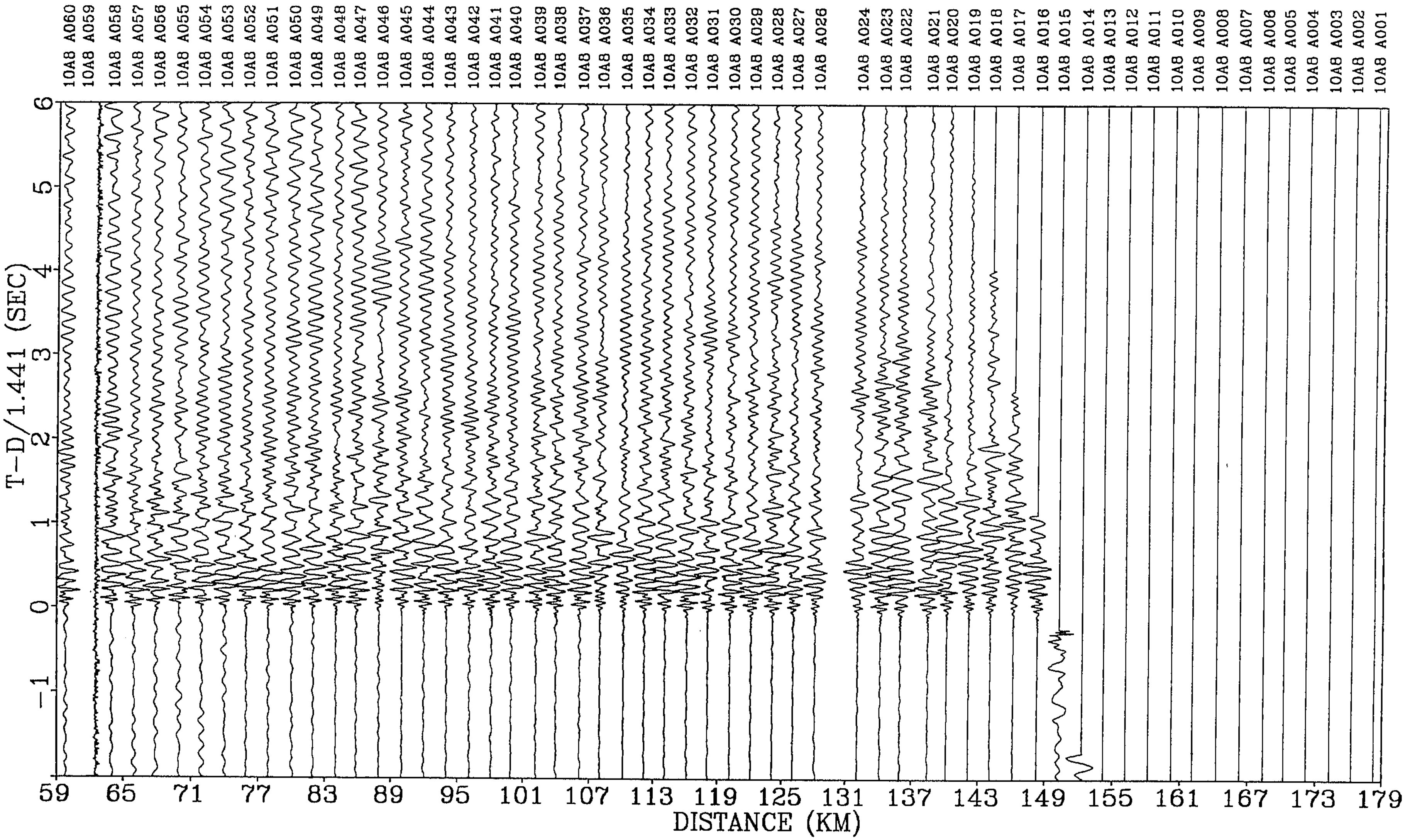
ICE ISLAND 1990:

Line A Shot A7, Crustal Section



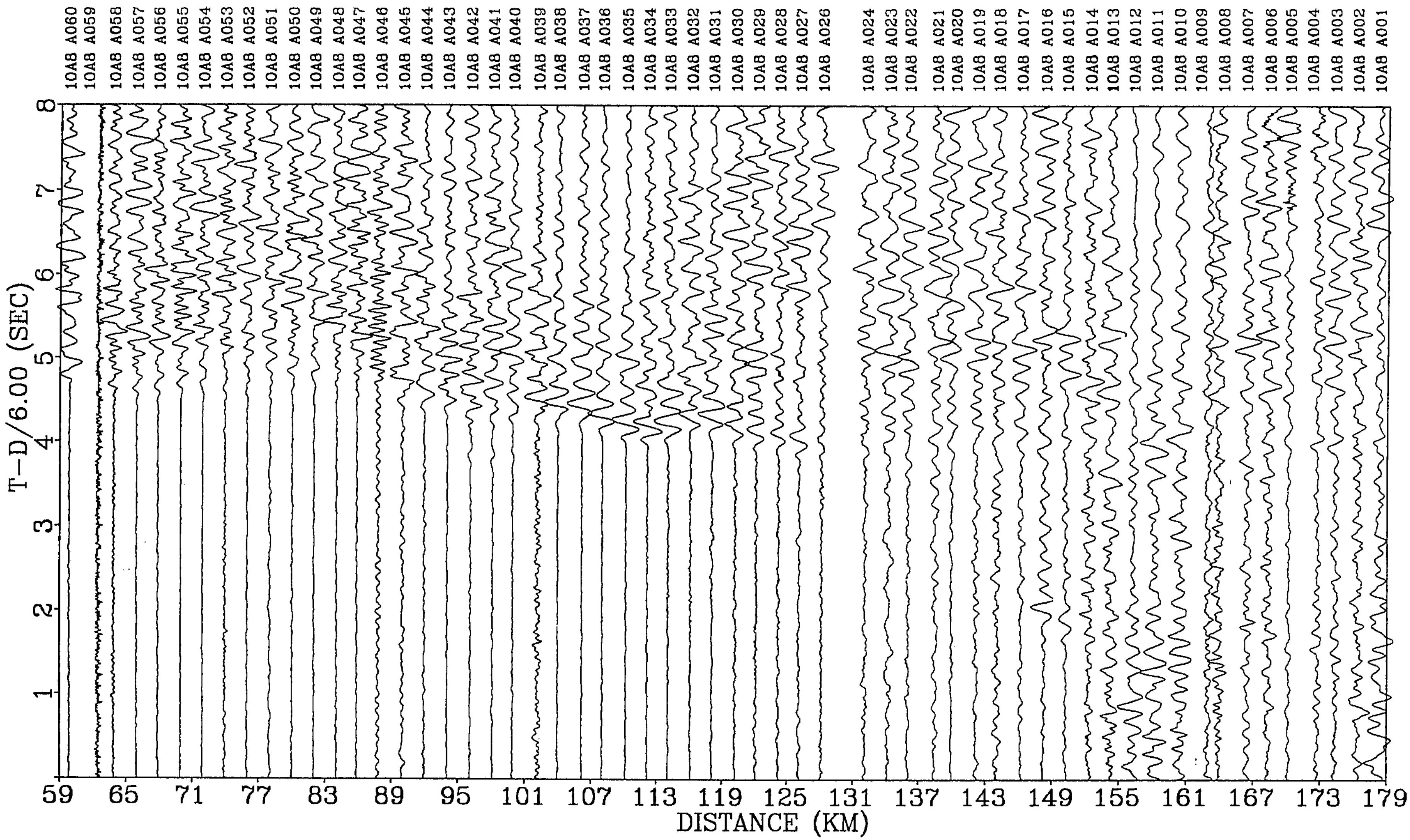
ICE ISLAND 1990:

