Geological Survey of Canada
Commission Geologique du Canada

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ACQUISITION OF REGIONAL SEISMIC REFRACTION DATA IN THE MACKENZIE DELTA-SOUTHERN BEAUFORT SEA - NORTHERN YUKON AREA

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1987

Introduction

The geology of the Mackenzie Delta [northwestern Northwest Territories] - southern Beaufort Sea - northern Yukon [Figure 1] records a series of major sedimentary basin forming episodes, punctuated by compressional or extensional tectonic events, beginning in the Proterozoic. Development of the economically-important ?Upper Jurassic-Neogene Beaufort-Mackenzie Basin is still underway and is presumed to be related to the Mesozoic origins of the Canada Basin of the western Arctic Ocean.

An extensive database of industry seismic reflection data exists in the area and is augmented by considerable knowledge of the subsurface geology of the Beaufort-Mackenzie Basin, both on and offshore, obtained from oil and gas exploration wells drilled since 1962. Deep [16- 20-second] seismic reflection data on the Mackenzie Delta [Cook et al., 1987] and in the southern Beaufort Sea were acquired by the Geological Survey of Canada [GSC] in early 1986 and late 1987 respectively. GSC regional gravity data exist for all of the area shown in Figure 1 while airborne magnetic coverage is available north of 68 degrees.

In March 1987 the Geological Survey of Canada undertook a major regional seismic refraction survey in the Mackenzie Delta - southern Beaufort Sea - northern Yukon area in order to complement the existing geophysical and geological data with information on the velocity structure of the crust and upper mantle. In particular, the purpose of the seismic refraction survey was to map the Mohorovicic discontinuity and any intermediate crustal boundaries and to investigate the

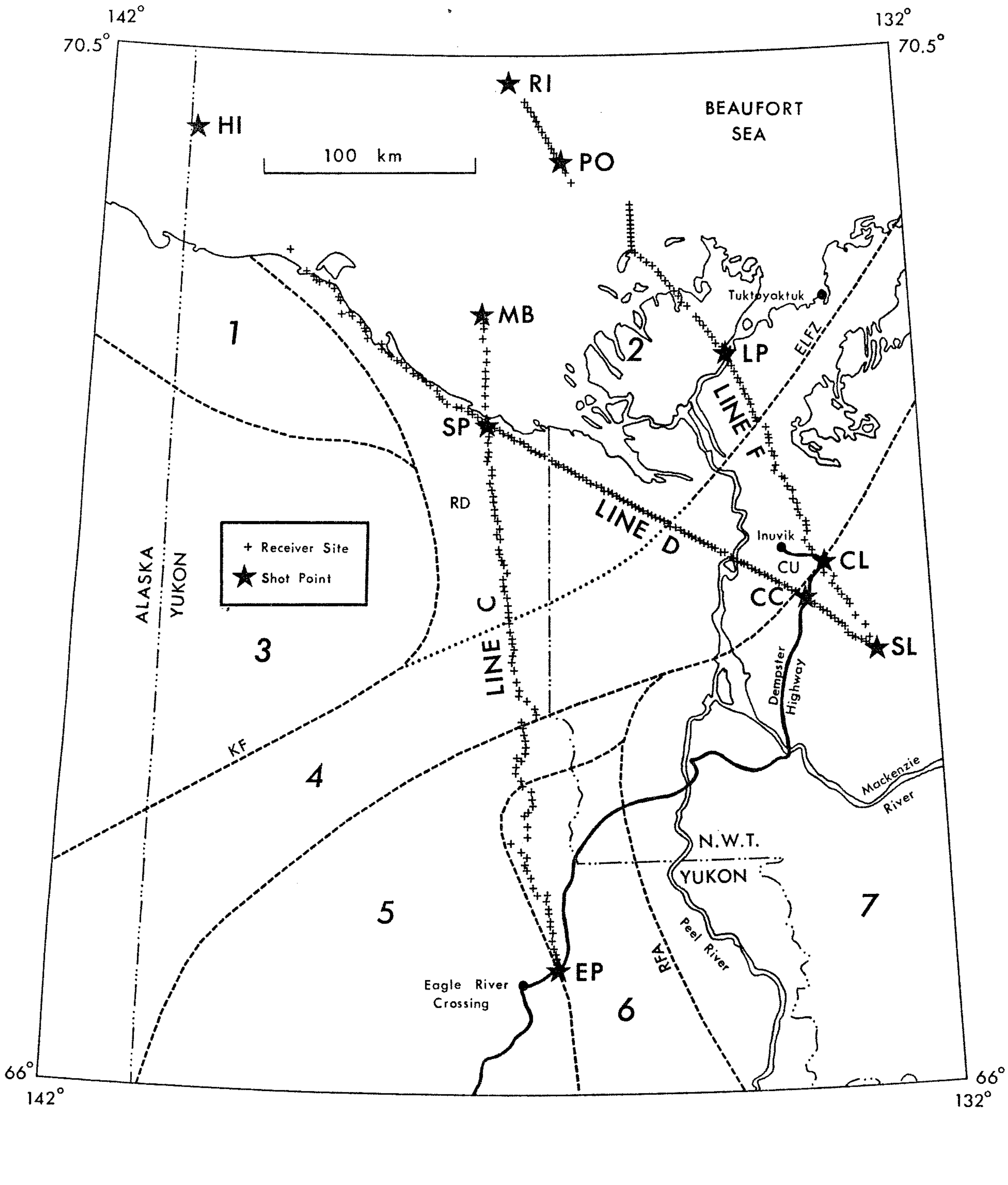


Figure 1. Geological setting of the 1987 seismic refraction survey. Tectonic elements are [Norris, 1974]: 1 - Romanzof Uplift, 2 - Beaufort-Mackenzie Basin, 3 - Old Crow Basin [KF - Kaltag Fault], 4 - Aklavik Arch Complex [CU - Campbell Uplift], 5 - Eagle Fold Belt, 6 - Richardson Anticlinorium [RFA - Richardson Fault Array], and 7 - Peel Plateau.

relationship of crustal structure to major tectonic elements, especially the development of sedimentary basins. The interpretation of these refraction data is underway at the present time [e.g. Stephenson et al., 1987, 1988; Stephenson and Zelt, 1989; Zelt, 1988a,b].

The purpose of this Open File report is to describe the acquisition of the seismic refraction data and to document and graphically present the resulting data, including the final seismic refraction sections. By doing so, these data are released to the public and are made available to potential users as nine-track magnetic tapes and mini-floppy diskettes. They can be obtained from the Regional Geology Subdivision [Northern Canada Regional Studies], Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, 3303-33 Street Northwest, Calgary, Alberta T2L 2A7.

Geological Setting

The tectonic and geological history of the area of the seismic refraction survey is long, complex, and ongoing. Some simplification is afforded by considering the "principal tectonic elements" introduced by Norris [1974] and reproduced in part in Figure 1. The structural interpretation of these tectonic elements bears upon unresolved problems regarding the interaction of the North American and Eurasian continental plates and the origin of the Canada Basin to the north.

The stratigraphic basement in the northern Yukon and northwestern District of Mackenzie [NWT] is presumed to be a western continuation of the Early Proterozoic igneous and metamorphic Canadian Shield exposed east and north of Great Bear Lake [Norris, 1980], associated with the culmination of the Hudsonian [2.1-1.8 Ga] Wopmay orogen [Hoffman, 1980]. The stratigraphic succession overlying the presumed Hudsonian basement ranges in age from Proterozoic [Hadrynian, possibly as old as Aphebian] to Quaternary. Proterozoic strata have been compressionally deformed during the Late Proterozoic ?Racklan Orogeny, inferred from geophysical data [Cook, 1988]. They are believed to underlie much of the Peel Plateau shown in Figure 1. They are unconformably overlain by relatively thin, gently dipping layers of latest Proterozoic-early Paleozoic strata. For the most part, pre-Mesozoic sediments of are those of an ancient northwestern North American continental margin, formed prior to the North American Cordilleran Orogen and the Canada Basin.

Episodes of Paleozoic and earlier uplift and deformation, including igneous activity, are recorded in the complicated stratigraphy of the Aklavik Arch Complex, a northeast-trending series of depressions and uplifts extending from the Yukon to Banks Island [Norris and Yorath, 1981]. One phase of Paleozoic deformation affecting the Aklavik Arch coincides in age, and possibly style [Bell, 1973], with the Ellesmerian Orogeny recorded by the Franklinian Fold Belt in the Canadian Arctic archipelago. Bell [1973] has suggested that the northern Yukon deformation may be an extension of the latter. Deep seismic reflection data from the Campbell Uplift area [CU, south of

Inuvik; Figure 1] can be interpreted to suggest Late Paleozoic compressional deformation [Cook et al., 1987]. The Kaltag Fault [KF; Figure 1], which may have accommodated strike-slip motions during the Paleozoic [Norris and Yorath, 1981], marks the general boundary between the Aklavik Arch Complex and the Old Crow Depression, an area of Tertiary and Quaternary sediment. Farther east, the Eskimo Lakes Fault Zone [ELFZ; Figure 1] separates the Aklavik Arch Complex from the Beaufort-Mackenzie Basin, which contains up to 12 km of Upper Cretaceous to Tertiary sediment [Cook et al., 1987] and rests upon the continental margin adjacent to the Arctic Ocean. Oceanic crust in this area is thought to have formed mainly during the Cretacous [e.g. Sweeney, 1985].

Jurassic and Cretaceous sediments in the Eagle Plain Basin have been deformed by gentle Laramide uplift and folding, trending north-northwesterly, and related local faulting. Roughly parallel to the the fold axes of the Eagle Fold Belt is the Richardson Anticlinorium. It is a horst-like structure plunging gently to the north and marked on its eastern boundary [with the Peel Plateau] by a major, near-vertical [?] fault system [RFA; Figure 1], apparently linked with the Eskimo Lakes Fault Zone to the northeast, such that part of the Aklavik Arch Complex in this area was offset during the Cretaceous [Norris and Yorath, 1981]. The bulk of present-day seismicity in the northern Yukon appears to be associated with the Richardson Anticlinorium [Leblanc and Wetmiller, 1974] so that the fault systems associated with this structure remain tectonically active.

Objectives of the Refraction Survey

The principal goal of the seismic refraction program was to acquire information on the deep structure of the region to allow the development of improved models of the origin and evolution of the various structural/tectonic terranes. The regional refraction data are expected to provide velocity control for deep seismic reflection processing and interpretation; the geometry of deep boundaries, particularly the Moho, where the reflection method often cannot map or results in speculative interpretations; and velocity information for constraints on the materials and conditions [e.g. density and temperature] at depth.

The particular objectives of the 1987 Beaufort-Mackenzie refraction survey include (i) provision of constraints on the structure and possible location of the oceanic-continental transition in the southern Beaufort Sea; (ii) examination of offshore crustal structure in Mackenzie Bay, to be interpreted in conjunction with potential field data, and to relate it to the crustal structure of the Rapid Depression and Mackenzie Delta to the south; (iii) determination of the role of crustal tectonics in the evolution of the complex of sedimentary basins of mainland northwestern Arctic through provision of velocity control and integrated interpretation with the deep seismic reflection data, to trace the position and nature of the crystalline basement beneath the Mackenzie Delta and Campbell Uplift, and to examine the crustal controls on the evolution of the Delta and Campbell Uplift [e.g. does the crustal structure show any evidence that the Delta is the pivot for the opening of the western Arctic

Ocean?]; (iv) detection of the presence and nature of the presumed Proterozoic-Paleozoic passive continental margin and associated [?Franklinian] sedimentary basin in this area; and (v) investigation of whether the thick sedimentary succession in the Rapid Depression is accompanied by thinning of continental crust as would be expected for a rift-generated basin and to determine whether the geometry of thinning is indicative of a particular mode of crustal deformation.

These questions and problems will be addressed in a series of forthcoming scientific papers.

The Seismic Refraction Survey

Introduction

The Mackenzie Delta - southern Beaufort Sea - northern Yukon seismic refraction survey was conducted by the Geological Survey of Canada, with the participation of the Universities of British Columbia and Calgary and the Geodetic Survey of Canada [Table 1], between March 15 and March 28, 1987, from a base at Inuvik. All activities, except for several in the vicinities of Inuvik and Eagle River Crossing, were carried out using aircraft - three Bell 206L helicopters used primarily for recorder deployment, one DHC6-300 [Twin Otter] used primarily for offshore fuel caching and seismic blasting, and occasional use of one Bell 206B helicopter and one Cessna 206 aircraft.

Table 1. Participants, Mackenzie Delta - southern Beaufort Sea - northern Yukon seismic refraction survey.

Geological Survey of Canada	
Institute of Sedimentary and Petroleum Geology, Calgary	Randell Stephenson Mike Thomas [cook] Karen McInnis
Lithosphere and Canadian Shield Division, Ottawa	Isa Asudeh Dave Forsyth Carl Spencer
Geophysics Division, Ottawa	Bob Schieman
Department of Geophysics and Astronomy, University of British Columbia, Vancouver	Bob Ellis Andy Boland Andrew Calvert Bob Meldrum
Geodetic Survey of Canada, Ottawa	Al Eaton
Department of Surveying Engineering, University of Calgary, Calgary	Dale Arden Chris Wiita
Thing Geophysical [consultant], Calgary	Barry Zelt

Fifty-four Portable Refraction Seismographs with 2 Hz seismometers [EDA Instruments Inc. PRS1s and Mark Products L4As respectively; see Appendix A] were available for deployment during the course of the seismic refraction survey. The recording equipment was supported by personal computers [in the present case, two COMPAQ PORTABLE units and one COMPAQ DESKPRO-386 unit with 0.25 inch magnetic tape cartridge back-up tape drive], used for programming common recording parameters and for recovering data. The seismic recording equipment is owned and maintained by the Intrumentation Laboratory, Geophysics Division, Geological Survey of Canada, Ottawa, and forms part of the Lithoprobe seismic equipment laboratory. The supporting hardware [PCs] and EDA software were maintained by the Seismology and Electromagnetism Section, Lithosphere and Canadian Shield Division, Geological Survey of Canada, Ottawa.

The refraction survey consisted of seven recorder deployments and, for various reasons, fewer instruments than the fifty-four that were available were used on most deployments. The seven deployments were used to obtain coverage along three lines [Figure 1] resulting in the acquisition of approximately 830 km of reversed, 110 km of unreversed, and 650 km of broadside seismic profiling with an average recorder spacing of 3 km. Line F runs roughly southeast to northwest along the eastern edge of the Mackenzie Delta [approximately coincident with the deep seismic reflection profile recorded by the Geological Survey in 1986; Cook et al., 1987] thence onto the Beaufort Sea and comprises eight shots from five in-line shotpoints [SL, CL, LP, PO, and RI; Figure 1 and Table 2]; Line D crosses the Mackenzie

Table 2. Receiver sites and shots for each deployment. Stations F066 - F104, C001 - C012, D136 and D138 were located on sea ice, offshore; Sites F002, F004, F006, F008, F018, F054, F087, F103, D084, and D137 were never occupied.

Deployment	Day	Line	Receiver sites occupied	Shots
DY01	74	F	F001, F003, F005, F007, F009-F017, F019-F053, F104	CLA, LPA, RIA, SLA
DY02	80	F	F017, F053, F055-F086, F088-F102, F104	LPB, POA, RIB, SLC
DY03	76	D	D001-D050, D199, F017	CCA, EPA, SLB, SPA
DY04	82	D	D001, D020, D050-D083, D085-D099, F017	CLB, EPB, HIA, SLD, SPB
DY05	84	D	D100-D136, D138, D199, D299, F017	CLB, POB, SPC
DY06	85	C	C001-C049, F017	EPC, MBA, SLE, SPD
DY07	87	C	C048, C050-C076, C078-C099, F017	EPD, MBB, SLF, SPE

Delta from the southeast to the northwest thence running along the north shore of Yukon, and comprises nine shots from five in-line shotpoints [SL, CC, CL, SP, and HI] and three shots from two off-line shotpoints [EP and PO]; and Line C runs south-north along the strike of the northern Richardson Mountains, west of the Mackenzie Delta, thence onto the Beaufort Sea, and comprises six shots from three in-line shotpoints [EP, SP, and MB] and two shots from one off-line shotpoint [SL].

The seven deployments are known as DY01, DY02, etc. Because of weather-related contingencies DY03 occurred before deployment DY02. Receiver sites are identified by a four-character alphanumeric code. The first character is a letter that identifies the line [C, D, or F] and the last three characters identify the line-specific recorder site number. Shotpoints are identified by a three-letter code. The first two letters correspond to one of the ten shot locations [Figure 1]. The third letter identifies a particular shot at that location. Table 2 summarizes the receiver sites occupied and shots fired for each deployment and Table 3 lists the receiver sites corresponding to each shot site.

Positioning

Onshore positioning. The positions of all onshore sites were marked on NTS 1:50 000 air photo maps or topographic maps. For receiver sites, this was done from the helicopter at the time of deployment and/or recovery of intruments. For shot positions, it was usually done during preparation of explosives or occasionally by a recording crew in the vicinity. Errors associated with positions derived in this manner are expected to be less than 100 m. As well, two onshore shot positions [SPA and at a location central to shots LPA and LPB] were located using GPS [global positioning system] satellite data observed by either the Geodetic Survey of Canada [using WM101 receivers] or the University of Calgary [Trimble 4000S receivers]. Errors associated with these GPS-derived positions are less than 100 m and the two sets of GPS coordinates were used in conjunction with maps to accurately locate all of the shot positions at SP and LP.

Onshore elevations were read from the 1:50 000 maps. For shotpoints, map-derived surface elevations have been used.