Line A Shot A8, Water Wave Section



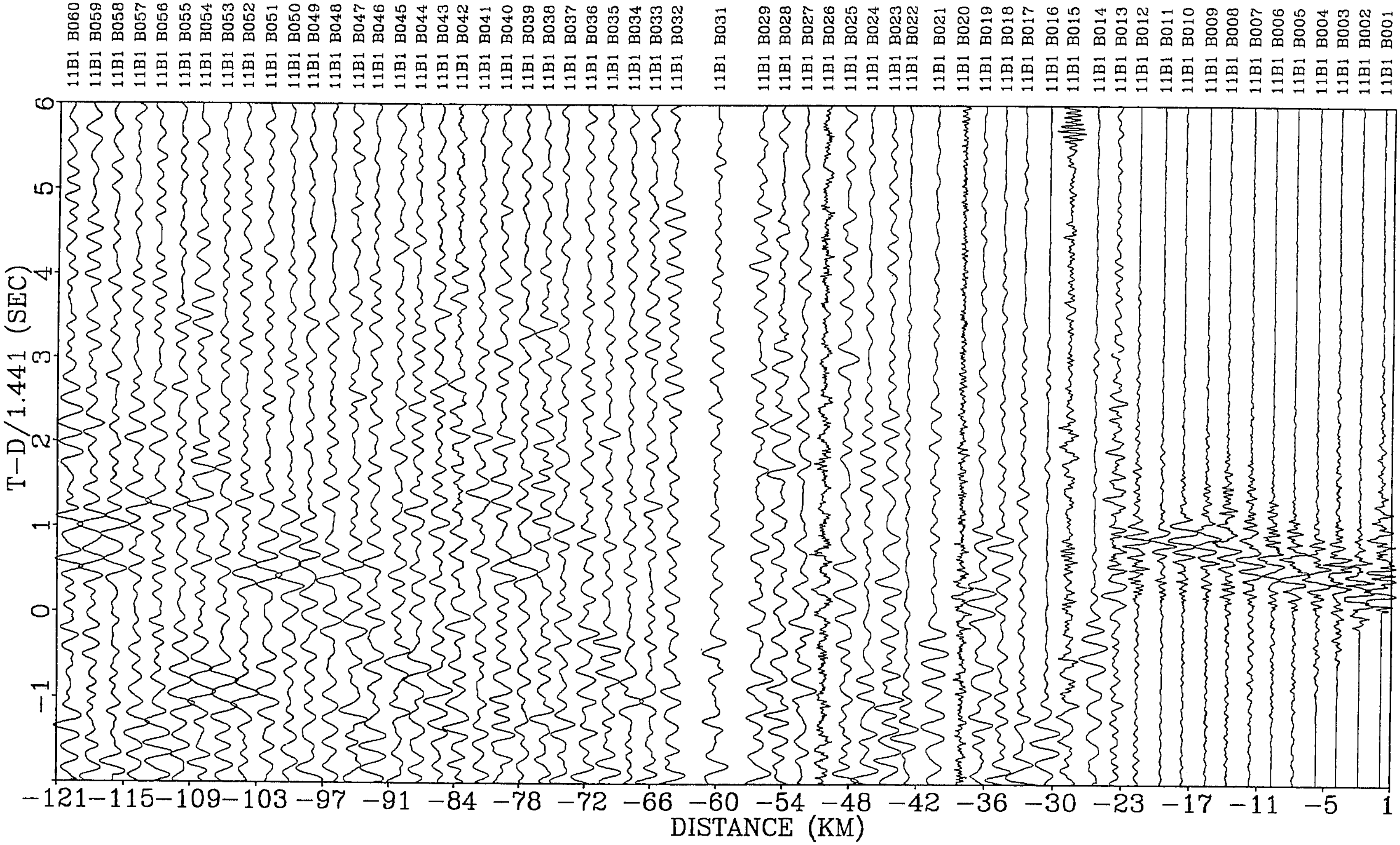
ICE ISLAND 1990:

Line A Shot A8, Crustal Section



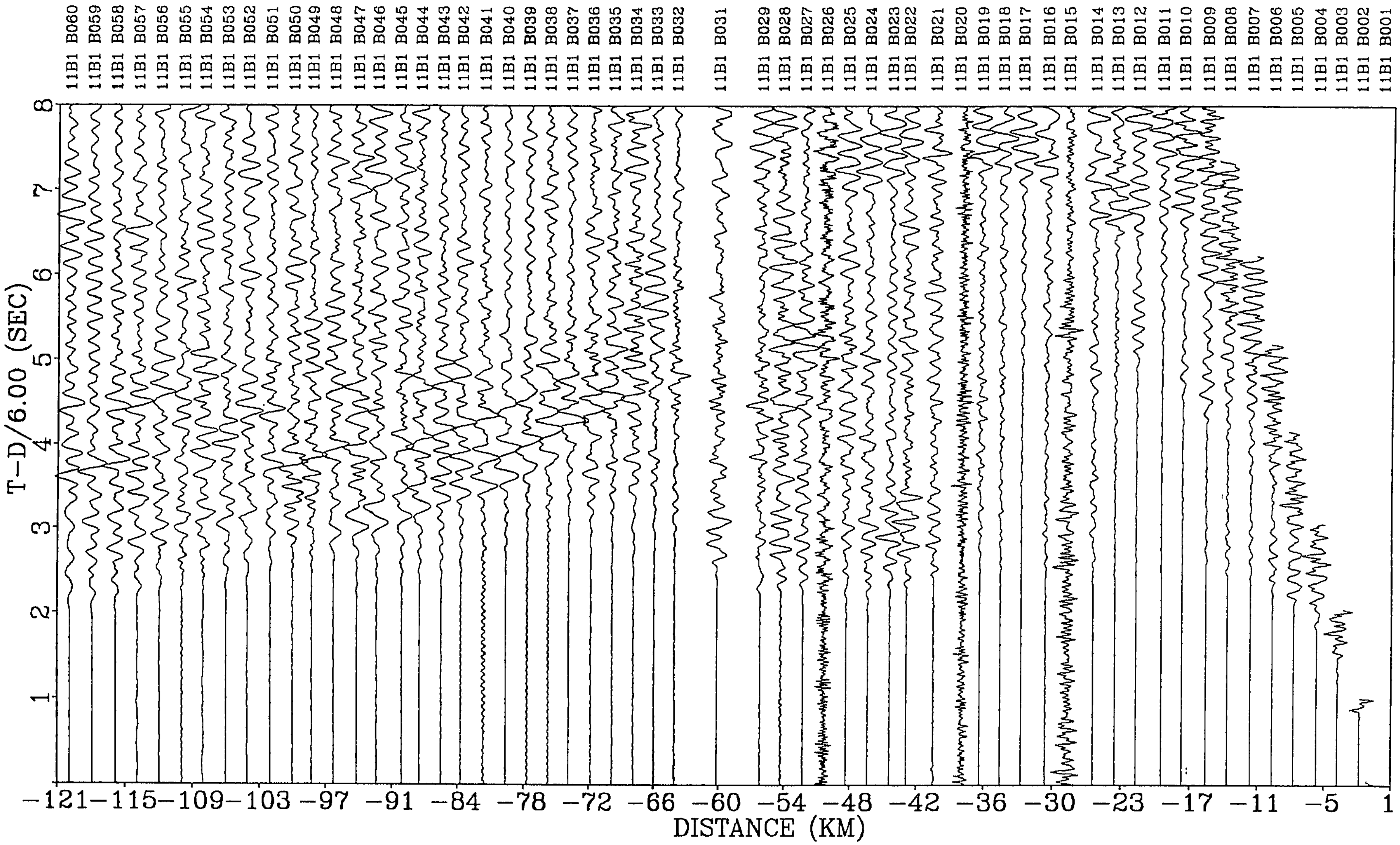
ICE ISLAND 1990:

Line B Shot B1, Water Wave Section



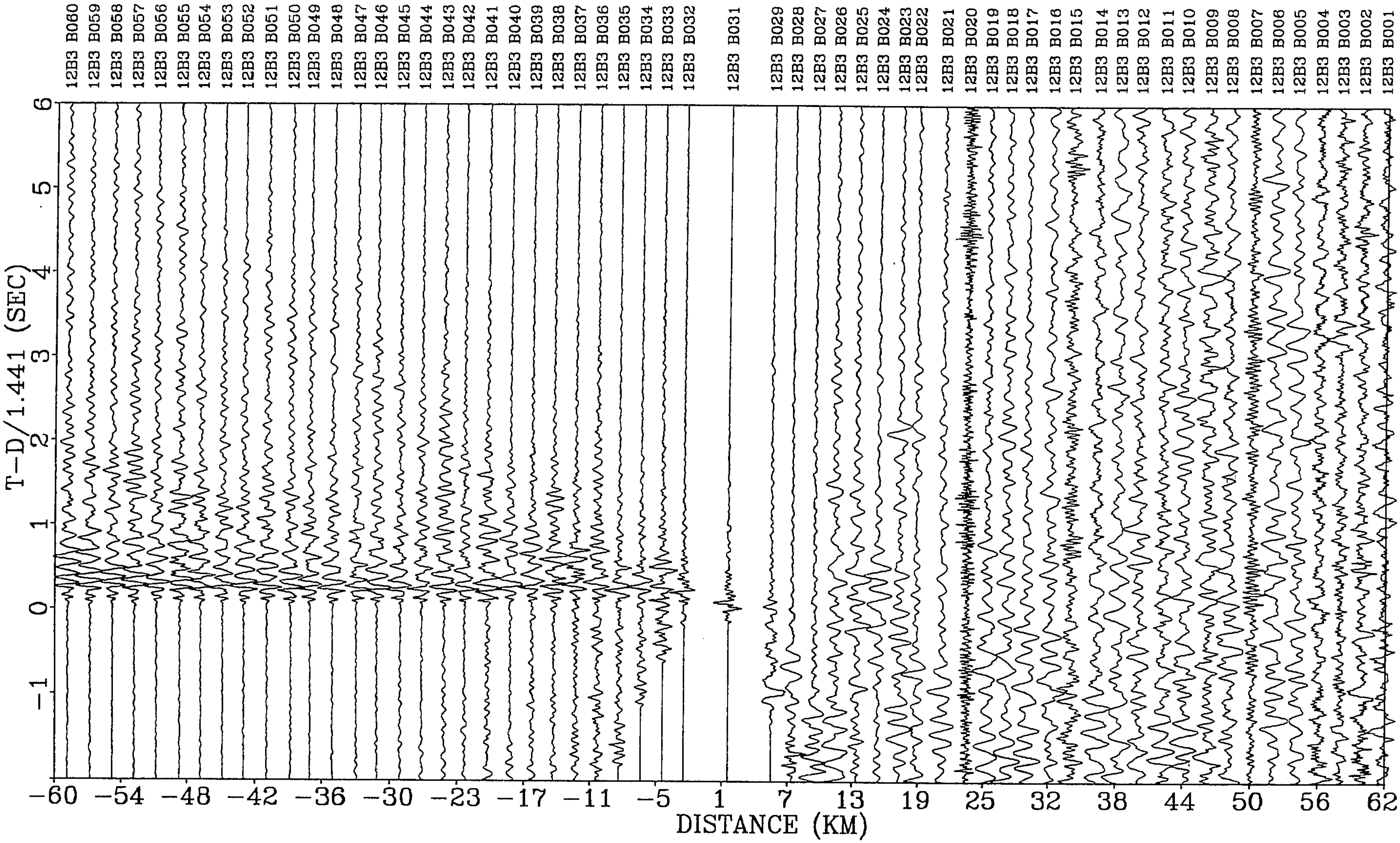
ICE ISLAND 1990:

Line B Shot B1, Crustal Section



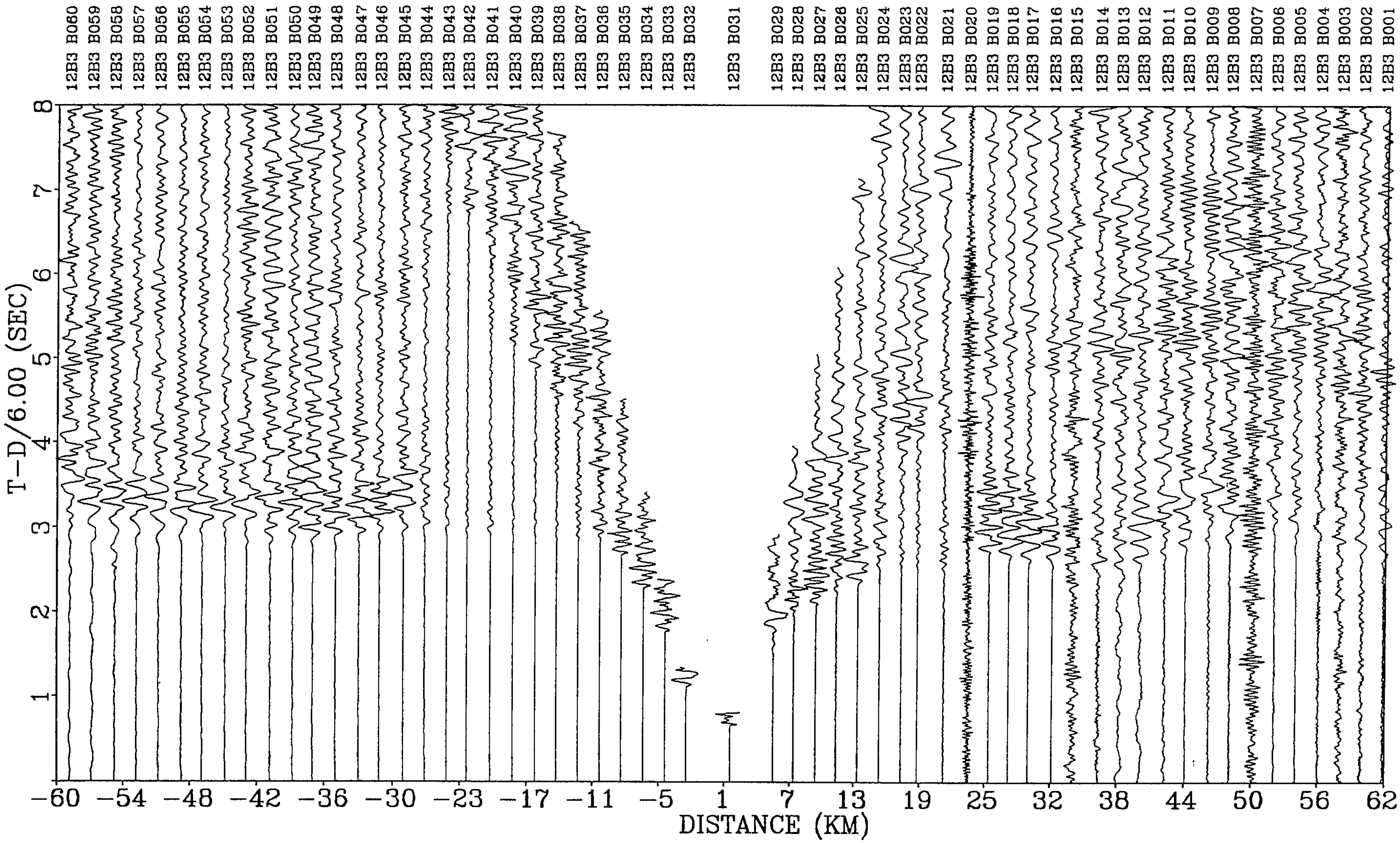
ICE ISLAND 1990:

Line B Shot B3, Water Wave Section



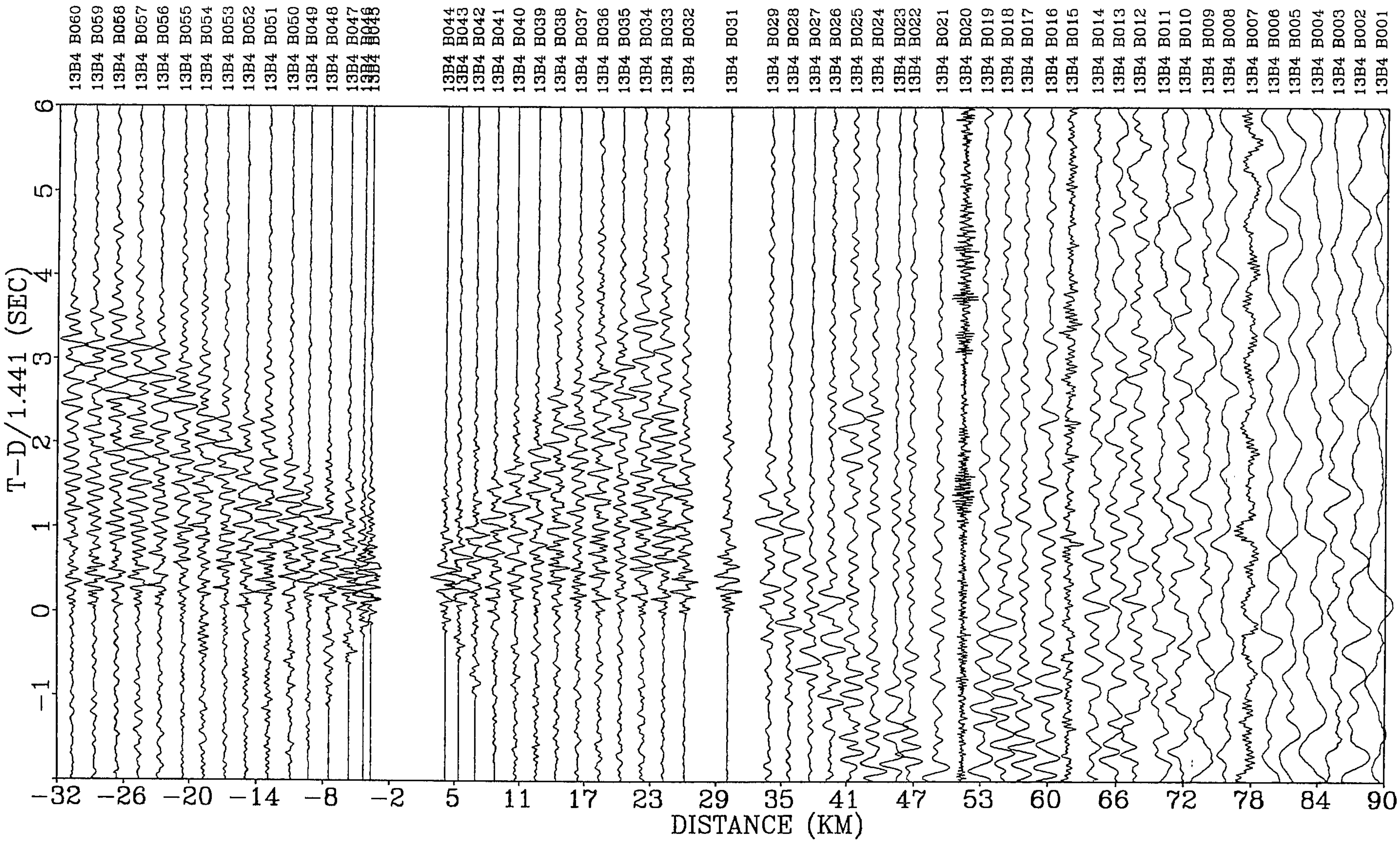
ICE ISLAND 1990:

Line B Shot B3, Crustal Section



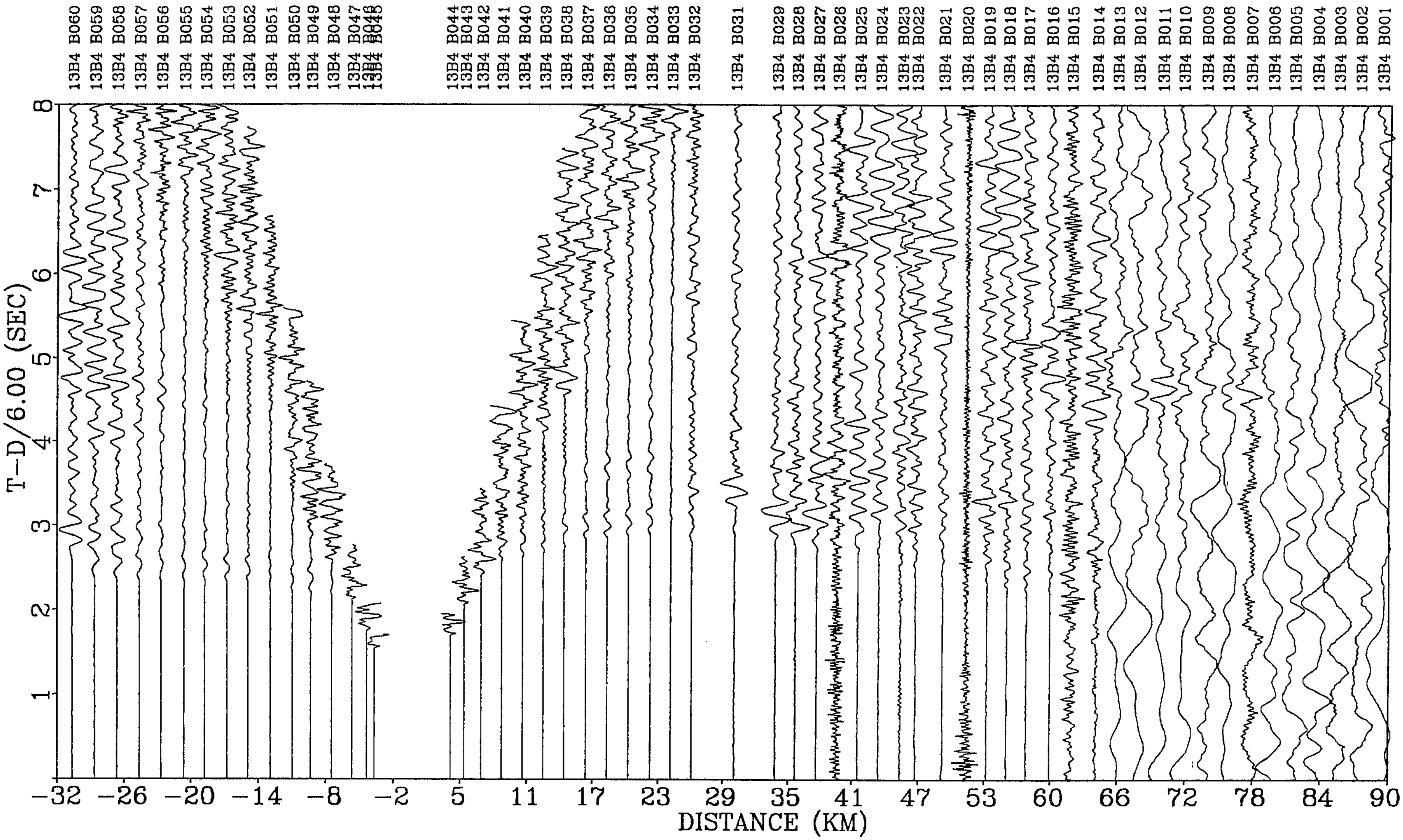
ICE ISLAND 1990:

Line B Shot B4, Water Wave Section



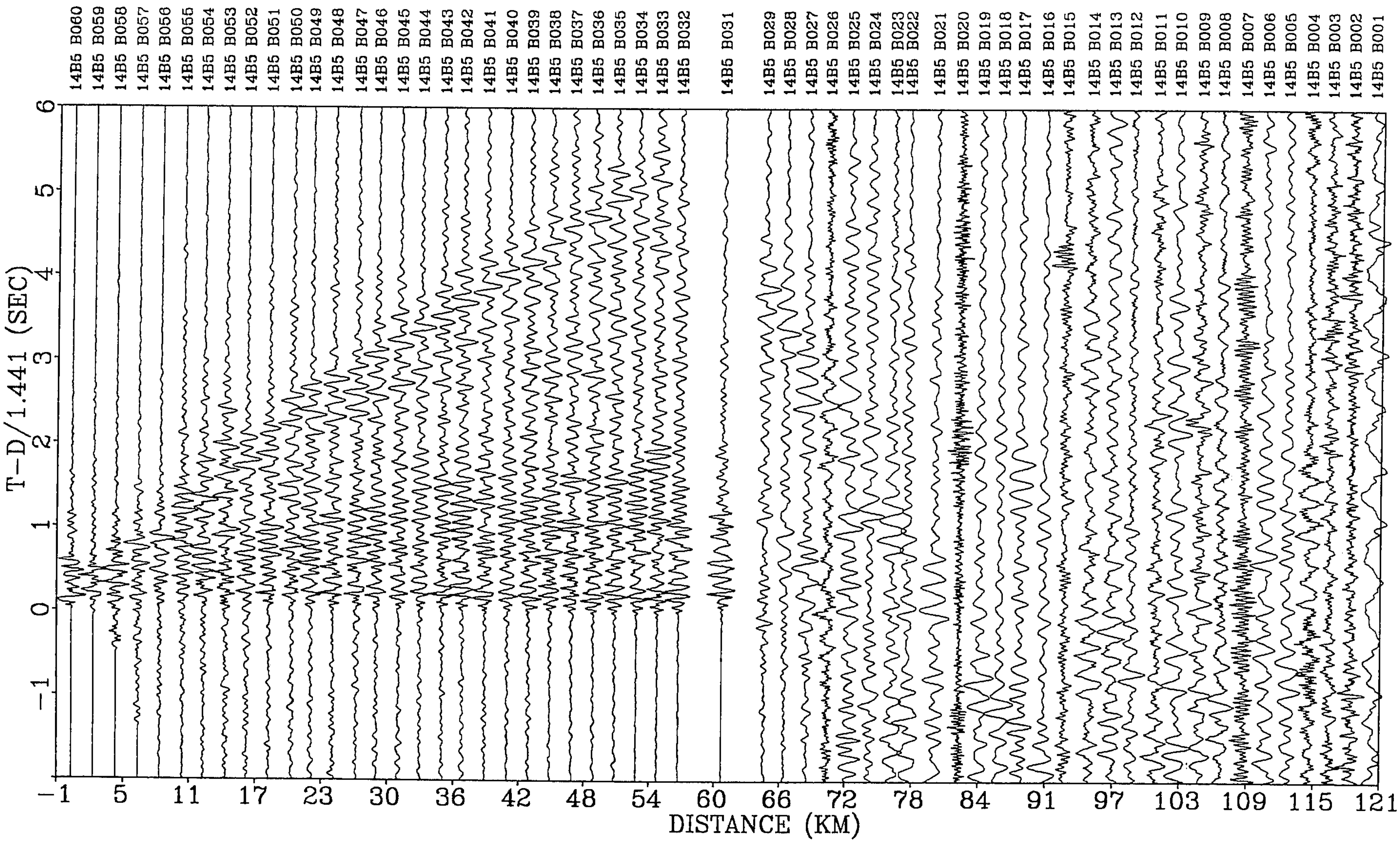
ICE ISLAND 1990:

Line B Shot B4, Crustal Section



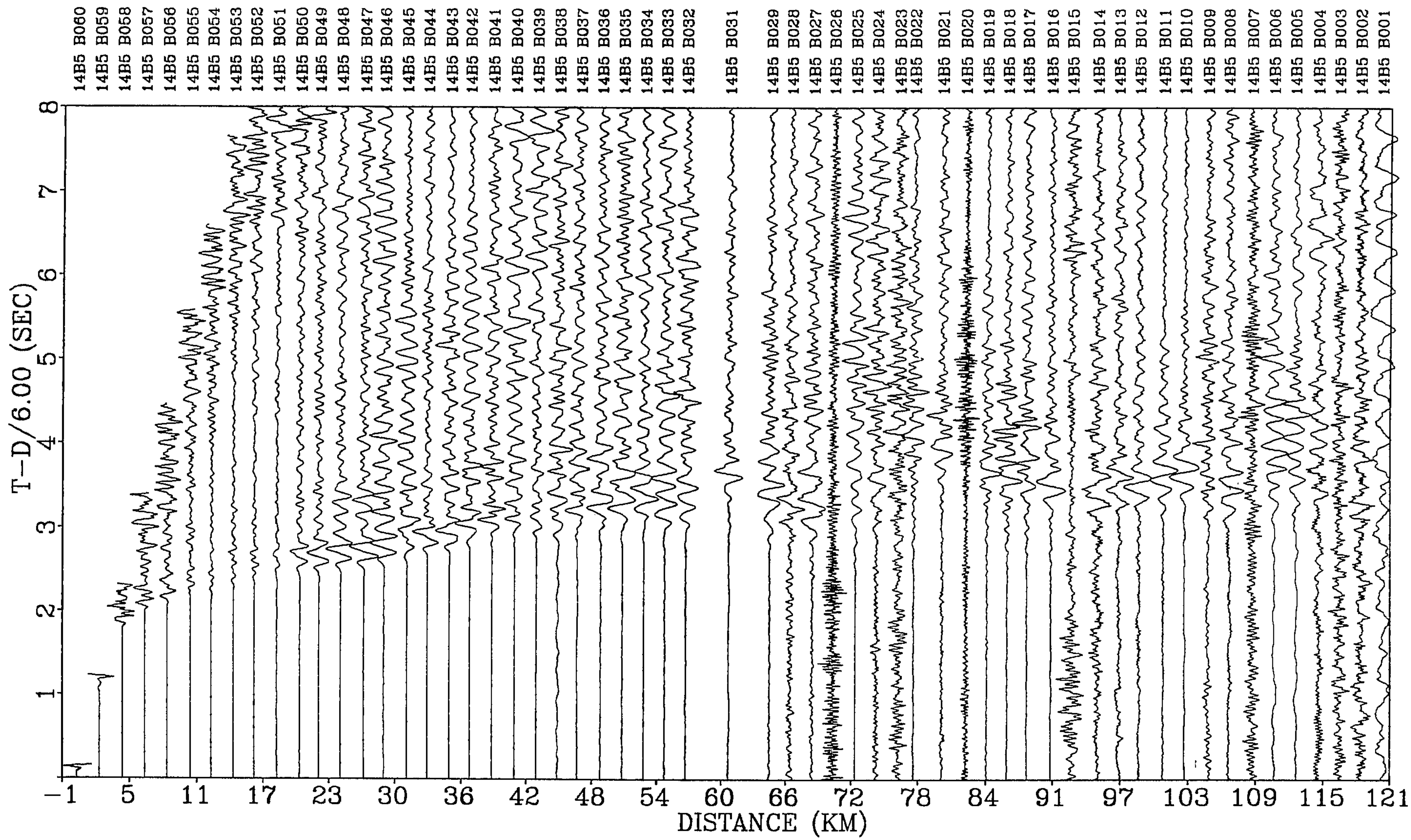
ICE ISLAND 1990:

Line B Shot B5, Water Wave Section



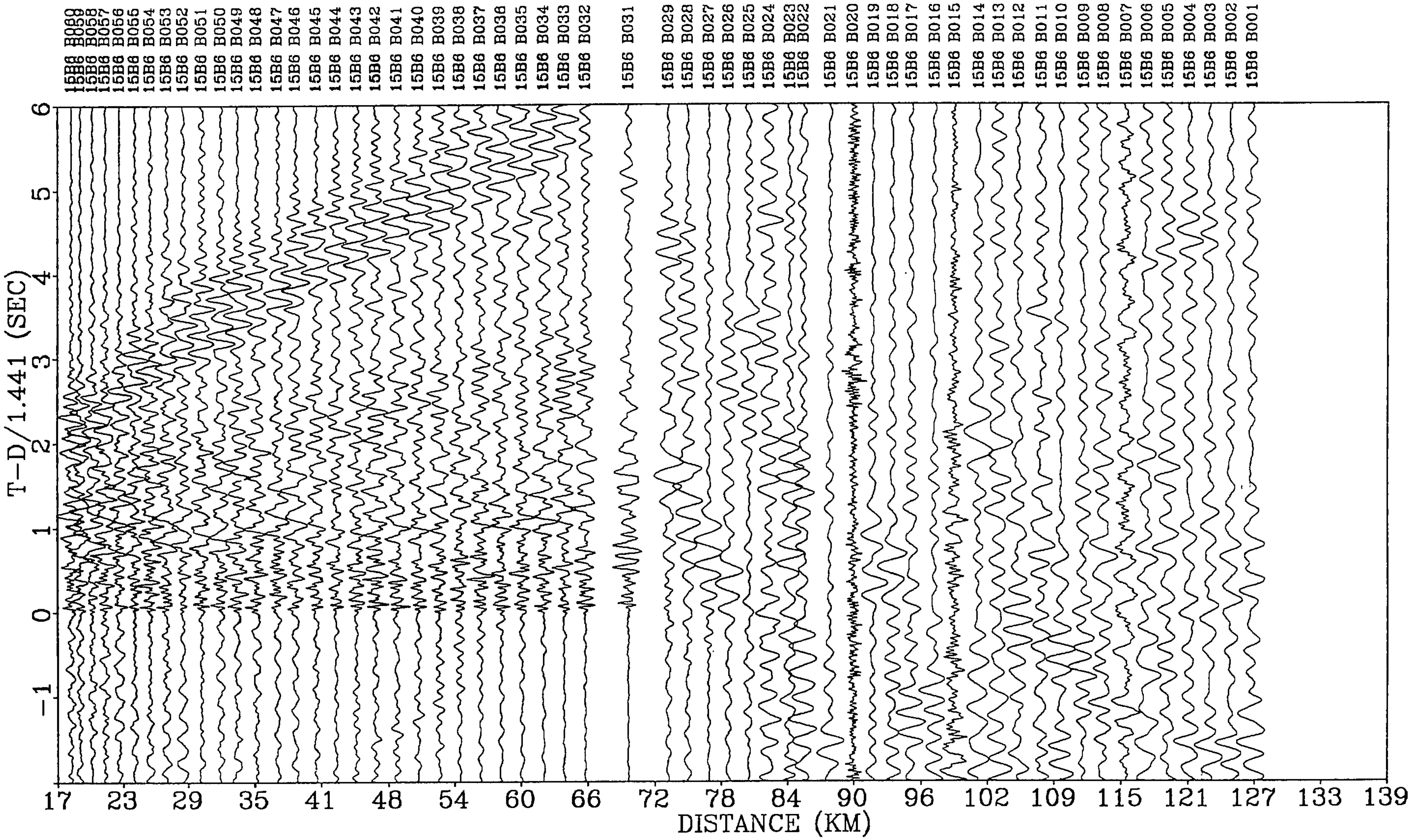
ICE ISLAND 1990:

Line B Shot B5, Crustal Section



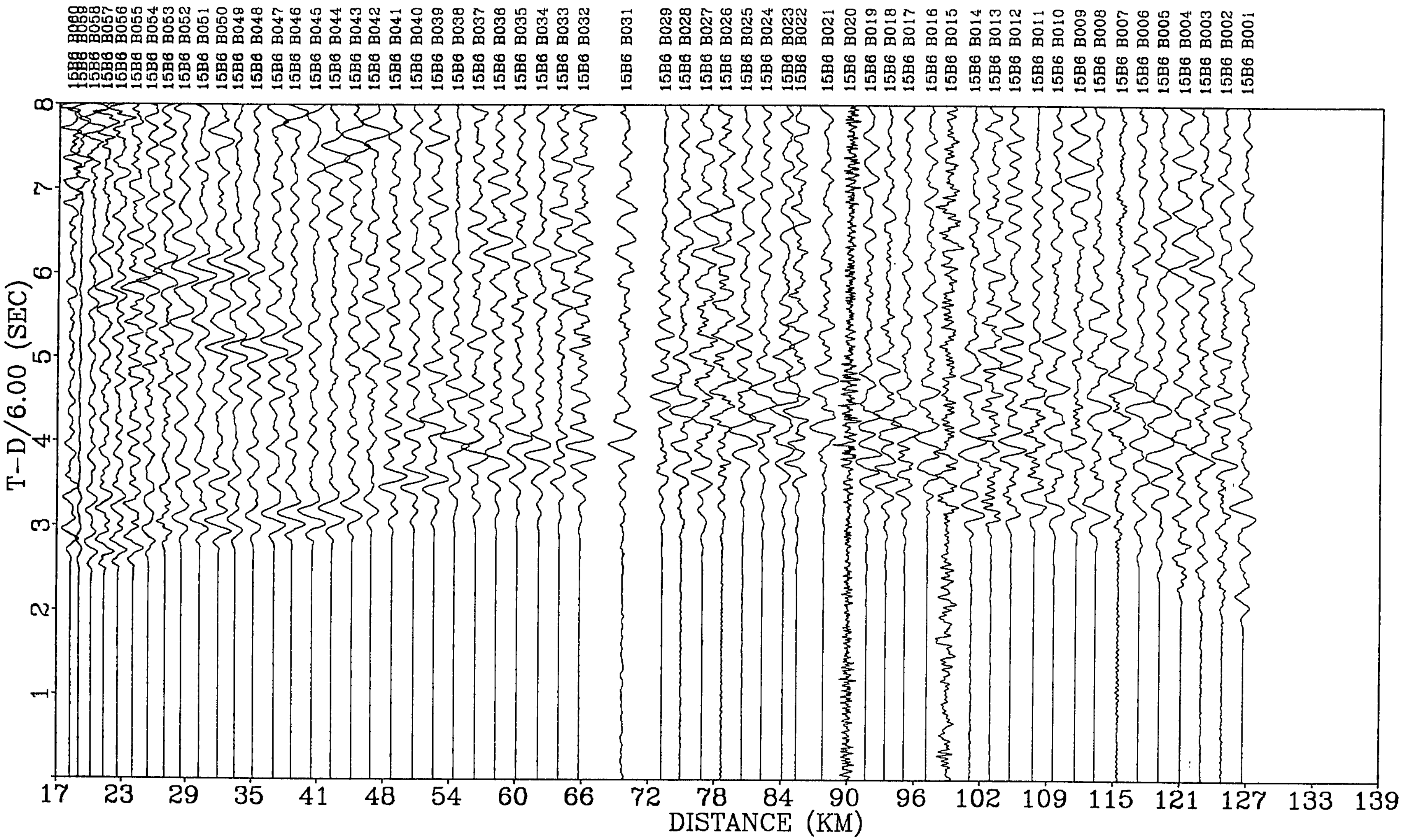
ICE ISLAND 1990:

Line B Shot B6, Water Wave Section



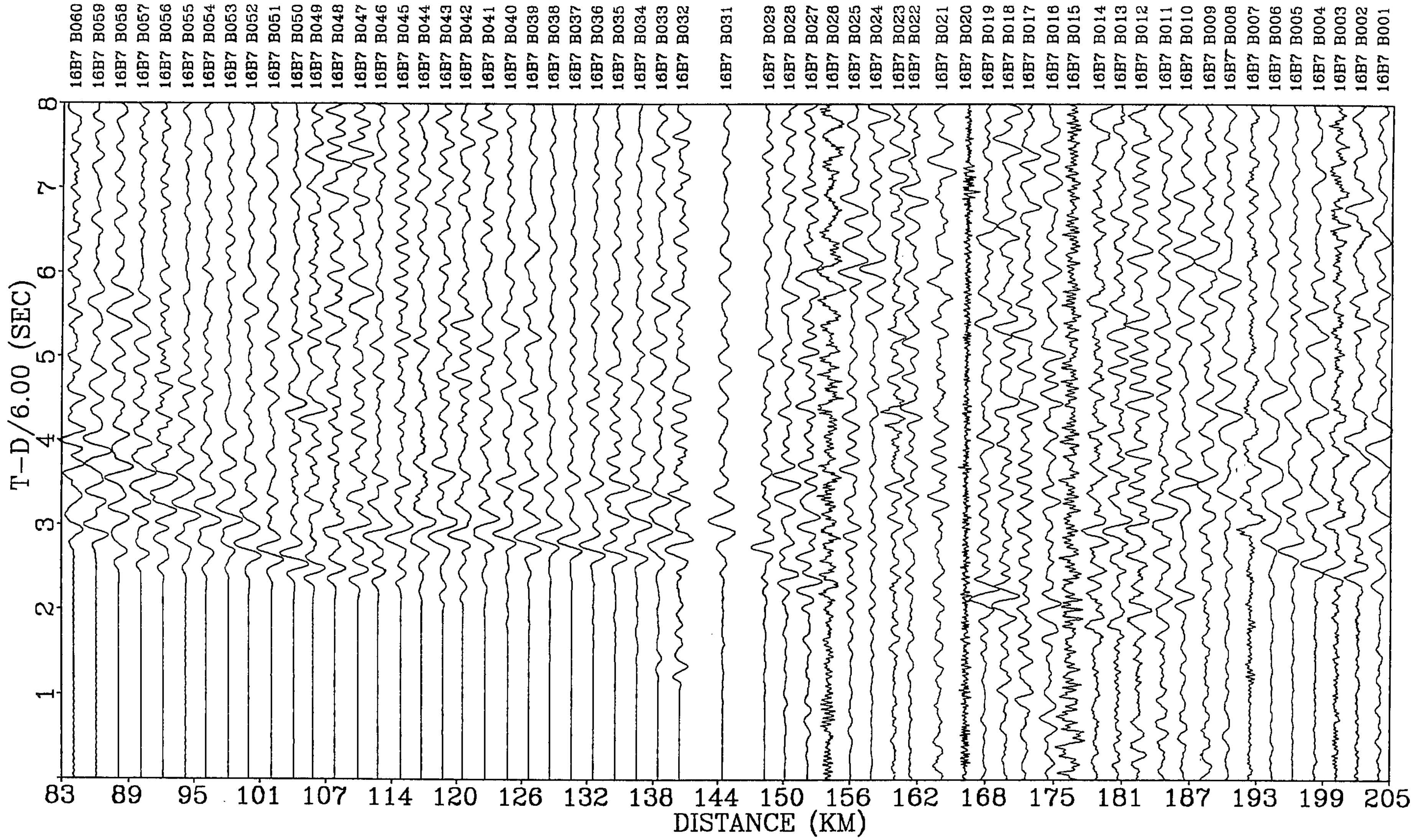
ICE ISLAND 1990:

Line B Shot B6, Crustal Section



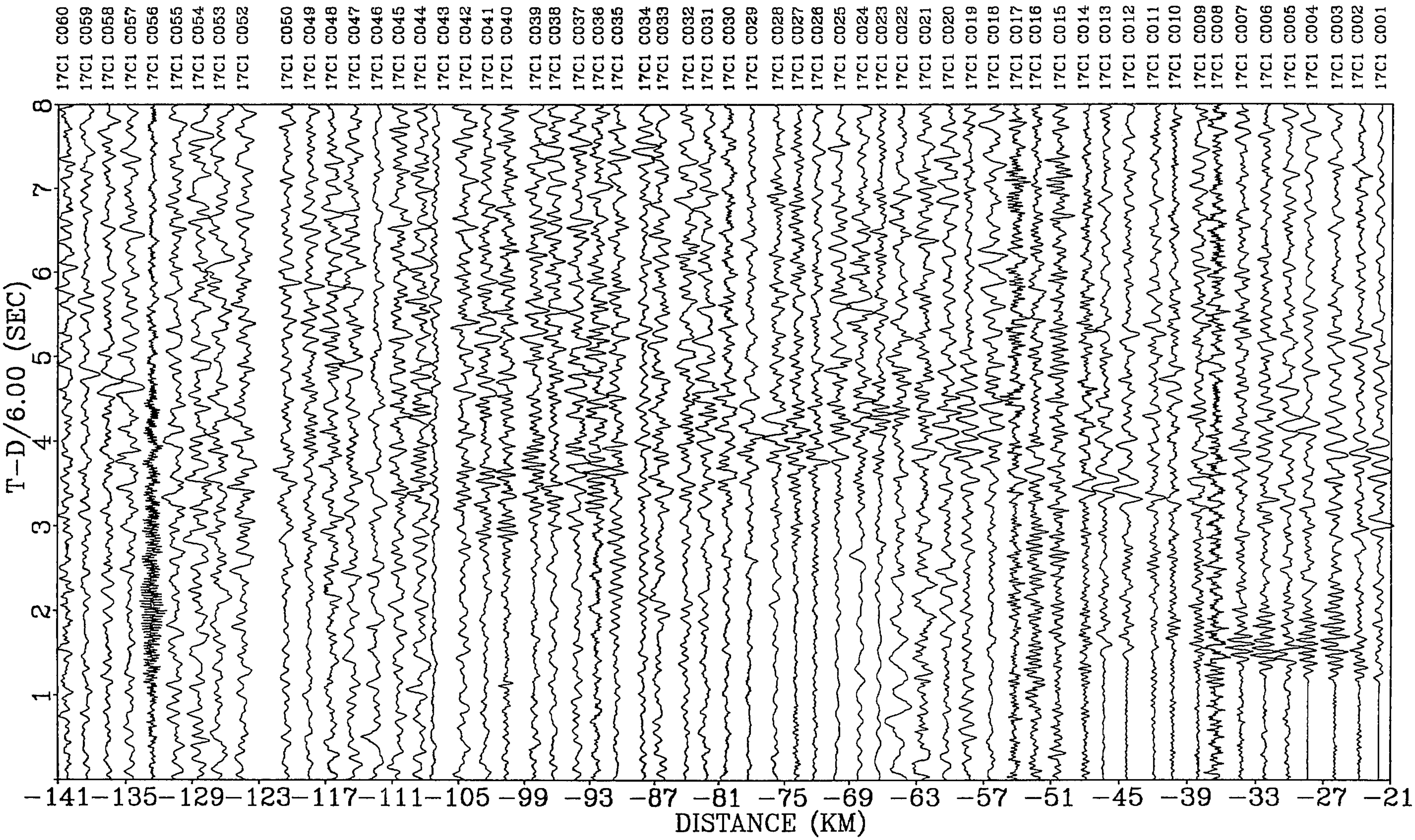
ICE ISLAND 1990:

Line B Shot B7, Crustal Section



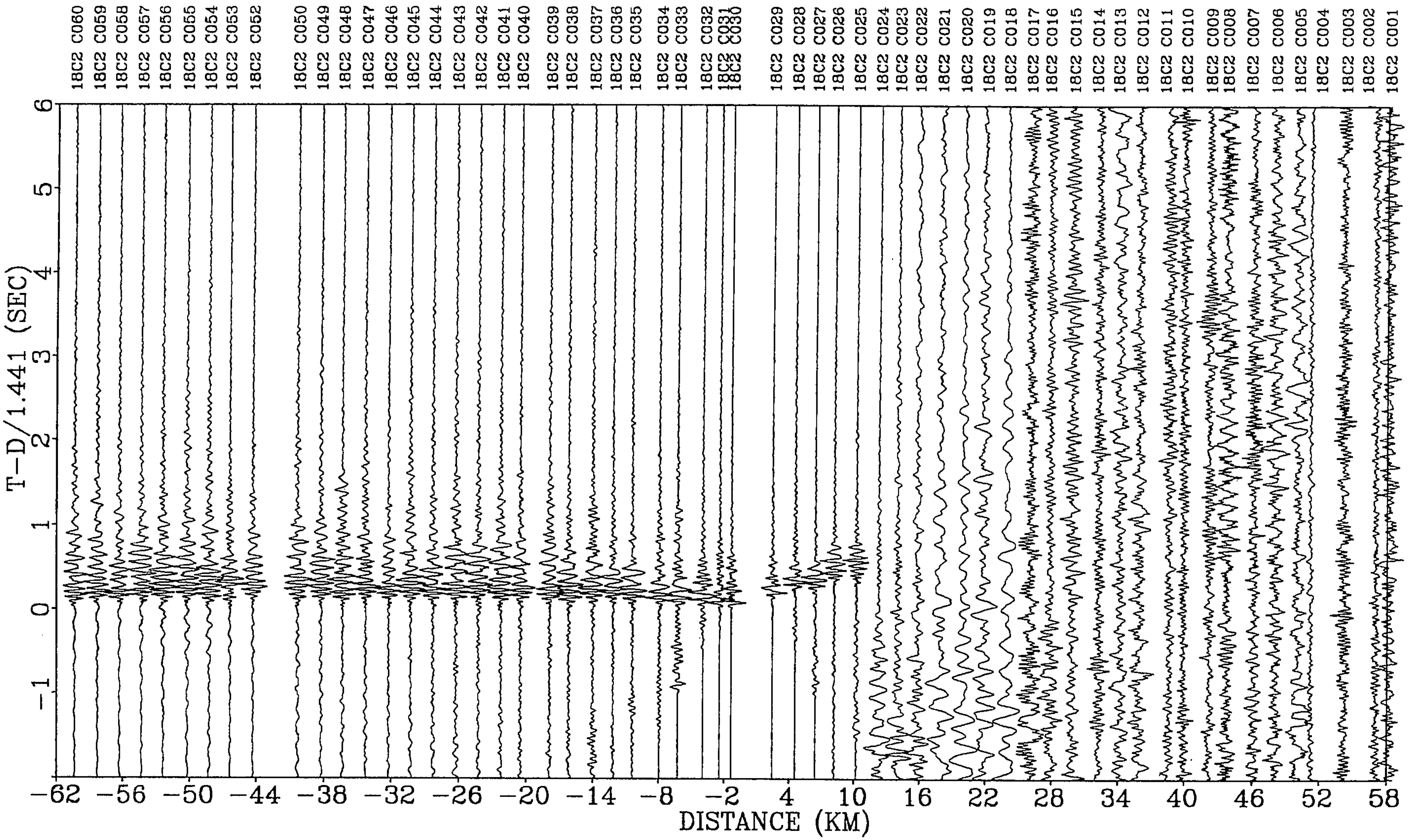
ICE ISLAND 1990:

Line C Shot C1, Crustal Section



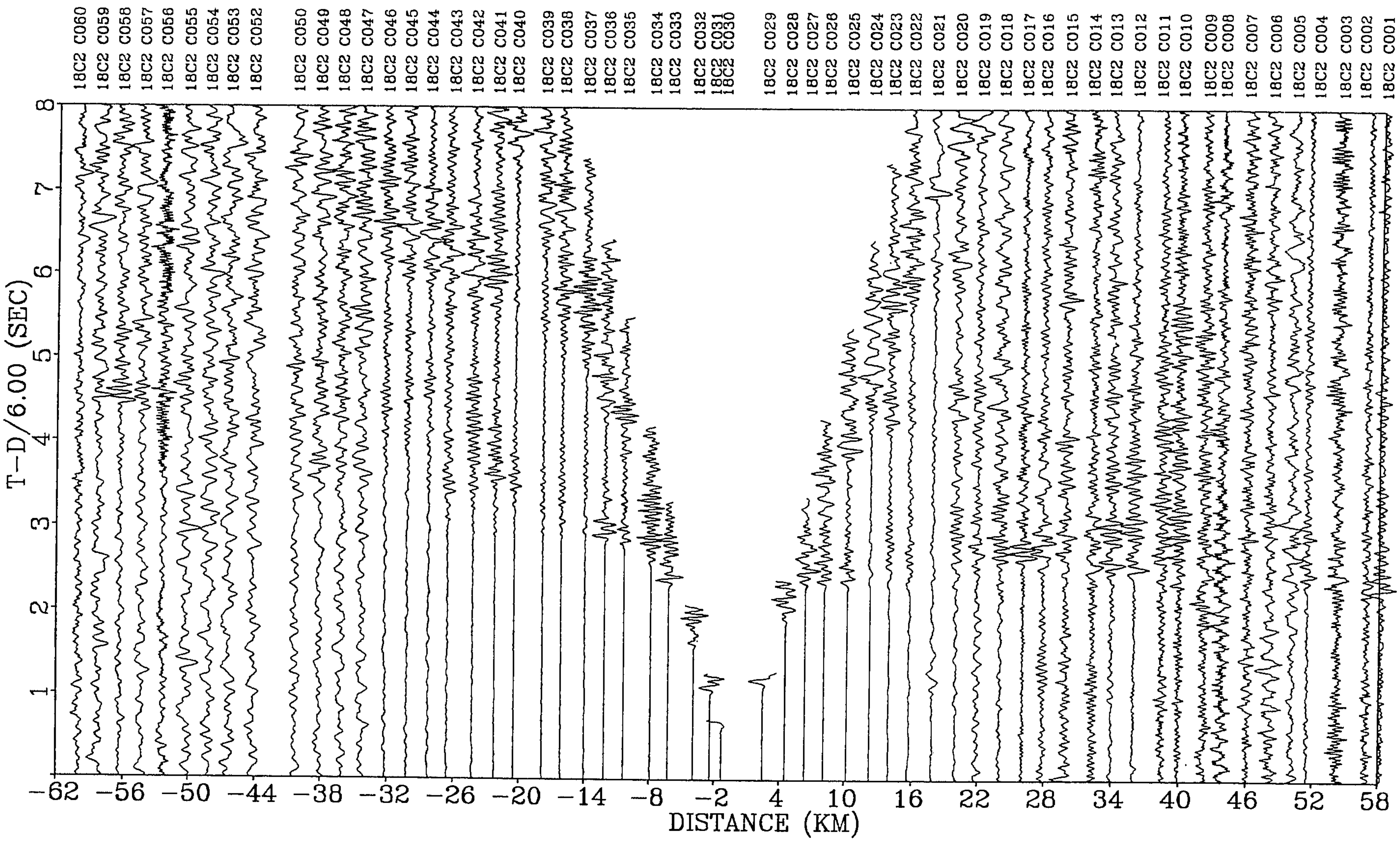
ICE ISLAND 1990:

Line C Shot C2, Water Wave Section



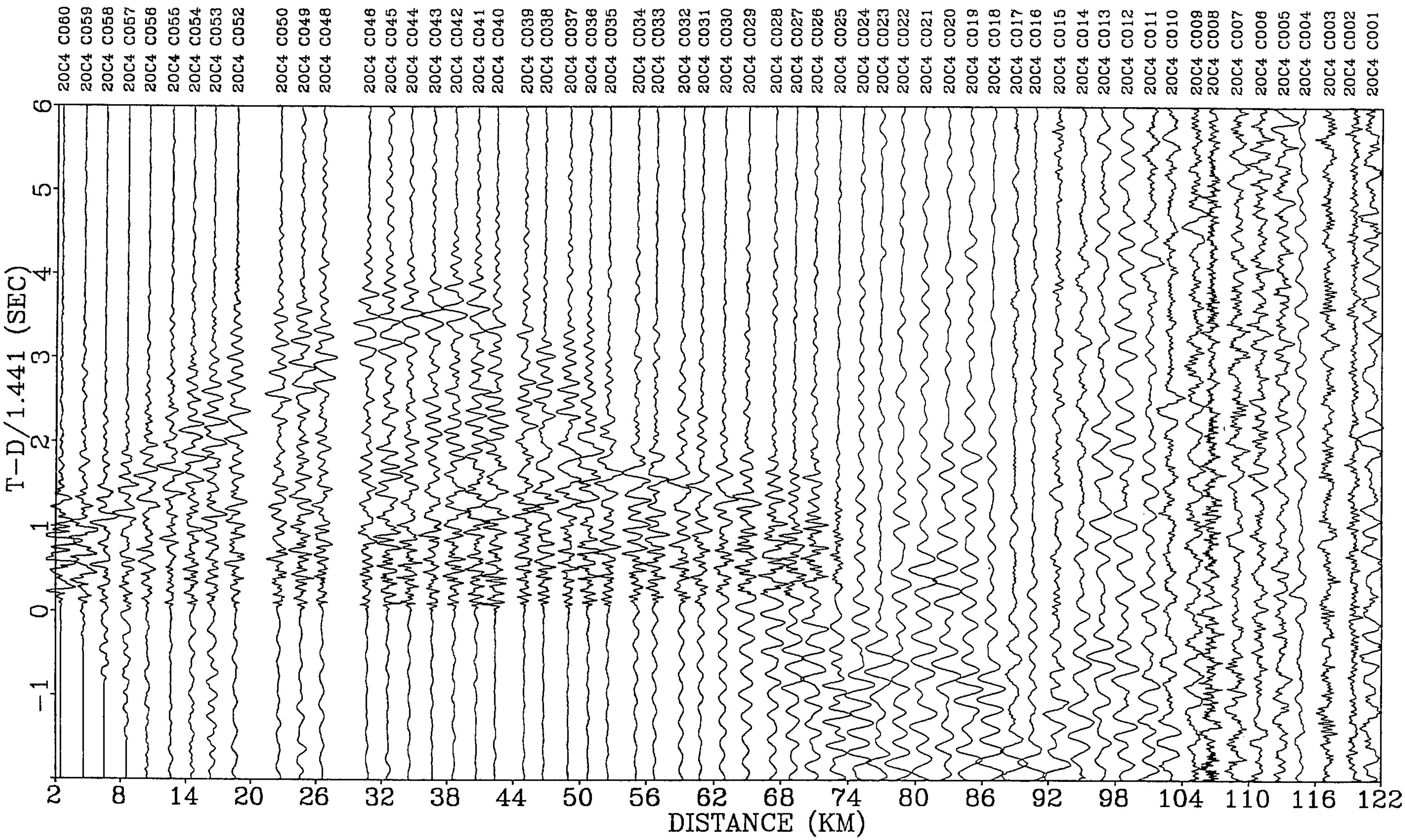
ICE ISLAND 1990:

Line C Shot C2, Crustal Section



ICE ISLAND 1990:

Line C Shot C4, Water Wave Section



ICE ISLAND 1990:

Line C Shot C4, Crustal Section