Offshore positioning. All offshore receiver sites on lines C [C001-C012] and D [D136 and D138] were located on landfast ice at stations that were positioned using GPS and marked with flags and VHF radio beacons [see Appendix A] on the day prior to receiver deployment.

Offshore receiver sites on line F [F066-F086, F088-F102, F104] were first occupied during receiver deployment, mostly according to coordinates obtained using a helicopter mounted Omega Navigation System [ONS]. Errors associated with positions derived from ONS observations in the Beaufort Sea region are likely in the order of several kilometres and are too great for seismic positioning purposes. During deployment these stations were marked with flags and VHF beacons to allow subsequent reoccupation with GPS satellite receivers. Sites F076-F085 were mislocated during deployment because of ONS instrument and/or

Table 3. Receiver sites corresponding to shot sites. Sites F017 and D299 occupy the same position near CL, the latter established in order to record the shot at CL into the western part of line D. Similarly, site C199 was occupied to record the fan shot from SL into line C. Sites D099 and D199 correspond to two slightly different locations at the SP shot site (D199 is near SPA, D099 is near SPB). No receiver was ever positioned in the immediate vicinity of HI.

Shotpoint	Nearest receiver site(s)
CC [Caribou Creek]	D020
CL [Campbell Lake]	F017, D299
EP [Eagle Plains]	C099
LP [Lousy Point]	F053
MB [Mackenzie Bay]	C001
PO [Pissed Off]	F090
RI [Richards Island]	F104
SL [Sunny Lake]	F001, D001, C199
SP [Shingle Point]	D099, D199, C014
HI [Herschel Island]	--

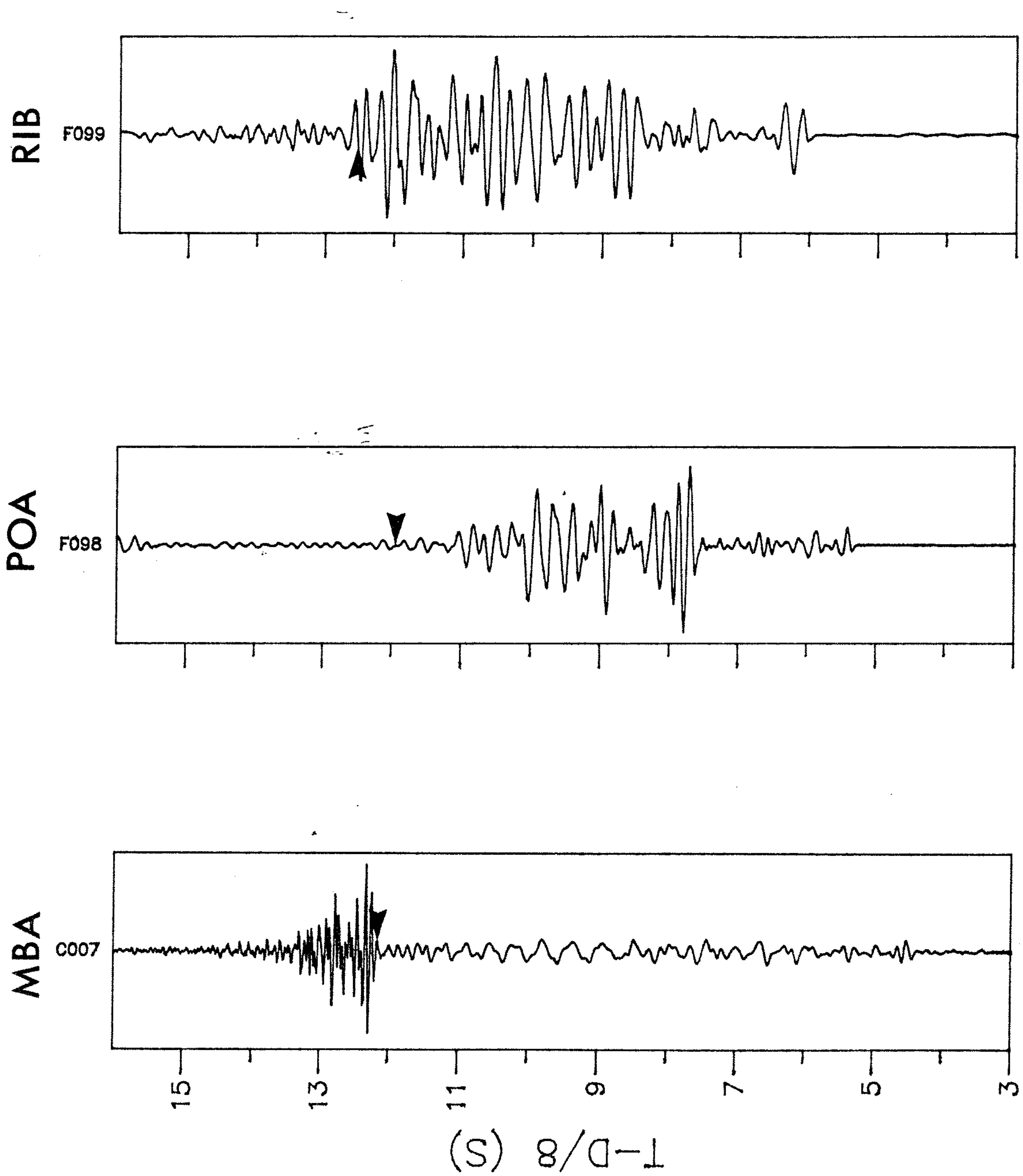
operator malfunction, resulting in a gap of approximately 30 km between stations F085 and F086 [cf. Figure 1]. Receiver sites F066-F069 [those nearest the shore] were positioned on landfast ice during deployment by a line-of-sight method and marked for later GPS reoccupation. GPS observations were made the day following receiver deployment. No significant motion of the non-landfast ice was evident by this time and, because of the prevailing calm weather conditions, was likely negligible; the observed GPS coordinates are assumed to be accurate. Because of anticipated changes in weather conditions and related ice motions, and constraints afforded by limited GPS satellite visibility, only 14 of the 37 line F offshore sites were reoccupied and surveyed using GPS [Table 4]. Coordinates for the non-reoccupied sites on the original field tapes are nominal coordinates [i.e., coordinates of the planned deployment] and are not accurate. They have been updated by interpolating or extrapolating coordinates on the basis of the interspersed GPS-derived positions, illustrated by Table 4, and of visual inspection of the resulting seismic sections. In regard to the latter, the extrapolated positions of sites F086, F088, and F089 [which nominally have been retained in the present database] appear to be significantly in error.

There is an unexplained lack of distinct water wave arrivals from shots at PO and RI at offshore receiver sites along line F that, otherwise, may have allowed further constraints to be placed on the locations of receiver sites not surveyed using GPS [e.g. Asudeh et al., 1985]. Figure 2 shows selected GPS-

Table 4. Line F offshore receiver sites [except for F065 which is the northernmost line F receiver site on land] showing those with GPS-derived positions [except for F065, derived from its map location] and those with positions, in brackets, interpolated from contiguous GPS coordinates or extrapolated, also in brackets, along best-fitting lines through adjacent sets of GPS coordinates, as shown by the subdivision of sites. All coordinates refer to UTM zone 8.

	UTM Coordinates (m)	
Site	Northing	Easting
F065	7704825	506325
F066	[7707337	504293]
F067	[7709853	502257]
F068	[7712370	500221]
F069	7714886	498185
F070	7716700	497001
F071	[7719085	494284]
F072	[7721474	491562]
F073	7723864	488839
F074	[7726254	486116]
F075	[7727557	484601]
F076	7729650	484489
F077	[7731745	484433]
F078	[7733839	484376]
F079	7735934	484320
F080	[7737881	484180]
F081	7739828	484347
F082	7742031	484278
F083	[7744491	484180]
F084	[7746952	484081]
F085	7749412	483983
F086	[7760830	456188]
F088	[7765756	453530]
F089	[7768216	452202]
F090	[7770679	450873]
F091	7773074	449416
F092	[7775339	448259]
F093	7777603	447101
F094	[7780216	445826]
F095	7782829	444550
F096	[7785558	442854]
F097	7788286	441157
F098	[7790705	440206]
F099	7793124	439255
F100	[7795378	437688]
F101	7797632	436120

Figure 2. Computed water wave arrivals [arrows, based on a velocity of 1.52 km/s from C007] on traces C007 [Shot MBA], F098 [Shot POA], and F099 [Shot RIB].



positioned traces, with approximately equal shot-receiver offsets, from shots POA and RIB [stations F098 and F099, respectively], indicating no significant wave arrival at the expected times, compared to a typical trace recording shot MBA [station C007], showing a very clear and distinct water wave arrival at the expected time.

All offshore shotpoints except for MBB, POB, and RIB were initially established, and marked with flags and radio beacons, using ONS in the Twin Otter aircraft and subsequently surveyed using GPS at the time of shot detonation. Of the exceptions, MBB has been assigned the GPS-derived coordinates of MBA because these shots were sited at the same location on landfast ice and ice motion between occupations can be assumed to be negligible. The position of shot POB is very questionable. In the survey database POB has been assigned ONS coordinates taken the day before the shooting but ice motion was probable in the vicinity of PO at the time and significant ice motion was clearly evident since the time of detonation of the GPS-positioned shot POA. Similarly, the position of site RIB, although at the same ice pack location as RIA, can be assumed to be at a different absolute location due to ice motion between occupation days. As noted above, and shown in Table 4, line F receiver sites F091, F093, F095, F097, F099, F101, F102 were surveyed using GPS the day after the deployment in which RIB was detonated and the coordinates for these sites are assumed to be accurate on the basis of their internal and regional consistency and on the basis of the lack of observed apparent ice motion between the time of GPS occupation and receiver deployment. All of these receiver sites, as well as F104, which was known to be about 100 metres northwest of shot site RIB, were also surveyed using the helicopter-mounted Omega Navigation System at the time of deployment. A systematic offset is assumed to exist between GPS and ONS coordinates for the receiver sites where both survey methods were employed [Table 5] and the average has been used to compute a position for RIB based on the ONS coordinates for a location 100 m southeast of receiver site F104. This position is approximately 3.4 km northwest of shot site RIA. It is expected that there is a substantial error in the calculated position of shot site RIB [cf. standard deviations on Table 5]. The approximate magnitude of this error as well as the difference in location between RIB and RIA must be taken into account when traveltime modelling the RI seismic section in terms of crustal velocity structure [cf. Zelt, 1988a,b].

All offshore station heights, including shotpoints, have been taken to be sea level.

Timing

In general, accurate shot times were obtained by using a chronometer-generated firing pulse. The clocks used for this purpose were synchronised with clocks receiving geostationary orbiting environmental satellite [GOES] time code prior to each deployment. After the deployment each shooting clock was rated against the GOES clock to obtain a measurement of the time drift in the shooting clock. Typically the time drifts were less than

Table 5. GPS and ONS coodinates of line F sites used to locate RIB. All coordinates refer to UTM zone 8. Site F104 was 100 m northwest of RIB. The GPS positions [in brackets] for F104 and thence RIB are based on the average difference between GPS and ONS coordinates for the other sites.

	GPS		ONS		GPS - ONS	
Site	Northing	Easting	Northing	Easting	Northing	Easting
F091	7773074	449416	7770361	448370	2713	1046
F093	7777603	447101	7775096	444608	2507	2493
F095	7782829	444550	7779120	439830	3709	4720
F097	7788286	441157	7785494	437850	2792	3307
F099	7793124	439255	7789748	438721	3376	534
F101	7797632	436120	7793952	434619	3680	1501
F102	7800178	434847	7796742	434572	3436	275
				AVERAGE	3173	1982
			STANDARD	DEVIATION	+/-456	+/-1495
F104	[7811259	424685]	7808086	422703	--	--
RIB	[7811189	424615]	--	--	--	--
	[+/-460	+/-1500]				

30 ms over 24 hours. Similarly, the internal time clock of each receiver was synchronised before each deployment and then rated upon recovery. Receiver clock time drifts between deployment and recovery were generally less than 10 ms .

During the course of the survey two shots were fired manually [SLA and POB; see Appendix A]. To obtain an accurate time correction for shot SLA, receiver site F003, which had been occupied to record SLA on DY01, was reoccupied to record SLC on DY02. A correction of -92 ms, taking into account the slightly different locations of SLA and SLC, was determined by comparing the resulting seismic traces recorded at F003. Determination of an accurate shot time for POB is problematic because of the uncertainty associated with its location [see above subsection on offshore positioning]. A timing error of approximately -16.2 seconds has been calculated by examining traces recorded at site F017 for this shot and for POA but it does not take into account the probable difference in locations for POA and POB. F017 is the only site that was occupied for both PO shots.

Shotpoints

The explosive used as the energy source at all shotpoints was Geogel 60%, packaged as 4.5 kg, 75 mm diameter, Fast-lok format charges. Charges in this size and format are commonly used by the seismic exploration industry and, for this reason, were available in Inuvik at the time of the seismic refraction survey. Although, they were not the preferred explosive format for either onshore or offshore operations [cf. Ellis et al., 1986 and Asudeh et al., 1985], requisitioning deadlines prevailed that prevented the purchase of custom made charges more suitable to the large energy source requirements in this survey.

At onshore shotpoints, explosives were contained in 30 m holes of 4.5 inch diameter during several weeks prior to receiver deployment and blasting. Charges of 90 to 99 kg of explosives were loaded in each hole, leaving a tamped upper collar of no less than 14 m, with reinforced detonating cord [Primacord] piercing the uppermost charge and brought to the surface for subsequent capping and detonation. Shotholes were nominally arranged in five-hole groups [pentangles], with a minimum separation of 30 m between holes. Blasting took place after further site preparation, using detonating cord and/or multiple basting caps to join and synchronously detonate the desired number of shotholes.

At offshore shotpoints, explosives were loaded through holes augered through first-year sea ice and suspended at depths up to 100 m or placed upon the sea floor, using rope and detonating cord. Multiples of the 4.5 kg charges were locked together and intertwined with rope or detonating cord and lowered at a single auger hole with multiple auger holes being loaded depending on the desired total charge size. Loading and other preparation of offshore shotpoints took place on the day before or on the day of blasting.

Table 6 lists shotpoint parameters.

Table 6. Shot parameters. All shot times are at the zero second and do not include timing corrections. All UTM coordinates refer to UTM zone 8 except for HIA which is in zone 7. Latitudes and longitudes are shown in degrees and decimal minutes. Charge weights refer to Geogel 60%.

Shot	Time			UTM Coords (m)		Lat(N)		Long(W)		Elev	Charge
ID	D	H	M	N	E	deg	min	deg	min	(m)	(kg)
CCA	76	14	00	7557800	564000	68	7.71	133	27.63	30	270
CCB	82	14	30	7558000	563875	68	7.82	133	27.08	30	1260
CLA	74	15	00	7574850	573700	68	16.74	133	12.92	25	540
CLB	84	11	40	7574725	573650	68	16.67	133	13.00	25	2250
EPA	76	14	50	7380650	438800	66	32.43	136	22.66	685	1440
EPB	82	14	10	7380900	438950	66	32.57	136	22.47	680	1584
EPC	85	14	20	7380750	438925	66	32.49	136	22.49	685	2736
EPD	87	14	50	7380800	438900	66	32.51	136	22.53	685	1089
HIA	82	14	40	7783315	503500	70	9.48	140	54.46	0	1728
LPA	74	16	00	7676120	528125	69	11.72	134	17.43	15	630
LPB	80	13	10	7676070	528175	69	11.69	134	17.35	15	720
MBA	85	13	20	7698215	411030	69	22.81	137	15.84	0	675
MBB	87	14	30	7698215	411030	69	22.81	137	15.84	0	1431
POA	80	14	00	7771016	450849	70	2.58	136	17.42	0	648
POB	84	11	50	7781687	434333	70	8.10	136	43.90	0	918
RIA	74	13	40	7809145	427249	70	22.75	136	56.49	0	1836
RIB	80	15	00	7811189	424615	70	23.80	137	0.81	0	918
SLA	74	15	50	7531400	598350	67	52.93	132	39.54	280	540
SLB	76	13	00	7531325	598350	67	52.89	132	39.54	280	450
SLC	80	13	20	7531650	598500	67	53.06	132	39.31	280	1800
SLD	82	15	40	7531450	598450	67	52.95	132	39.39	280	1350
SLE	85	13	40	7531525	598475	67	52.99	132	39.35	280	2070
SLF	87	13	40	7531700	598450	67	53.09	132	39.38	280	2070
SPA	76	13	50	7644215	411555	68	63.78	137	12.08	70	1386
SPB	82	14	00	7645000	411950	68	54.21	137	11.54	60	720
SPC	84	12	00	7643980	411360	68	53.65	137	12.36	70	747
SPD	85	13	50	7644080	411510	68	53.71	137	12.14	70	495
SPE	87	13	30	7643955	411500	68	53.64	137	12.15	70	1386

The Seismic Refraction Data

Introduction

All of the products of the seismic refraction survey, including the uncollated field products, initial and revised seismic trace data, and the field-generated and revised SEG-Y seismic sections, are available to potential users in the formats specified.

Field Products

Raw data. Prior to their deployment, the EDA PRS1s were programmed to record data during thirty time windows beginning every ten minutes, during the time over which shooting operations were planned to occur. The windows opened one second before a possible shot time and closed two minutes later. The sampling rate of the PRS1s is 120 samples per second, resulting in a total of 14400 data points per window. Following deployment, the entire 1 Mb memory of each PRS1 was recovered and copied onto 5.25 inch mini-floppy disks [1 disk per instrument per deployment, for a total of approximately 340 disks]. These memory-dump files are called ".raw" files and are named as follows: DY0n00xx.RAW, where 'n' identifies the deployment number [ranging from 1 to 7] and 'xx' is the two-digit PRS1 serial number ranging from [HEX] 01 to 43. No data were recovered from PRS1 2F at site F080 [DY02] so that no file DY02002F.RAW exists.

Seismic trace data. The .raw files were edited using EDA Field Service Unit software, selecting those windows during which shots were detonated for the given deployment. The seismic trace recorded during each of the selected windows was placed in a "z-file" named as follows: DY0n00xx.Zww, where 'n' and 'xx' are as above and 'ww' identifies the [HEX] window number [or, equivalently, the trace number within the raw file]. A total of approximately 1300 z-files were acquired and backed-up onto two 0.25 inch DC2000 tape cartridges [volumes MDI602 and MDI606]. The EDA editing software failed to edit 22 .raw files [Table 7] so that the affected z-files are not present on the two field-generated DC2000 back-up tapes.

SEG-Y data. In addition to the .raw files on floppy disks and the z-files on the 0.25 inch tape cartridges, 22 SEG-Y [Lithoprobe Data Storage format; see Appendix B] files on 9-track magnetic tapes were generated in the field. Each SEG-Y file represents one seismic section [all collinear traces in one direction from one of the ten shotpoints], consisting of between 11 and 96 traces each; the data are nonreduced and each trace is 60 seconds long. The smaller sections contain traces derived from single shots from one deployment. The larger sections [more than about 50 traces] are those comprising traces derived from two different shots from the same shotpoint during two deployments. A second set of field-generated SEG-Y [LDS format] files, corresponding to those on the 9-track tapes, exists on 5.25 inch mini-floppy disks. These are limited to 20 seconds of seismic trace, reduced at 7 km/s. Table 8 lists the field tape

Table 7. Results of recovery of data from corrupt .raw files.

Deployment	PRS1	Receiver Site	Traces Recovered	Traces With Good Data
DY01	15	F001	4	2
	29	F016	4	4
	25	F021	4	3
	1A	F025	*	-
	05	F040	*	-
DY02	3E	F053	*	-
	16	F062	4	0
	05	F095	2	0
DY03	3E	D022	4	0
	1B	D026	4	4
	29	D038	4	1
DY04	13	D059	5	3
	24	D076	5	0
	22	D094	3	1
DY05	23	D103	3	0
	1F	D110	3	0
	2B	D126	3	3
	21	D131	3	0
DY06	0B	C008	4	4
	0F	C013	4	0
	09	C045	4	4
	1D	C046	4	0
TOTAL			71	29

*.raw file was empty

Table 8. Field-generated 60-second LDS formatted tapes and 20-second [reduced at 7 km/s] mini-floppy disk files.

Tape reel number	Floppy disk file name (.SGY)	Shot(s)	Line	Direction (along line from shot)	Number of traces
1001	SLFAC	SLA, SLC	F	NORTH	91
1002	RIFAB	RIA, RIB	F	SOUTH	91
1003	LPFA	LPA	F	SOUTH	44
1004	LPFB	LPB	F	NORTH	46
1005	CLFA	CLA	F	NORTH	34
1006	CLFB	CLB	F	SOUTH	11
1007	POFA1	POA	F	NORTH	13
1008	POFA2	POB	F	SOUTH	36
1009	SLDCD	SLC, SLD	D	WEST	95
1010	HIDA	HIA	D	EAST	46
1011	SPDC	SPC	D	WEST	34
1012	SPDAB1	SPA, SPB	D	EAST	94
1013	CCDAB	CCA, CCB	D	WEST	76
1014	CCDA2	CCA	D	EAST	20
1015	PODB	POB	D	FAN SHOT	34
1016	CLDB	CLB	D	WEST	34
1017	EPDAB	EPA, EPB	D	FAN SHOT	93
1019	EPCCD	EPC, EPD	C	NORTH	96
1022	MBCAB	MBA, MBB	C	SOUTH	96
1023	SLCEF	SLE, SLF	C	FAN SHOT	96
1024	SPCDE1	SPD, SPE	C	SOUTH	85
1025	SPCD2	SPD	C	NORTH	12

reel numbers, the corresponding mini-floppy disk file names.

Revised Data

Updates. Data from corrupt .raw files that were not able to be edited in the field [Table 7] were recovered by fixing, on a file by file basis, the appropriate directory file headers and data file headers [Zelt, 1988b]. The decorrupted .raw files, that are now able to be edited using the EDA software, result in a set of nineteen duplicate .raw file names [decorrupted .raw files that were empty (cf. Table 7) were not created] reside on mini-floppy disks with volume names FIXEDRAW01-FIXEDRAW19. A total of 29 z-files with good data were recovered. The remainder of the z-files were, in general, series of spikes with no discernible seismic data. The traces with good data have been added to the database and the augmented inventory of z-files has been backed-up onto 0.25 inch DC2000 tape cartridges volumes MDI608 and MDI610.

New sets of SEG-Y files [LDS format] on nine-track magnetic tape and on mini-floppy disks have been generated [Table 9] and include the following modifications to the field tapes: (1) all shot and receiver coordinates on the field tapes were checked and corrected as necessary; (2) some traces that were missing on the field tapes have been added; (3) several traces that were misassigned to seismic sections have been removed; (4) traces recorded by instruments that were definitely not deployed at the time of shot detonation have been removed; (5) shot and receiver elevations and depth of shots have been added; (6) shot and

Table 9. Final 65-second non-reduced LDS formatted tapes and 20-second [reduced at 8 km/s] mini-floppy disk files.

Tape reel number	Floppy disk file name (.SGY)	Shot(s)	Line	Direction (along line from shot)	Number of traces	Figure number
9001	SLFACN	SLA, SLC	F	NORTH	76	3
9002	RIFABS	RIA, RIB	F	SOUTH	87	4
9003	LPFAS	LPA	F	SOUTH	45	5
9004	LPFBN	LPB	F	NORTH	26	6
9005	CLFAN	CLA	F	NORTH	33	7
9006	CLFAS	CLA	F	SOUTH	12	8
9007	POFAN	POA	F	NORTH	7	9
9008	POFAS	POA	F	SOUTH	32	10
9009	SLDBDW	SLB, SLD	D	WEST	96	11
9010	HIDAE	HIA	D	EAST	47	12
9011	SPDCW	SPC	D	WEST	35	13
9012	SPDABE	SPA, SPB	D	EAST	91	14
9013	CCDABW	CCA, CCB	D	WEST	76	15
9014	CCDAE	CCA	D	EAST	20	16
9015	PODBF	POB	D	FAN SHOT	36	17
9016	CLDBW	CLB	D	WEST	36	18
9017	EPDABF	EPA, EPB	D	FAN SHOT	94	19
9019	EPCCDN	EPC, EPD	C	NORTH	95	20
9022	MBCABS	MBA, MBB	C	SOUTH	96	21
9023	SLCEFF	SLE, SLF	C	FAN SHOT	97	22
9024	SPCDES	SPD, SPE	C	SOUTH	84	23
9025	SPCDN	SPD	C	NORTH	12	24
					1223	

receiver timing corrections, caused by drift in the PRS1 clocks and shooting box clocks, have been calculated and added [see subsequent note on POB timing correction]; (7) shot charge sizes have been included; (8) seismic traces residing on initially corrupted .raw files have been added; and (9) traces that unmistakably comprise instrument noise only have been removed. The new 9-track magnetic tapes SEG-Y files contain 65 seconds of non-reduced data. The new mini-floppy disk SEG-Y files contain 20 seconds of data reduced at 8 km/s. Table 9 lists the new tape reel numbers and the corresponding mini-floppy disk file names. Note that the timing corrections on tape 9015 and in mini-floppy diskette file PODBF.SGY [PO fan shot], because of software limitations, are zero rather than the calculated value of -16.2 s.

Seismic Sections. The twenty-two final refraction seismic sections, plotted with a reducing velocity of 8 km/s and with appropriate length scales and time windows for each, are shown in Figures 3-24, as listed in Table 9. The traces within a particular section have been scaled to a common maximum amplitude and for plotting efficiency only every second point has been plotted. The numbers along the top of the plots represent the receiver site number. Not all traces in a given SEG-Y file have been plotted for reasons such as the occasional existence of duplicates. A full documentation of potential and missing traces is provided in Appendix C. All traces were despiked prior to plotting but otherwise they have not been filtered. Zelt [1987, 1988a] reports that a 3-15 Hz bandpass filter improves signal:noise on most of the traces. Note that the RI section

Figure 3. Line F - Shot SL north [see Appendix C for details].

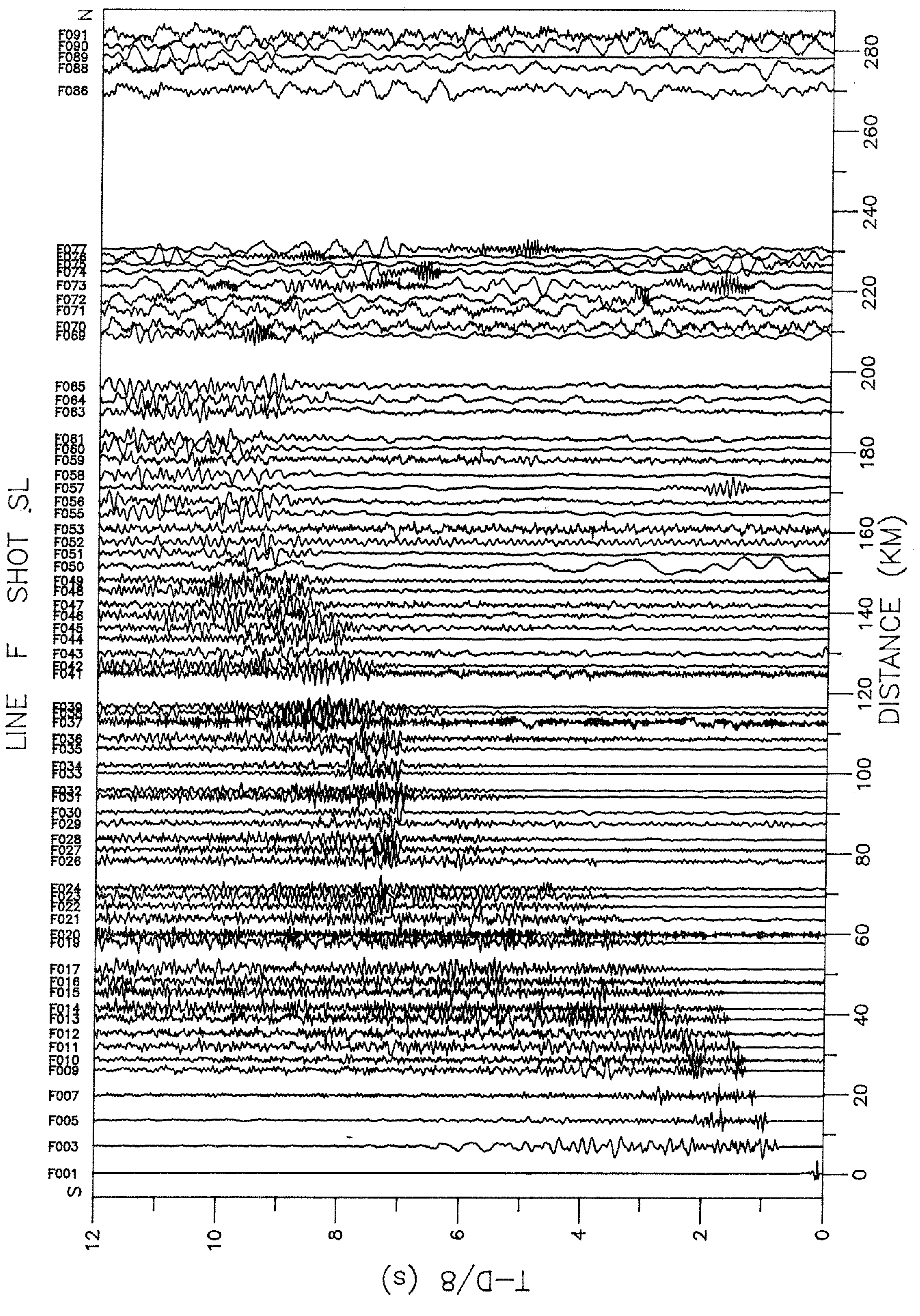


Figure 4. Line F - Shot RI south [see Appendix C for details].

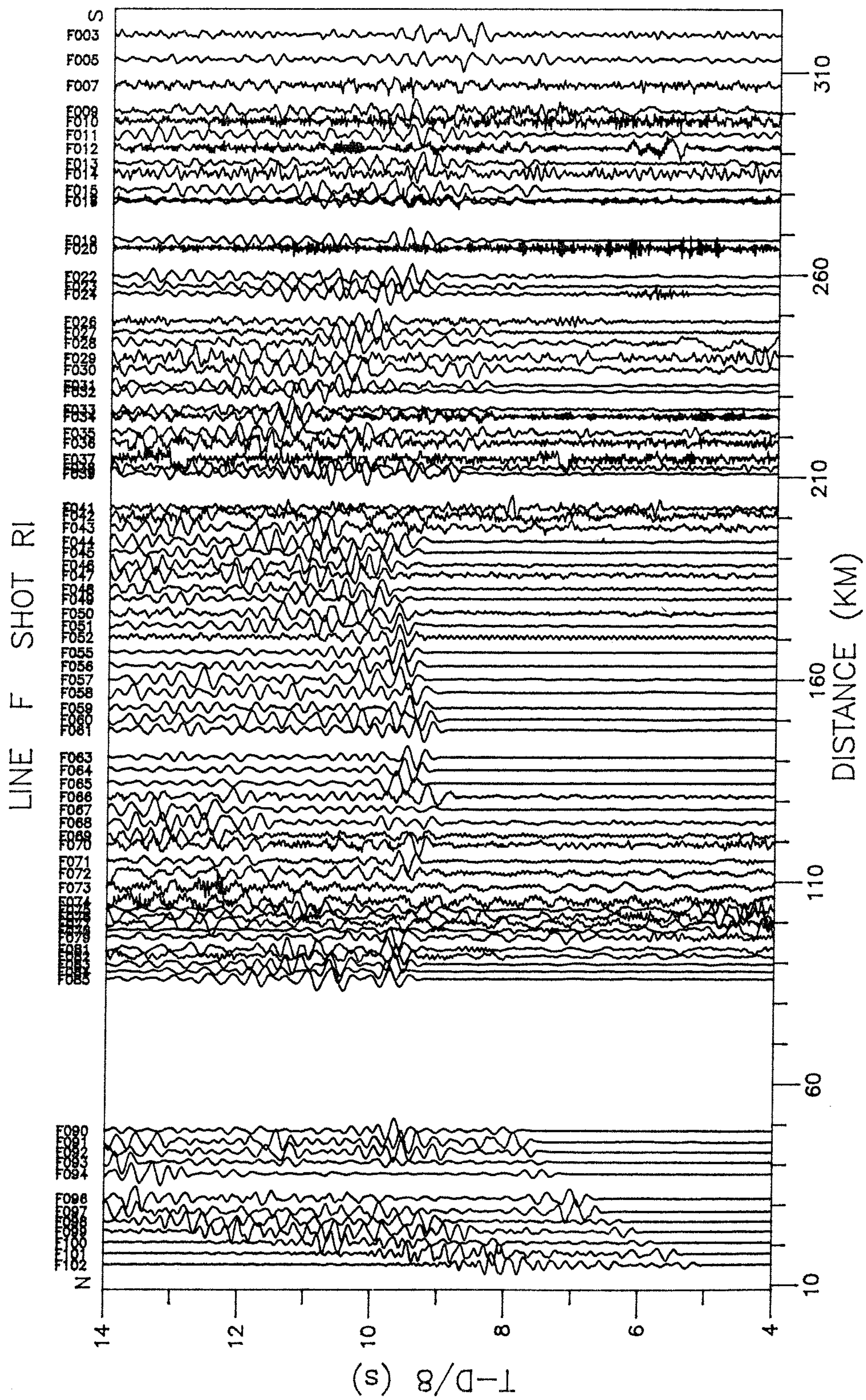


Figure 5. Line F - Shot LP south [see Appendix C for details].

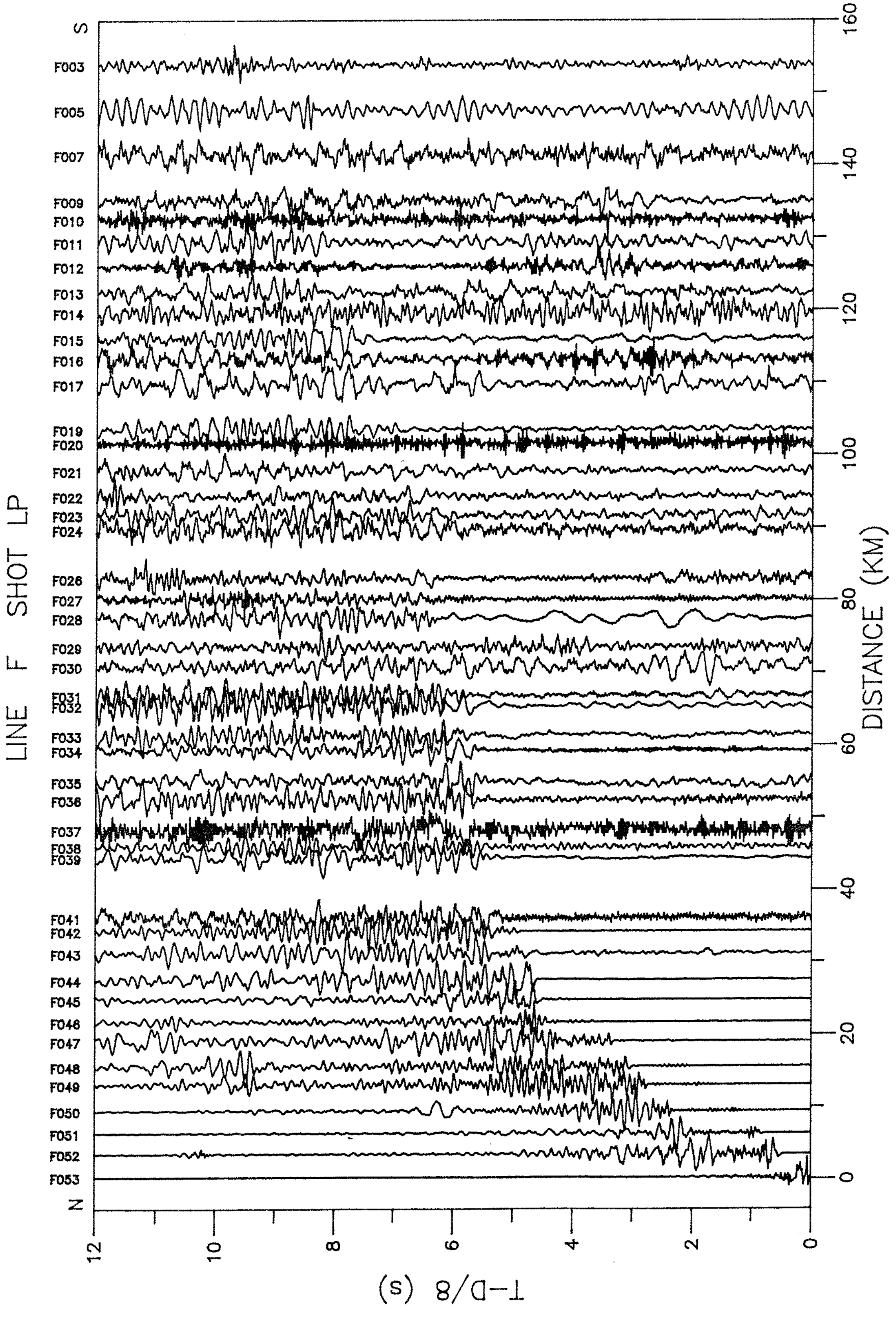


Figure 6. Line F - Shot LP north [see Appendix C for details].

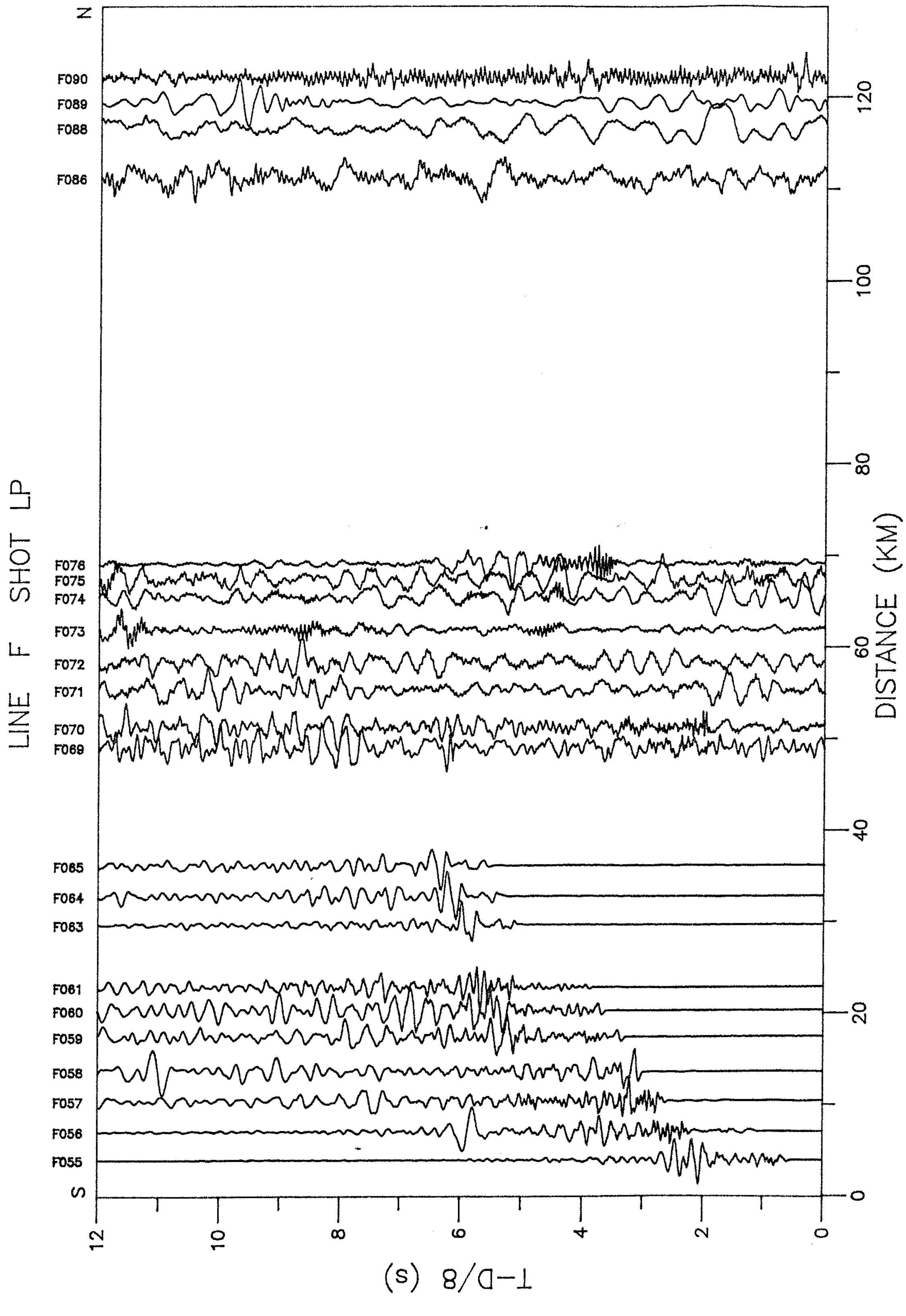


Figure 7. Line F - Shot CL north [see Appendix C for details].

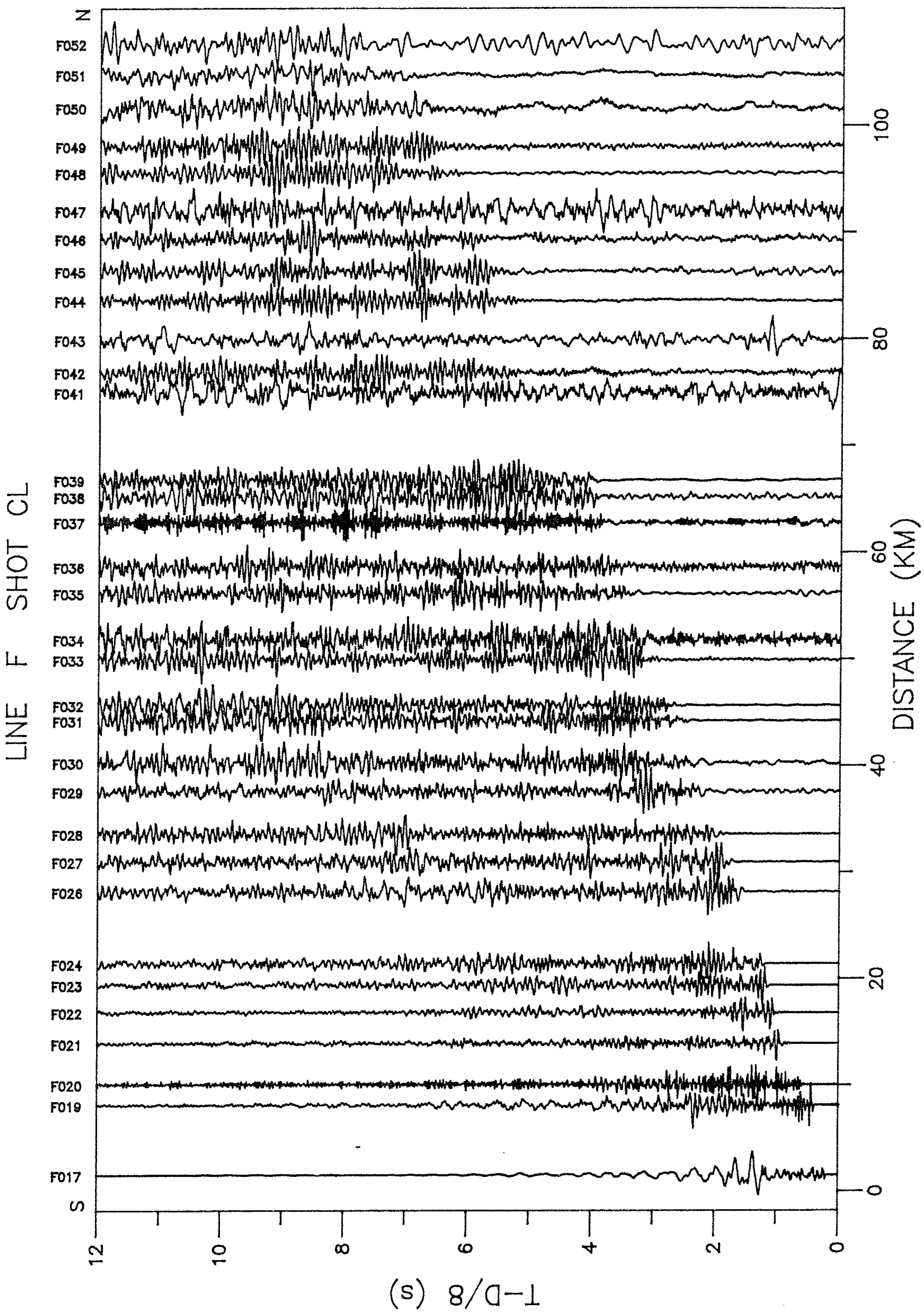


Figure 8. Line F - Shot CL south [see Appendix C for details].

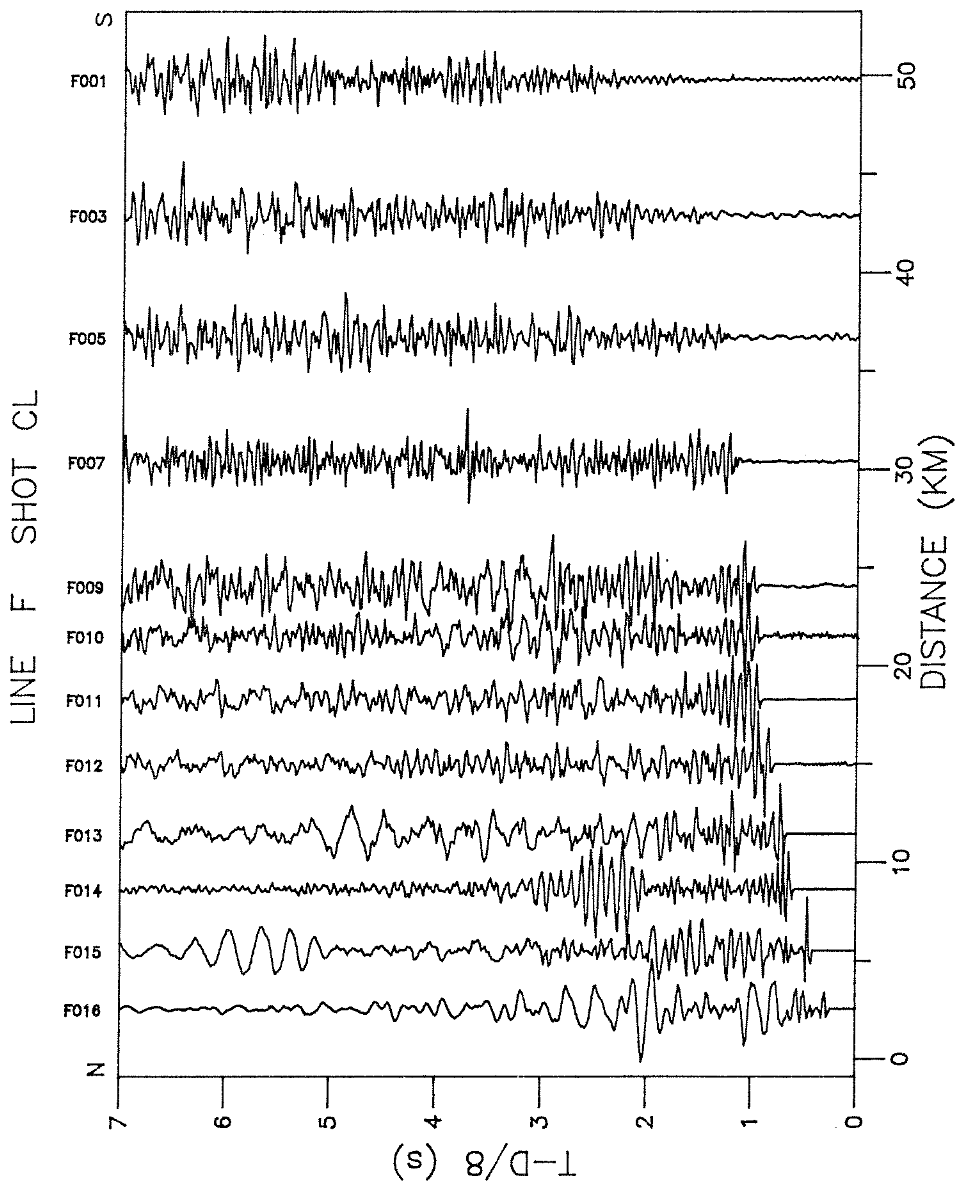


Figure 9. Line F - Shot PO north [see Appendix C for details].

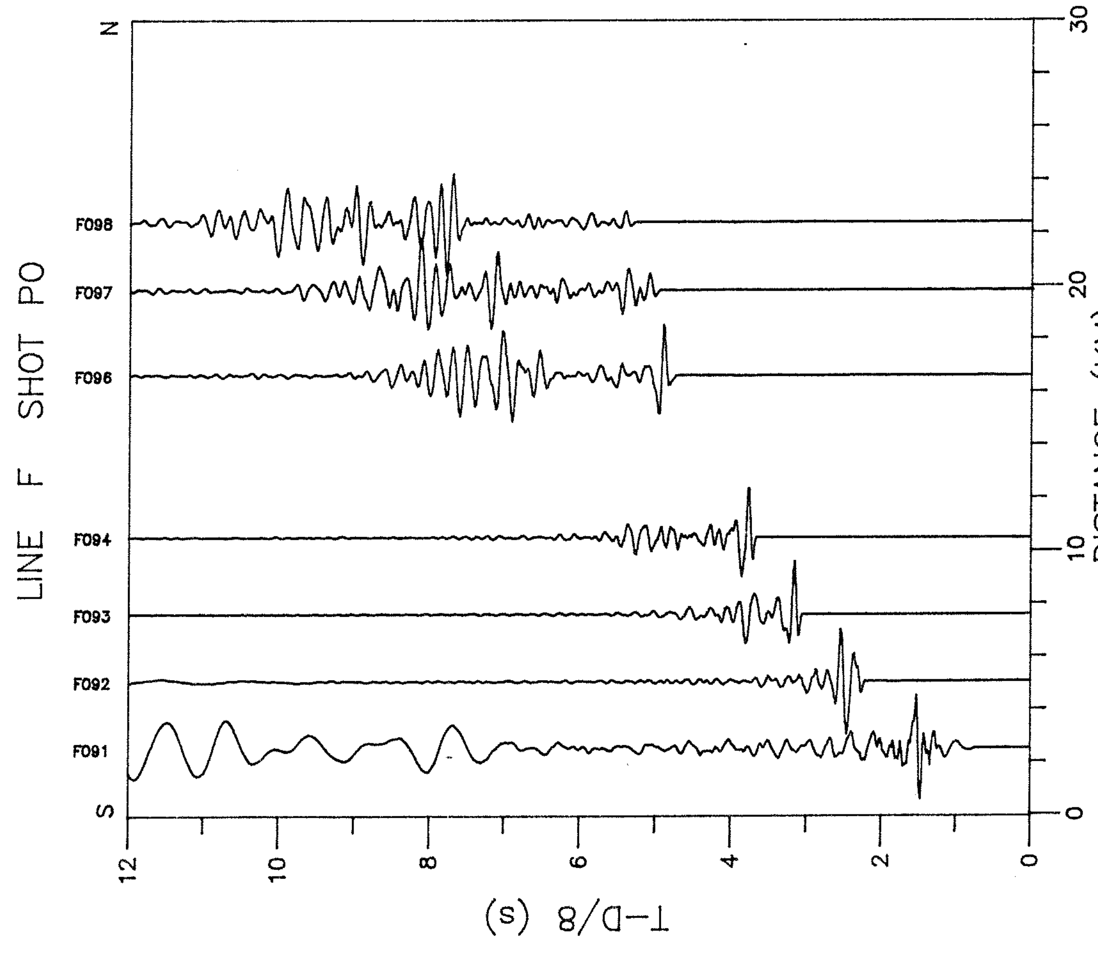


Figure 10. Line F - Shot PO south [see Appendix C for details].

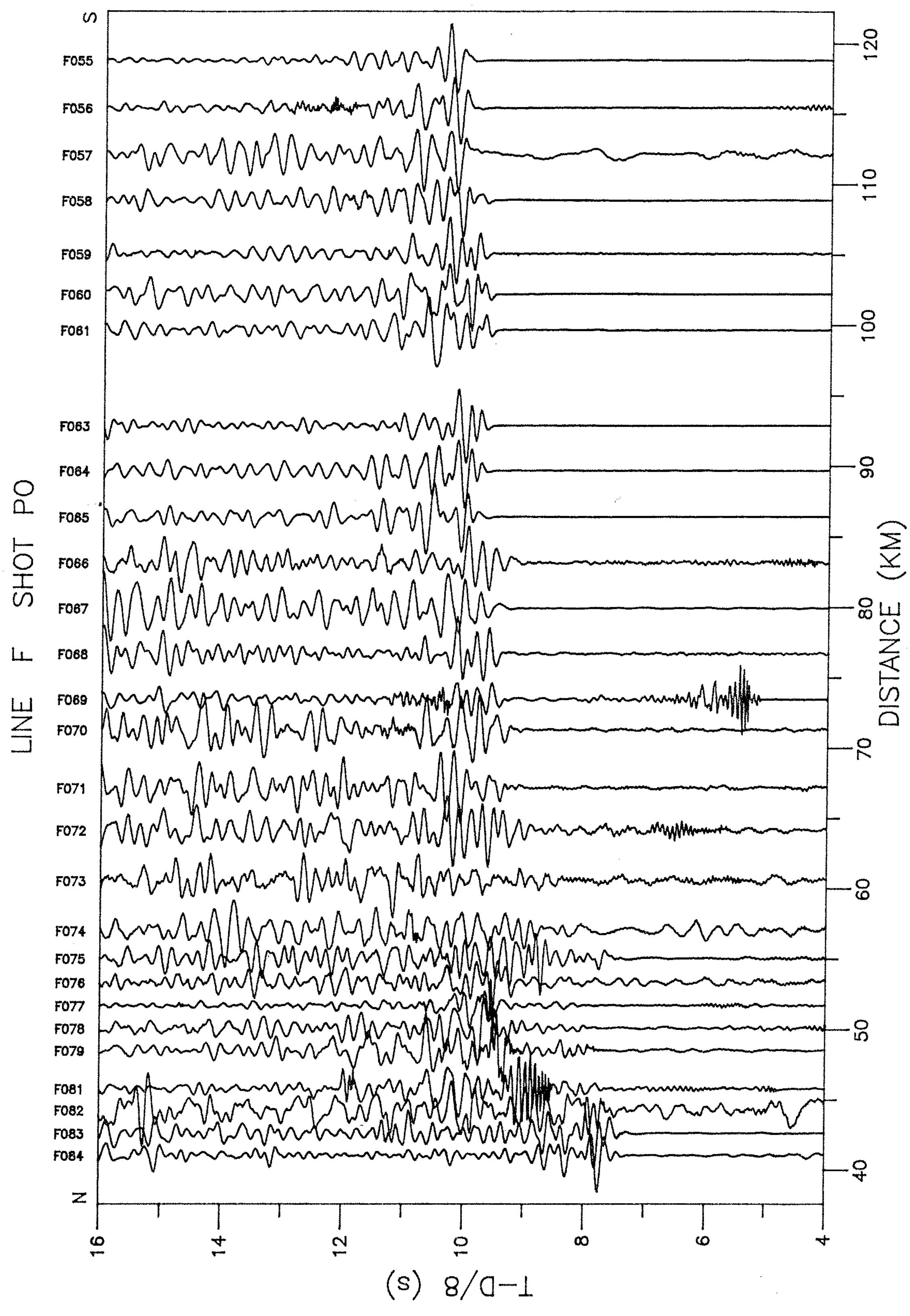


Figure 11. Line D - Shot SL west [see Appendix C for details].

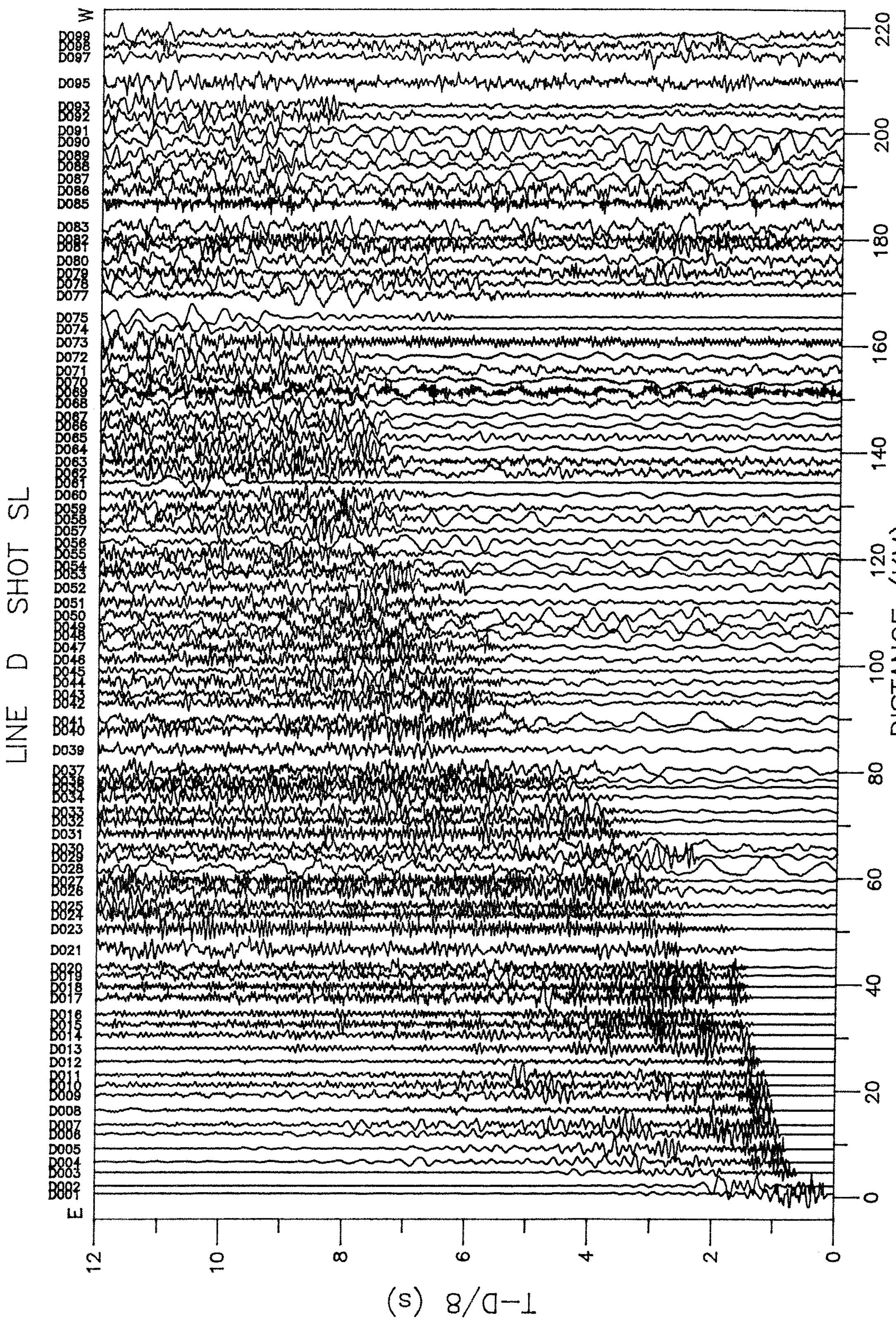


Figure 12. Line D - Shot HI east [see Appendix C for details].

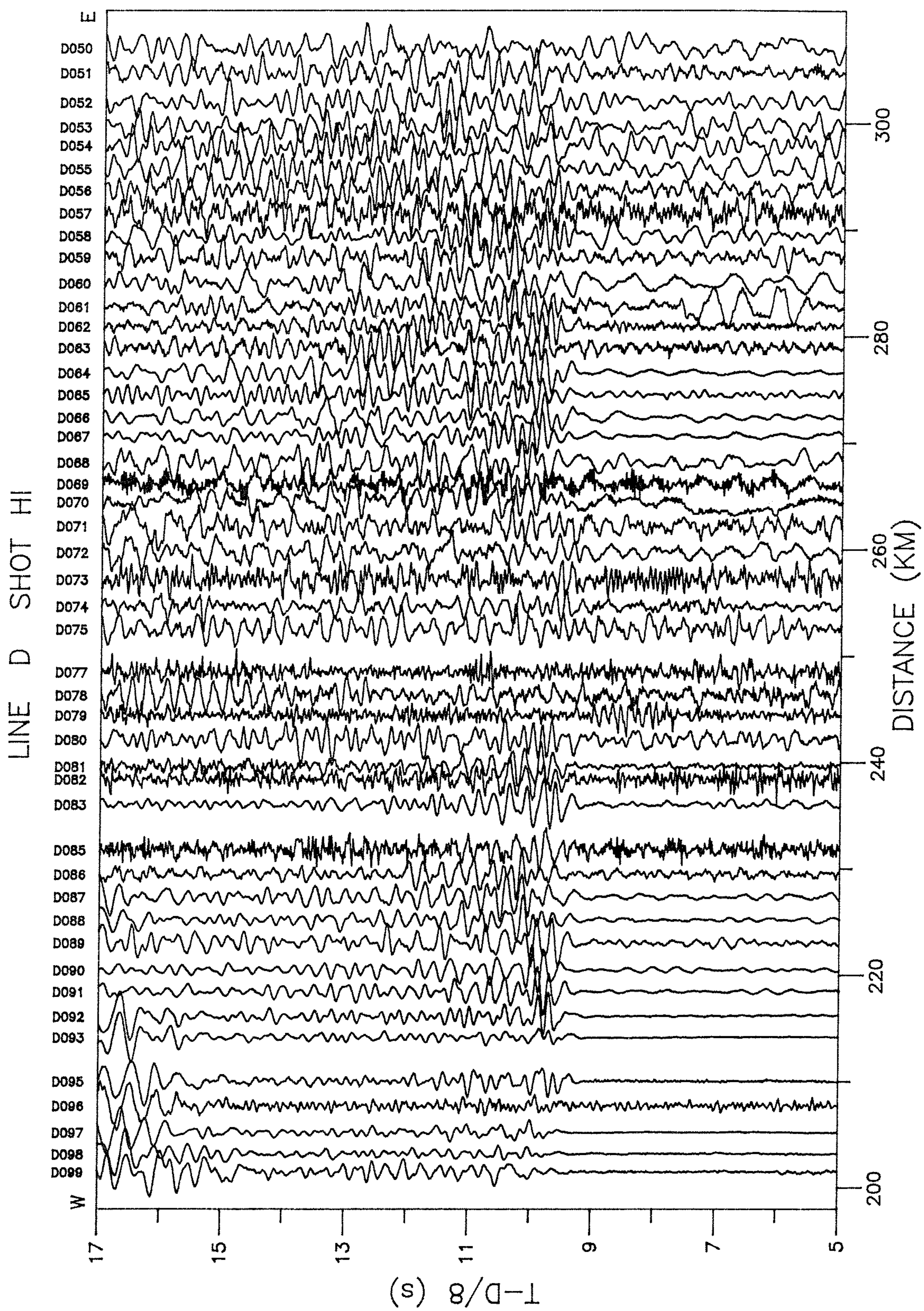


Figure 13. Line D - Shot SP west [see Appendix C for details].

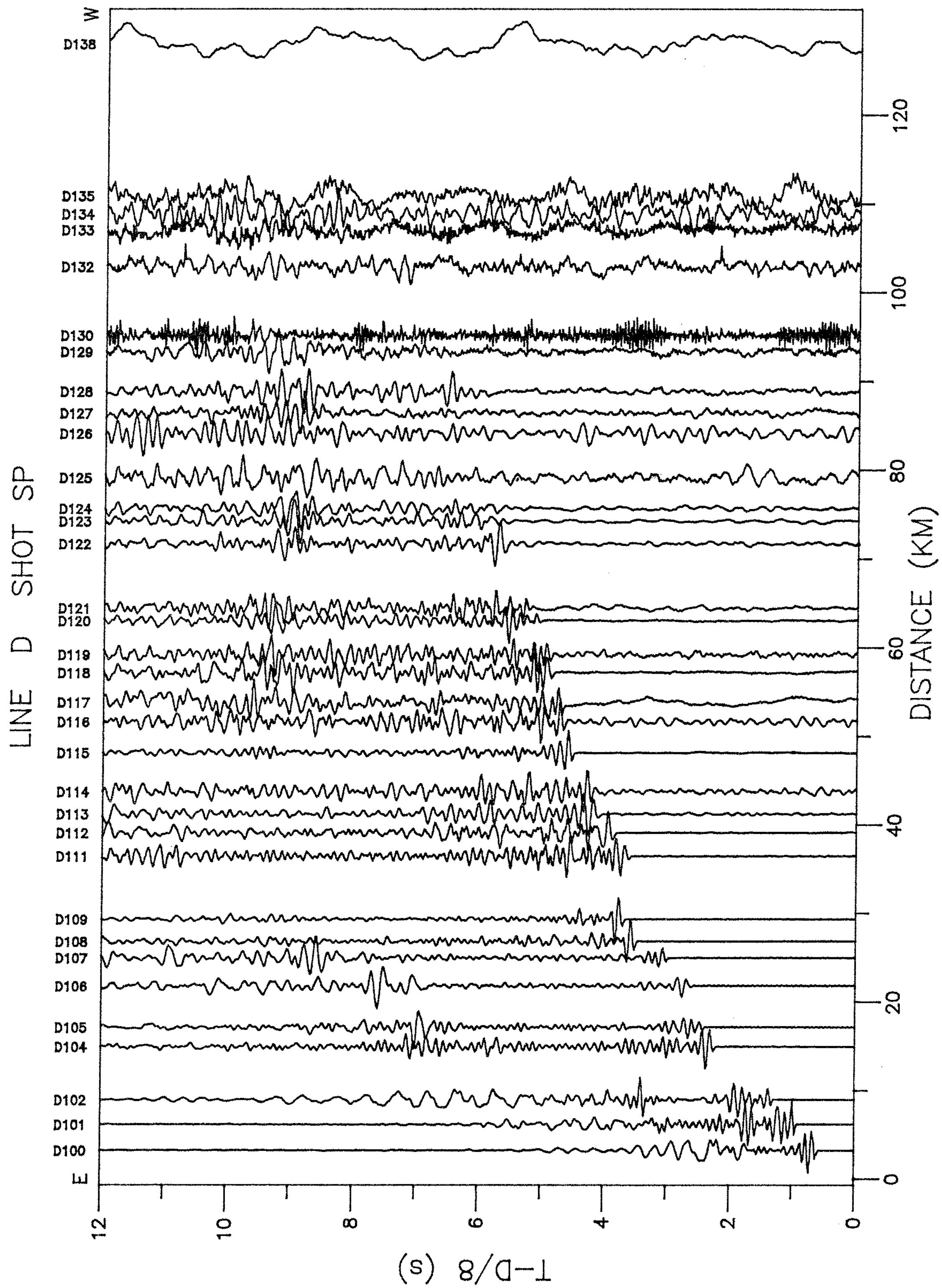


Figure 14. Line D - Shot SP east [see Appendix C for details].

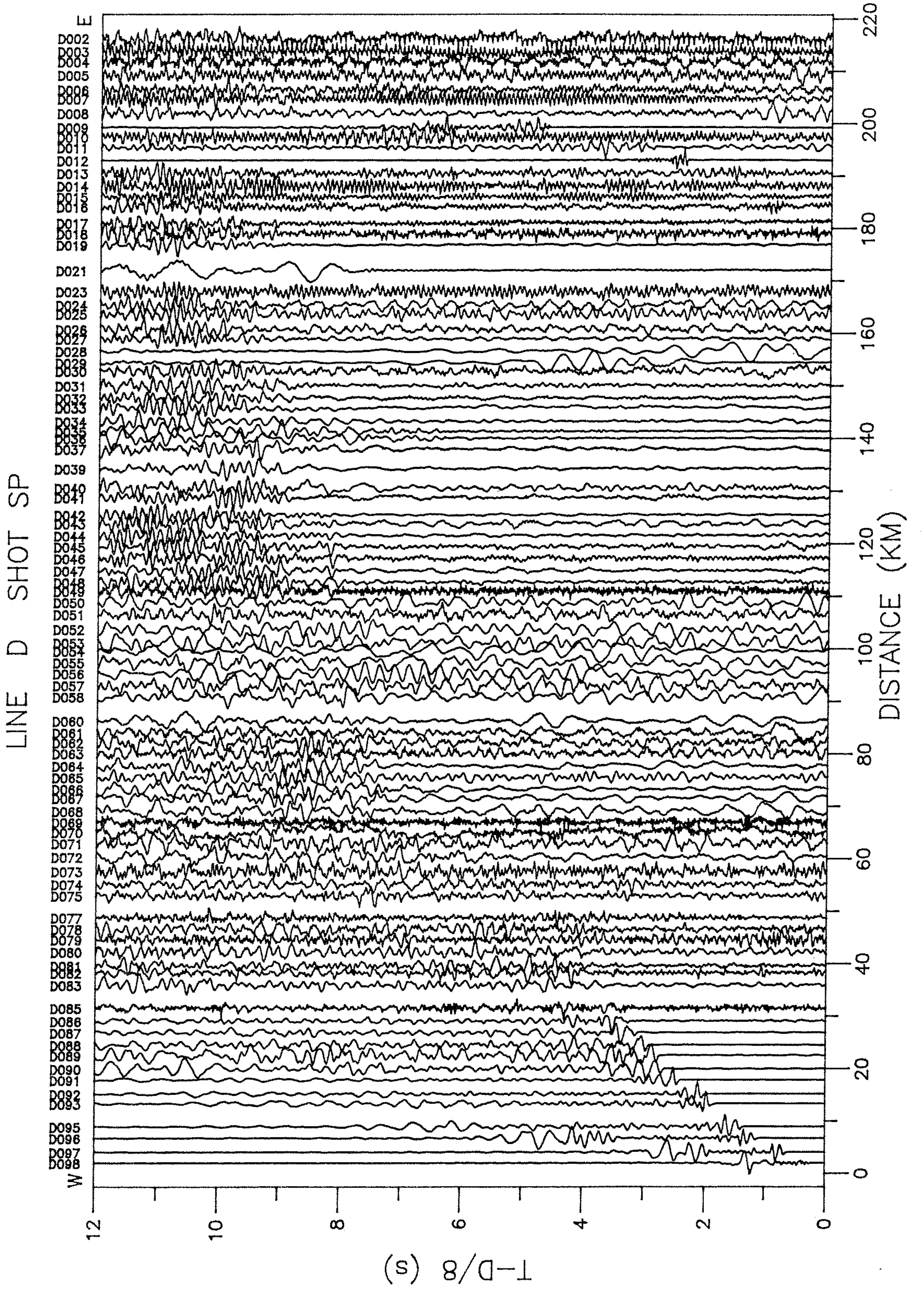


Figure 15. Line D - Shot CC west [see Appendix C for details].

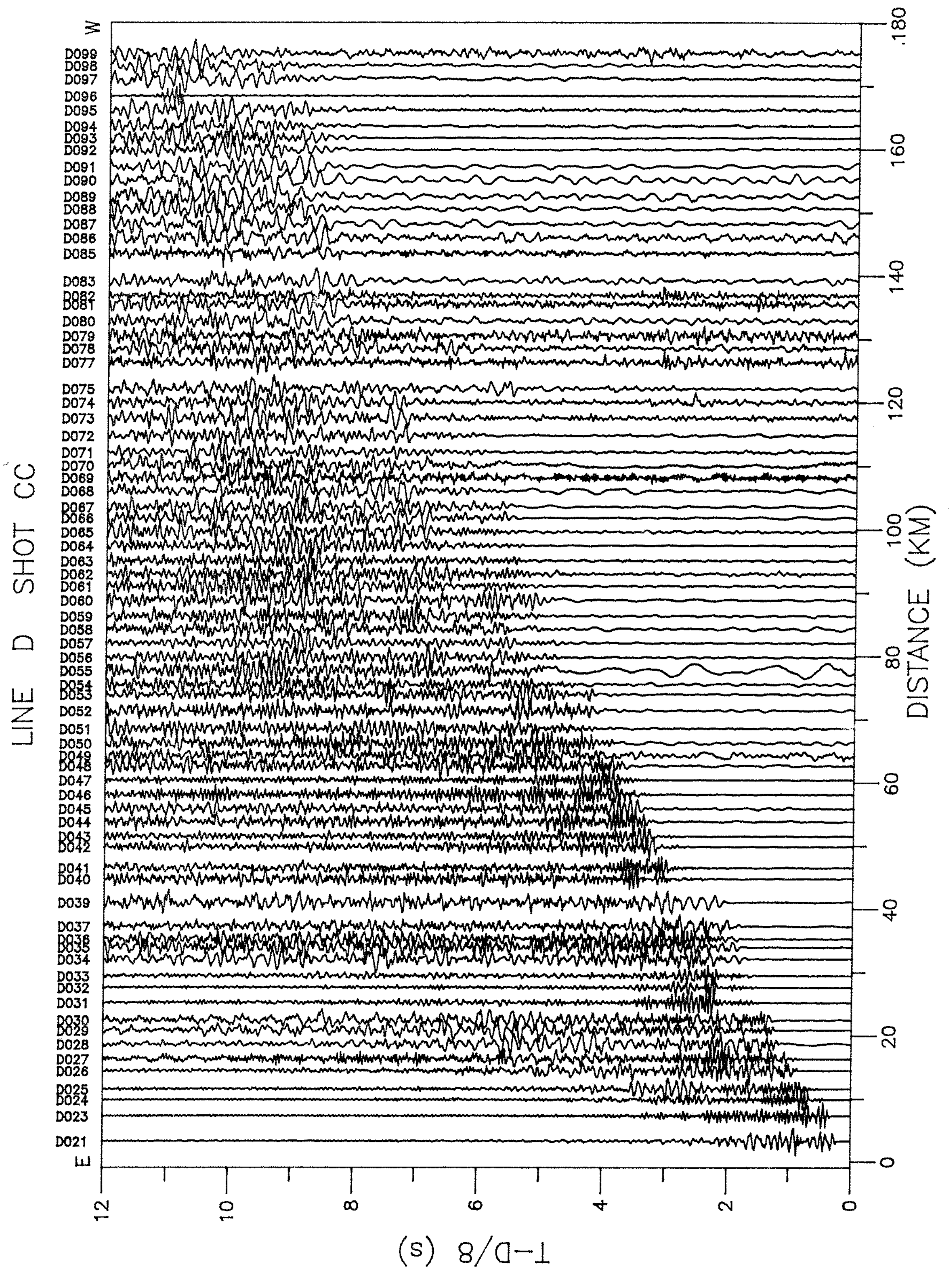


Figure 16. Line D - Shot CC east [see Appendix C for details].

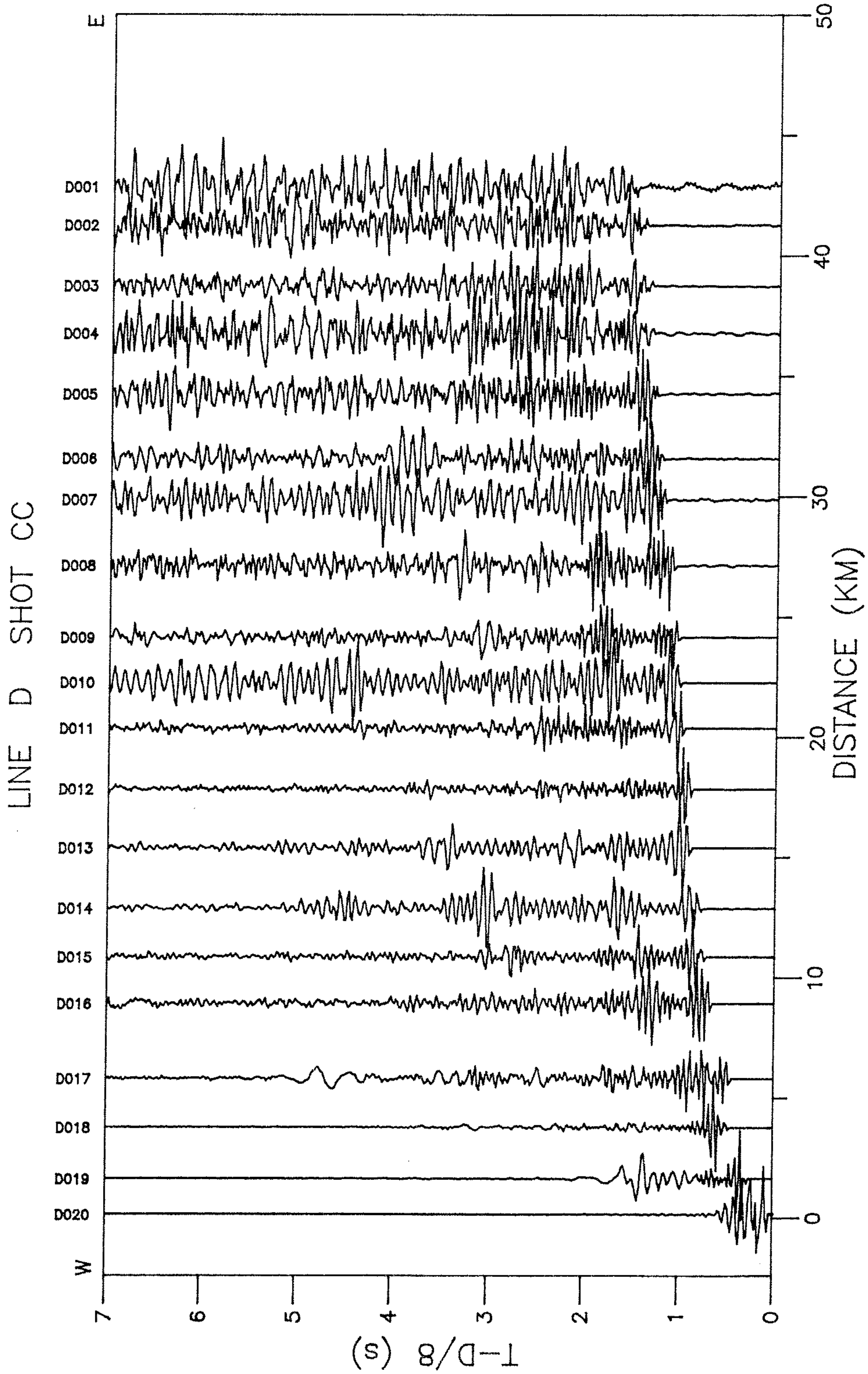


Figure 17. Line D - Shot PO fan [see Appendix C for details].

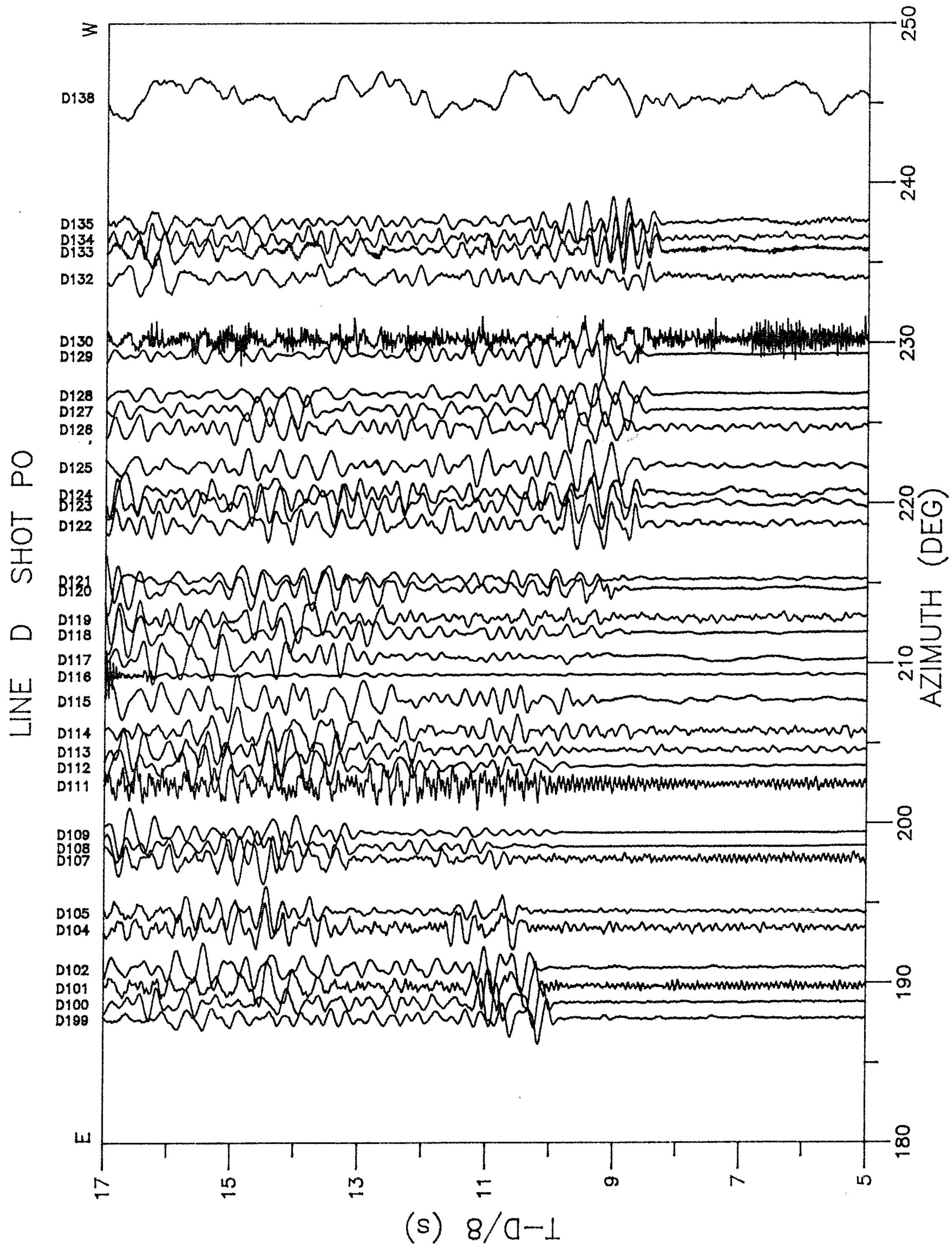


Figure 18. Line D - Shot CL west [see Appendix C for details].

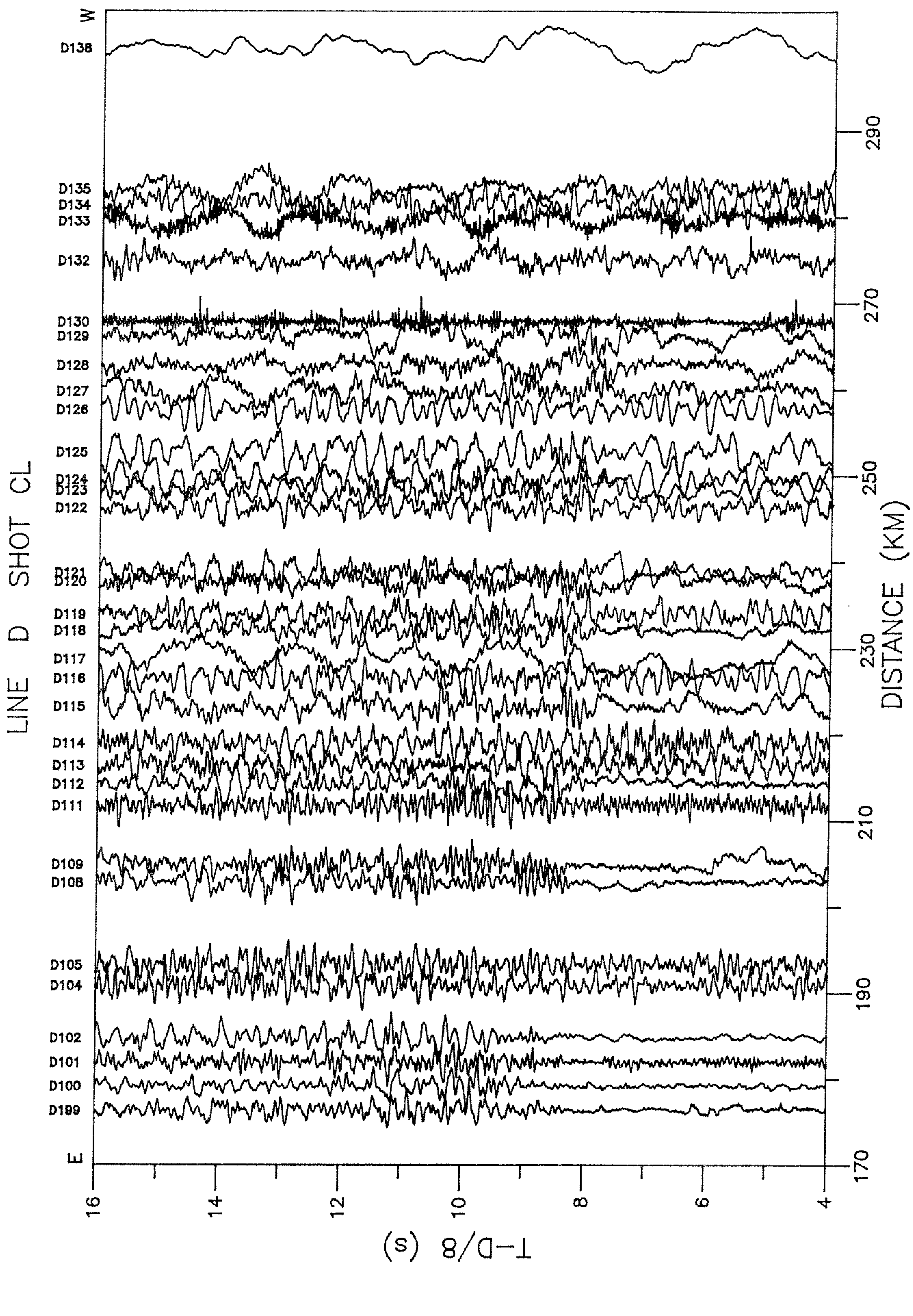


Figure 19. Line D - Shot EP fan [see Appendix C for details].

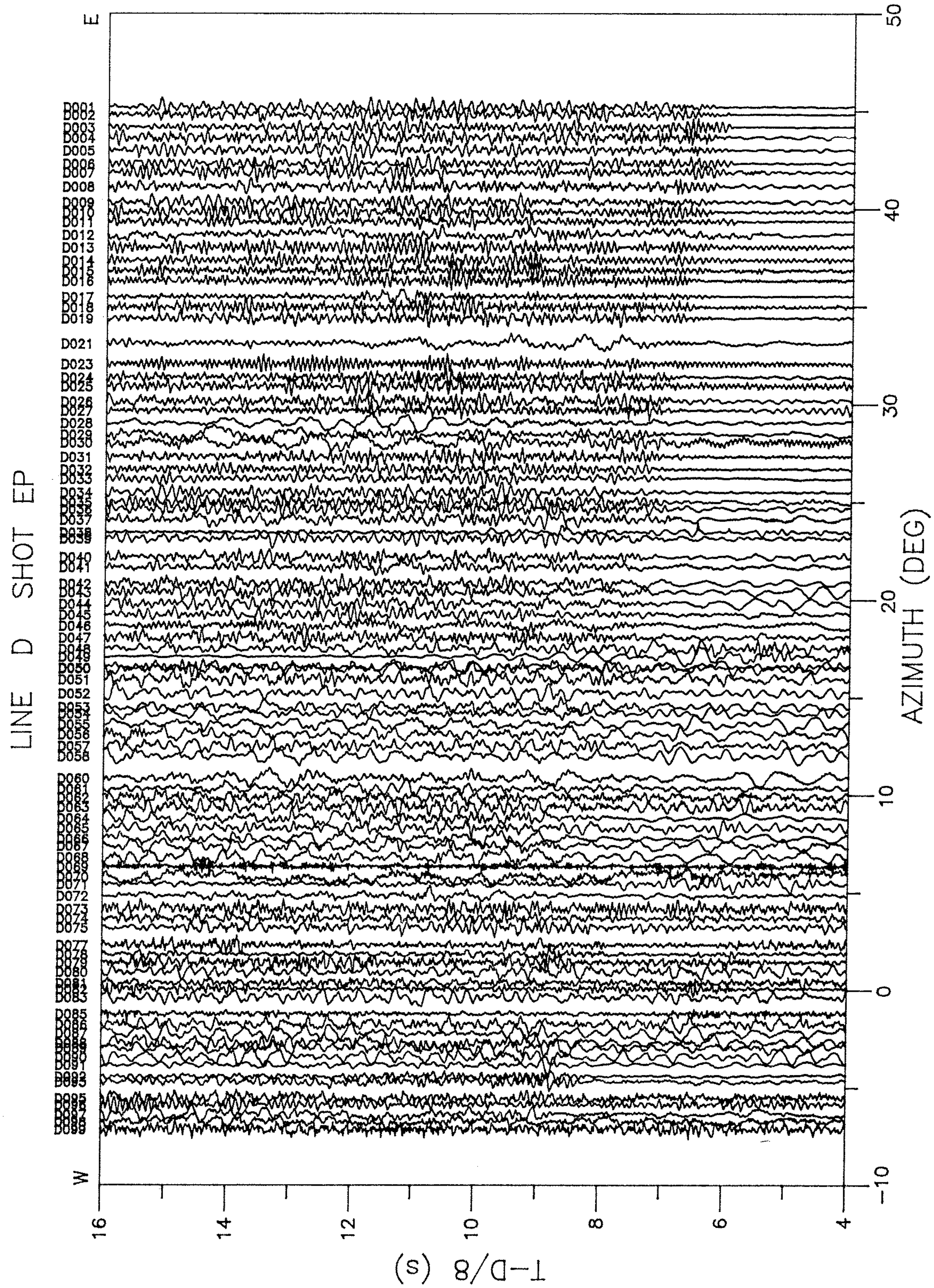


Figure 20. Line C - Shot EP north [see Appendix C.for details].

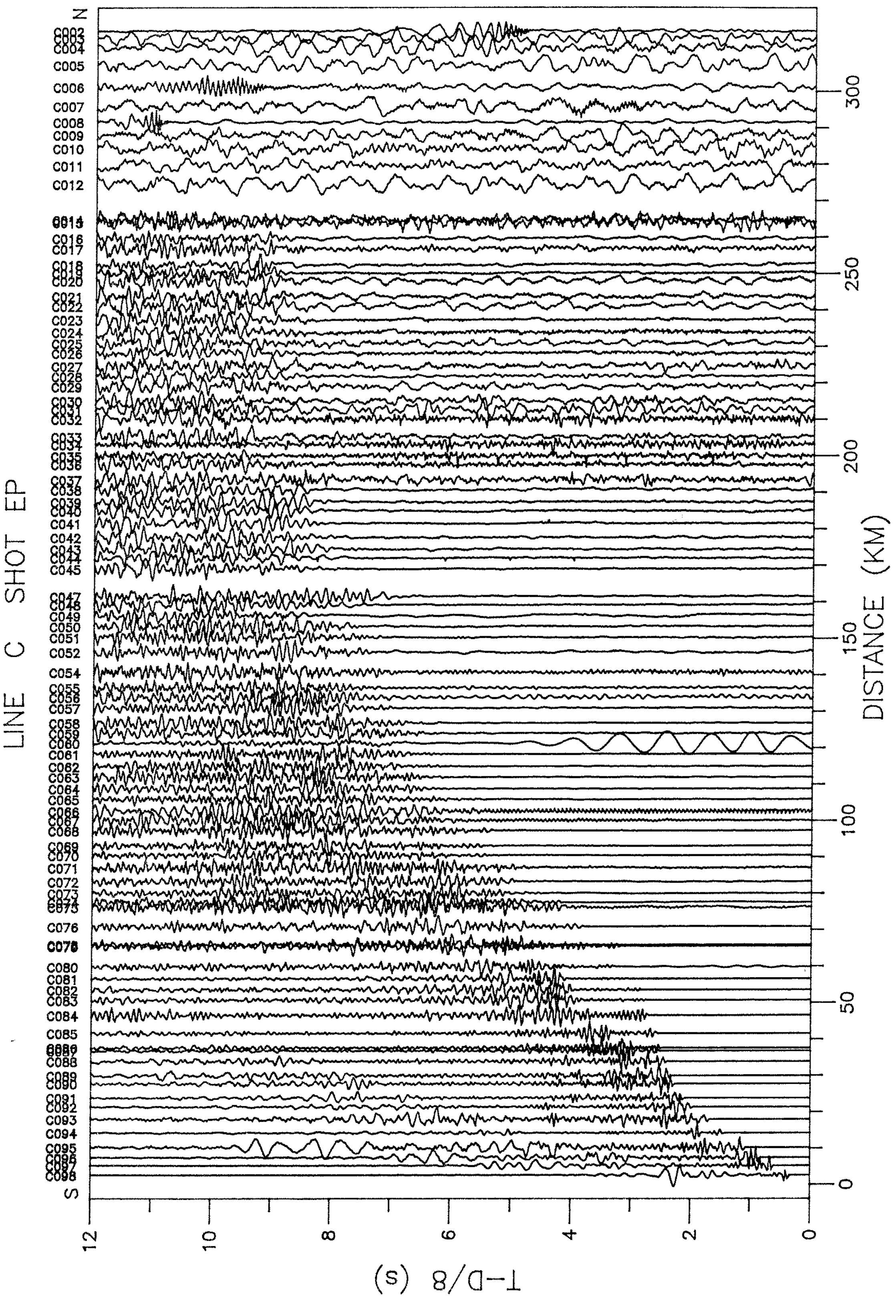


Figure 21. Line C - Shot MB south [see Appendix C for details].

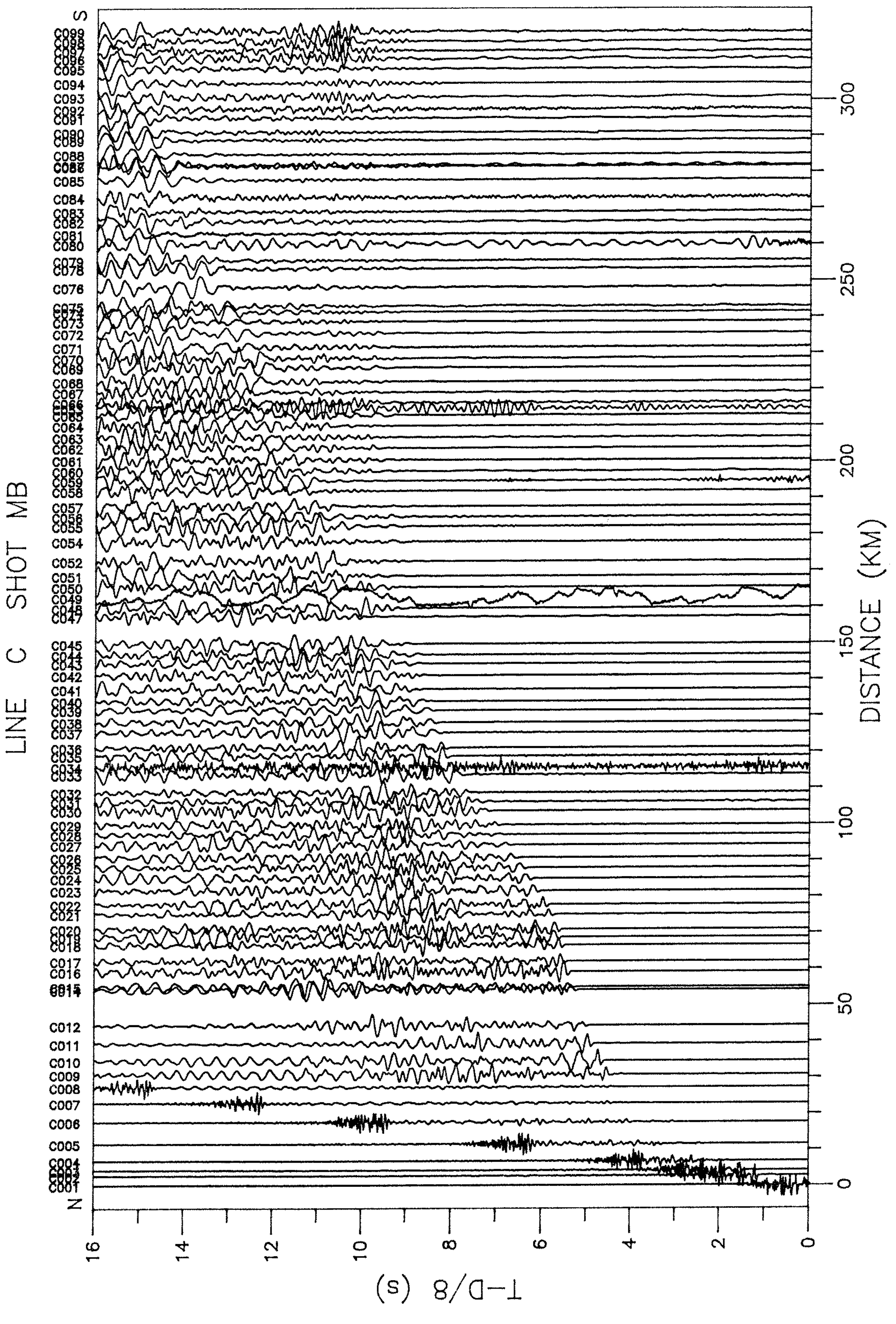


Figure 22. Line C - Shot SL fan [see Appendix C for details].

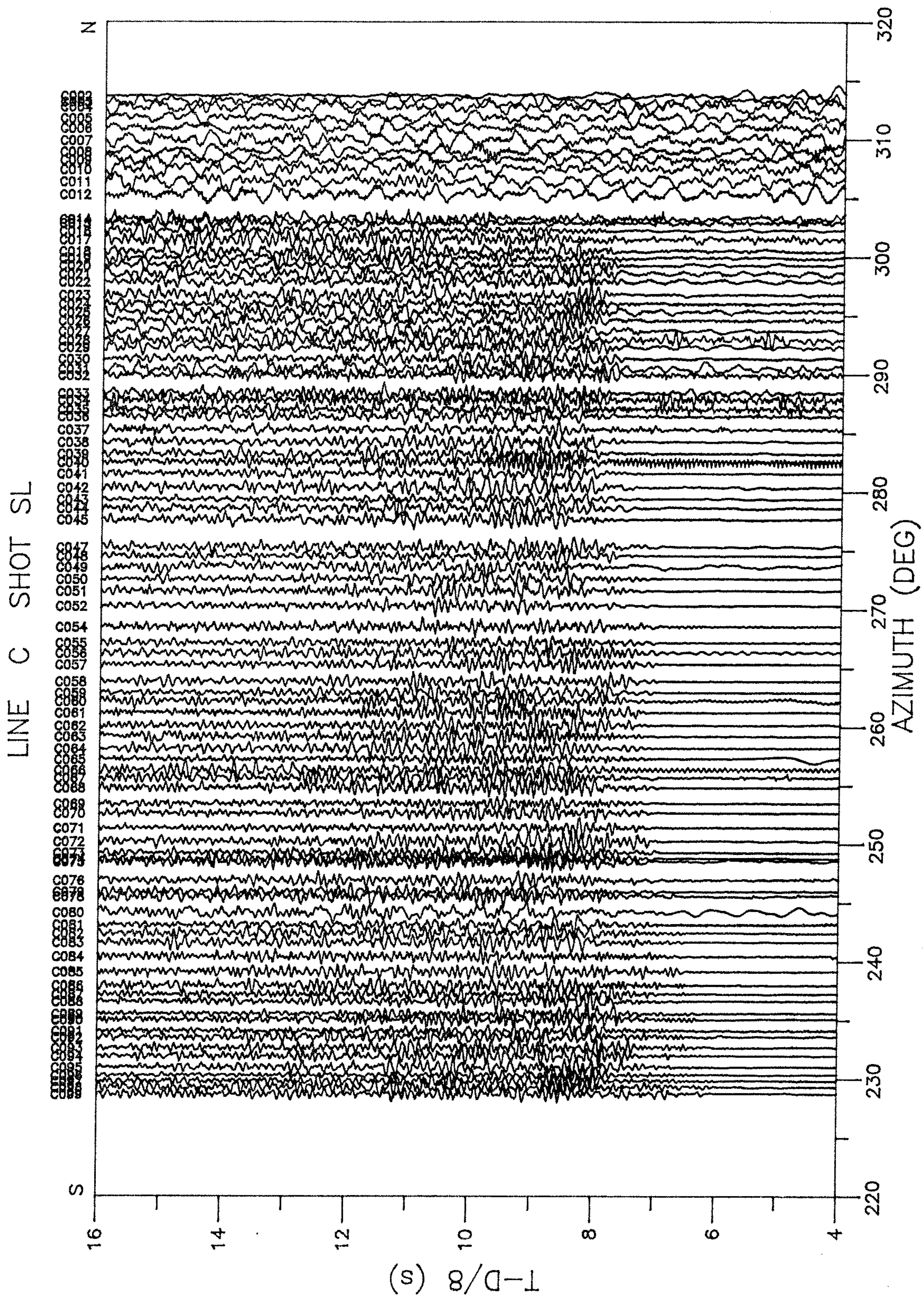


Figure 23. Line C - Shot SP south [see Appendix C for details].

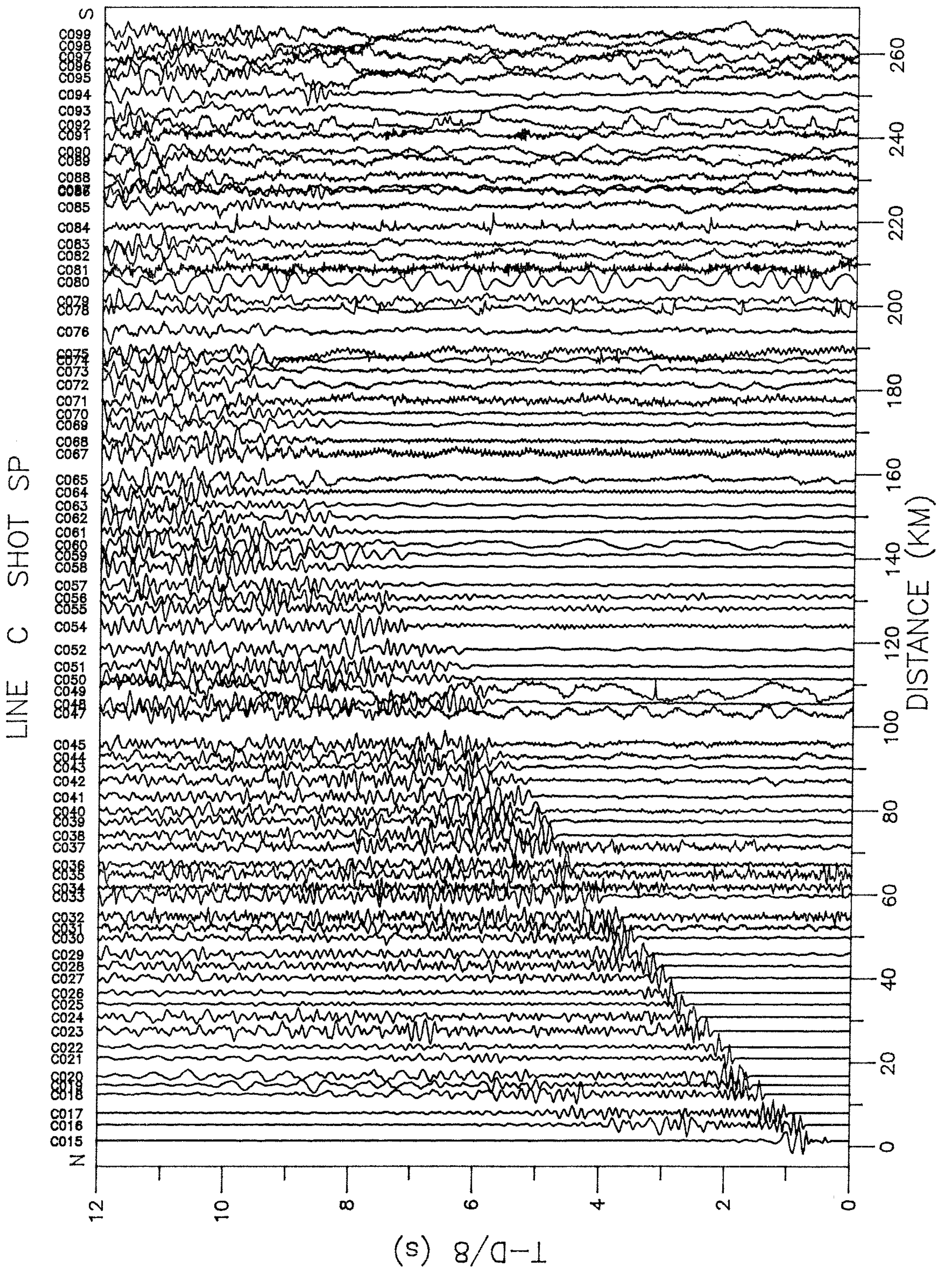
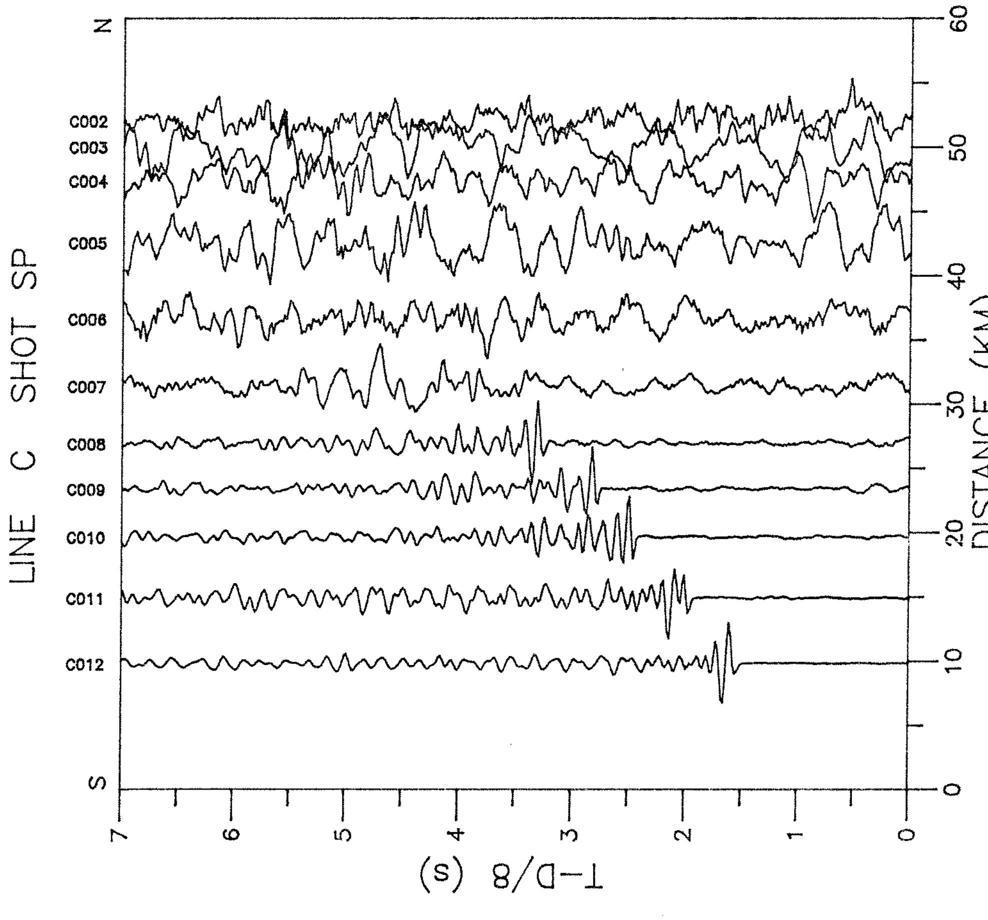


Figure 24. Line C - Shot SP north [see Appendix C for details].



[Figure 4] is a composite of traces recording shots [RIA and RIB] originating from different locations. The proximal traces [F055 - F102] are plotted at distances relative to the position of RIB and the distal traces [F003 - F052] are plotted at distances relative to the position of RIA.

Summary

In March 1987 the Geological Survey of Canada undertook a major regional seismic refraction survey in the Mackenzie Delta - southern Beaufort Sea - northern Yukon area in order to complement existing geophysical and geological data with information on the velocity structure of the crust and upper mantle. The refraction survey consisted of seven recorder deployments used to obtain coverage along three lines resulting in the acquisition of approximately 830 km of reversed, 110 km of unreversed, and 650 km of broadside seismic profiling with an average recorder spacing of 3 km. This report describes the acquisition of the seismic refraction data and documents the resulting data, including the final seismic refraction sections. By doing so, all of the products of the seismic refraction survey, including the uncollated field products, initial and revised seismic trace data, and the field-generated and revised final SEG-Y seismic sections, are released to the public and are made available to potential users as nine-track magnetic tapes and/or mini-floppy diskettes.

Acknowledgements

The field operations of the seismic refraction survey were made possible by laboratory and residential facilities provided by the Inuvik Scientific Laboratory operated by Indian and Northern Affairs Canada. We thank John Ostrick and all the others at the Inuvik Laboratory for their cooperation and tolerance.

Helicopters were chartered from Okanagan Helicopters by the Polar Continental Shelf Project [Geological Survey of Canada] and, casually, from Sunrise Helicopters, Inuvik. Fixed-wing aircraft were chartered from Kenn Borek Air Limited and, casually, from Antler Aviation, Inuvik. Explosives from Explosives Limited and ancilliary services were expedited by Wray Lyons of Inuvik. Shotholes were drilled and loaded by Double R Drilling Limited, Spruce Grove, Alberta.

Permits for land use operations were provided by Indian and Northern Affairs Canada, Northern Affairs Program, Whitehorse and Inuvik [onshore seismic drilling and blasting, Yukon and Northwest Territories]; Department of Fisheries and Oceans, Northwest Territories Affairs, Yellowknife [offshore blasting]; Environment Canada, Parks, Winnipeg [helicopter traversing and recorder deployments within Northern Yukon National Park]; and the Inuvialuit Land Administration, Tuktoyaktuk [recorder deployments within Inuvialuit lands].

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Appendix A - Field Report by Robert Schieman [Extract]

Problems and Recommendations

Shooting equipment. Shooting system #3 malfunctioned on first shooting day and the shot had to be fired manually. Problem was a defective OPTO ISOLATOR in the blaster box; once replaced the system worked well for the remainder of the experiment. [The only complaint about the shooting equipment was that is was too large and heavy when the shooting was being done in deep soft snow and that the display on the new shooter box would fade in the cold. It is recommended that a new smaller lighter blaster box be developed and that the blaster box and the new shooter box be enclosed in a case to protect them from the snow and cold.]

Static electricity. During the experiment static electricity was a major problem in the lab: it would cause the computer to malfunction the high speed link [to be referred as HSL] to hang up and in one case may have been the cause for the 6303 microprocessor on the HSL to be destroyed. The static problem was almost completely eliminated when a humidifier, anti-static floor and table mats and anti-static wrist bracelets were used. It is strongly recommended that anti-static precautions be taken on all future Arctic experiments.

High Speed Link [HSL]. An unsuccessful attempt was made to repair the HSL that had been damaged by static; it was shipped to the Blackburn Lab in Ottawa for repairs on March 17, 1987 and returned repaired by March 24, 1987.

A replacement HSL was obtained from EDA on March 20, 1987, with no documentation or cables.

The HSL from EDA was tried out and it would not work. Peter Graham from EDA and Terry Neufeld from the Blackburn Lab were contacted. It was found that the cable from the prototype HSL would not work on the EDA HSL without some changes in the connection. After the cable was modified, the EDA HSL worked but not very reliably and was replaced with the old prototype HSL.

The HSL was the major cause of all equipment delay during the experiment. It is hoped that the new HSL from EDA [that was not available for (this) experiment] will rectify the problems encountered. The new HSL boards must be checked out completely before they are sent out on the next experiment.

COMPAQ computers. The computers in general worked very well during the whole experiment. There were problems but they were caused mainly by rough handling by the airlines. The...cards in the computer would shake out of their sockets and would not make contact. This was fixed by opening all of the computers and reseating all of the cards. There is a design problem in the card cage in the COMPAQ. The problem is that the card holder does not always make good contact with the top of the cards. It is recommended that all COMPAQs be opened and checked after being shipped by a commercial carrier.

The COMPAQs were very sensitive to static electricity. Anti-static precautions must be taken to protect them and the data they hold.

Seismometers and connectors. Problems with the Bendix

Appendix B - Lithoprobe Data Storage Format

The tape storage format used for the data set is called Lithoprobe Data Storage [LDS] format. LDS format is a superset of SEG-Y format, making use of hitherto unused portions of SEG-Y headers for items unique to regional scale refraction data. SEG-Y format is described precisely by Barry et al. [1975]. A SEG-Y file on tape begins with a two-part reel identification header occupying two records: part 1 occupies 3200 bytes, is written in EBCDIC and contains character information [this header is blank for all of the files documented in this report]; part 2 occupies 400 bytes, is written in binary and contains numeric information. This is followed by the seismic trace data blocks, one for each trace. A trace data block consists of a 240 byte [binary] trace identification header followed by the trace data. Each block occupies a single record.

LDS format uses portions of the SEG-Y headers not previously defined. The principal additions to the SEG-Y headers are as follows.

Reel Identification Header Additions:

Byte Numbers [Part 2]	Description
61 - 62	Number of traces in the file
63 - 66	Mean amplitude of all samples in the file
67 - 68	Attribute information: 0 = velocity/displacement data 1 = instantaneous amplitude 2 = instantaneous frequency 3 = instantaneous phase 4 = slowness (m/ms) 5 = semblance (0 - 1000)
69 - 70	Domain information: 0 = Time - distance domain 1 = Frequency - wavenumber domain 2 = Intercept time - slowness domain
71 - 74	Reduction velocity in m/s if data is reduced (= 0 if not)

Note: Bytes 75 - 400 are not used.

Trace Identification Header Additions:

Byte Number	Description
181 - 184	Microseconds of trace start time
185 - 186	Milliseconds of timing correction to be added to reported times to get local or GMT times
187 - 188	Charge size in kg
189 - 190	Shot time - year
191 - 192	Shot time - day
193 - 194	Shot time - minutes

195 - 196	Shot time - hour
197 - 198	Shot time - second
199 - 202	Shot time - microsecond
203 - 204	Azimuth of receiver from shot (minutes)
205 - 208	Not assigned
** Note:	The remaining information is in EBCDIC **
209 - 212	Recording instrument number
213 - 216	Geophone serial number
217 - 220	Deployment name
221 - 224	Shotpoint name
225 - 228	Receiver site name
229 - 232	Shot ID
233 - 236	Line ID
237 - 240	Geophone Orientation (e.g. R40, Z)

A complete description of the LDS format is provided by Spencer and Asudeh [1987].

Appendix C - Traces on Final SEG-Y [LDS] Files and Plots

Line F - Shot SL north — 76 SEG-Y traces/70 plotted [Figure 3]

- Sites Occupied — 101
  - F001,3,5,7,9-17,19-53,104 [DY01]
  - F001,3,17,53,55-86,88-102,104 [DY02]
- Traces not on SEG-Y files — 25
  - F080 no recovery
  - F025,40,53[DY02] empty .raw file
  - F062 recovered, non-seismic
  - F078,79,81-85,92-102,104[DY01,02] not yet deployed
- Traces not plotted — 6
  - F066-68 noise, indeterminate origin
  - F001[DY01],3[DY01],17[DY01] duplicate

Line F - Shot RI south — 87 SEG-Y traces/84 plotted [Figure 4]

- Sites Occupied — 99
  - F001,3,5,7,9-17,19-53 [DY01]
  - F001,3,17,53,55-86,88-102 [DY02]
- Traces not on SEG-Y files — 12
  - F080 no data recovery
  - F025,40,53[DY02] empty .raw file
  - F001[DY01],21,62,95 recovered, non-seismic
  - F001[DY02],3[DY02],17[DY01],53[DY01] not yet deployed
- Traces not plotted — 3
  - F086,88,89 position very inaccurate

Line F - Shot LP south — 45 SEG-Y traces/45 plotted [Figure 5]

- Sites Occupied — 48
  - F001,3,5,7,9-17,19-53 [DY01]
- Traces not on SEG-Y files — 3
  - F025,40 empty .raw files
  - F001 recovered, non-seismic
- Traces not plotted — 0

Line F - Shot LP north — 26 SEG-Y traces/22 plotted [Figure 6]

- Sites Occupied — 48
  - F055-86,88-102,104 [DY02]
- Traces not on SEG-Y files — 22
  - F062 recovered, non-seismic
  - F078-85,91-102,104 not yet deployed
- Traces not plotted — 4
  - F066-68,77 noise, indeterminate origin

Line F - Shot CL north 33 SEG-Y traces/33 plotted [Figure 7]

Sites Occupied 36

F017,19-53 [DY01]

Traces not on SEG-Y files 3

F025,40 empty .raw file

F053 not yet deployed

Traces not plotted 0

Line F - Shot CL south 12 SEG-Y traces/12 plotted [Figure 8]

Sites Occupied 12

F001,3,5,7,9-16 [DY01]

Traces not on SEG-Y files 0

Traces not plotted 0

Line F - Shot PO north 7 SEG-Y traces/7 plotted [Figure 9]

Sites Occupied 13

F091-102,104 [DY02]

Traces not on SEG-Y files 6

F095 recovered, non-seismic

F099-102,104 not yet deployed

Traces not plotted 0

Line F - Shot PO south 32 SEG-Y traces/28 plotted [Figure 10]

Sites Occupied 36

F053,55-86,88-90 [DY02]

Traces not on SEG-Y files 4

F080 no data recovery

F053 empty .raw file

F062 recovered, non-seismic

F085 not yet deployed

Traces not plotted 4

F086,88,89 position very inaccurate

F090 noise, indeterminate origin

Line D - Shot SL west 96 SEG-Y traces/93 plotted [Figure 11]

Sites Occupied 101

D001-50,199 [DY03]

D001,50-83,85-99 [DY04]

Traces not on SEG-Y files 5

D022,38,76,94 recovered, non-seismic

D199 not yet deployed

Traces not plotted 3

D096 noise, indeterminate origin

D001[DY04],50[DY04] duplicate

Line D - Shot HI east 47 SEG-Y traces/47 plotted [Figure 12]	
Sites Occupied	49
D050-83,85-99 [DY04]	
Traces not on SEG-Y files	2
D076,94 recovered, non-seismic	
Traces not plotted	0

Line D - Shot SP west 35 SEG-Y traces/34 plotted [Figure 13]	
Sites Occupied	38
D100-136,138 [DY05]	
Traces not on SEG-Y files	3
D103,110,131 recovered, non-seismic	
Traces not plotted	1
D136 noise, indeterminate origin	

Line D - Shot SP east 91 SEG-Y traces/90 plotted [Figure 14]	
Sites Occupied	99
D001-50 [DY03]	
D001,50-83,85,98 [DY04]	
Traces not on SEG-Y files	8
D022,38,59,76,94 recovered, non-seismic	
D001[DY03,04],20 not yet deployed	
Traces not plotted	1
D050 [DY03] duplicate; noise, indeterminate origin	

Line D - Shot CC west 76 SEG-Y traces/75 plotted [Figure 15]	
Sites Occupied	80
D021-50,199 [DY03]	
D050-83,85-99 [DY04]	
Traces not on SEG-Y files	4
D022,38,76 recovered, non-seismic	
D199 not yet deployed or attenuated	
Traces not plotted	1
D050[DY03] duplicate	

Line D - Shot CC east 20 SEG-Y traces/20 plotted [Figure 16]	
Sites Occupied	20
D001-20 [DY03]	
Traces not on SEG-Y files	0
Traces not plotted	0

Line D - Shot PO fan 36 SEG-Y traces/34 plotted [Figure 17]

Sites Occupied 39
- D100-136,138,199 [DY05]

Traces not on SEG-Y files 3
- D103,110,131 recovered, non-seismic

Traces not plotted 2
- D106,136 noise, indeterminate origin

Line D - Shot CL west 96 SEG-Y traces/93 plotted [Figure 18]

Sites Occupied 39
- D100-136,138,199 [DY05]

Traces not on SEG-Y files 3
- D103,110,131 recovered, non-seismic

Traces not plotted 3
- D106,107,136 noise, indeterminate origin

Line D - Shot EP fan 94 SEG-Y traces/94 plotted [Figure 19]

Sites Occupied 101
- D001-50,199 [DY03]
- D001,50-83,85-99 [DY04]

Traces not on SEG-Y files 7
- D022,59,76,94
- D001,199 not yet deployed

Traces not plotted 0

Line C - Shot EP north 95 SEG-Y traces/92 plotted [Figure 20]

Sites Occupied 98
- C001-49 [DY06]
- C048,50-76,78-98 [DY07]

Traces not on SEG-Y files 3
- C013,46 recovered, non-seismic
- C001 not yet deployed or attenuated

Traces not plotted 3
- C0533 noise, indeterminate origin
- C048[DY07] duplicate

Line C - Shot MB south 96 SEG-Y traces/96 plotted [Figure 21]

Sites Occupied 99
- C001-49 [DY06]
- C048,50-76,78-99 [DY07]

Traces not on SEG-Y files 3
- C048[DY06] noisy duplicate
- C013,46 recovered, non-seismic

Traces not plotted 0

Line C - Shot SL fan 97 SEG-Y traces/94 plotted [Figure 22]	
Sites Occupied	99
C001-49 [DY06]	
C048,50-76,78-99 [DY07]	
Traces not on SEG-Y files	2
C013,46 recovered, non-seismic	
Traces not plotted	3
C001,53 noise, indeterminate origin	
C048[DY07] duplicate	

Line C - Shot SP south 84 SEG-Y traces/81 plotted [Figure 23]	
Sites Occupied	85
C015-49 [DY06]	
C048,50-76,78-99	
Traces not on SEG-Y files	1
C046 recovered, non-seismic	
Traces not plotted	3
C053,66 noise, indeterminate origin	
C048[DY06] duplicate	

Line C - Shot SP north 12 SEG-Y traces/11 plotted [Figure 24]	
Sites Occupied	13
C001-13 [DY06]	
Traces not on SEG-Y files	1
C013 recovered, non-seismic	
Traces not plotted	1
C001 noise, indeterminate origin or attenuated	