Columbia University
in the City of New York

LAMONT GEOLOGICAL OBSERVATORY
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Crustal Structure of the Arctic Regions from the Lg Phase

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Crustal Structure of the Arctic Regions from the L_g Phase

by

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ABSTRACT

The presence of the L_g earthquake surface wave phase is indicative of continental structure between the epicenter and recording station. This fact is used to explore the Arctic regions. Water covered areas of continental structure include the Canadian archipelago, parts of Baffin Bay and Davis Strait, the Barents Sea, Bering Strait and the shallow parts of the Bering Sea and Greenland Sea. Areas of non-continental structure include the Arctic Ocean, Beaufort Sea, Greenland Sea, Norwegian Sea, and the deep parts of the Bering Sea.

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INTRODUCTION

In a recent paper, Press and Ewing (1952, p. 219) described a seismic surface wave of unusually large amplitudes and characteristic appearance traveling only over paths of a continental nature. Although an adequate theory for this phase is not yet available, discrimination of crustal columns other than that typical of continents against the phase suggested the possibility of using its presence or absence to explore regions of unknown crustal structure. As an example of the method, the Gulf of Mexico was cited (Press and Ewing 1952, p. 228) as an area through which L_g did not propagate, indicating a non-continental structure for the underlying rocks. This conclusion was subsequently borne out by seismic refraction work. This paper presents the results of a similar study for the Arctic regions.

Press and Ewing assigned the symbol L_g to the phase, L because the particle motion was predominantly of the SH or Love type, g because the waves were thought to be the surface wave counterpart of S_g, propagated to large distances by a wave guide mechanism in the silicic crust. They presented experimental data for paths across North America, largely using earthquakes along the west coast recorded at Palisades.

Some sample seismograms illustrating the L_g phase are shown in Figures 1, 2, 3. Its distinctive characteristics are:

1. Sharp commencements with periods usually from 1/2 to 4 seconds, but occasionally as high as 7 seconds. In general, earthquakes slightly offshore or those at very great distances do not produce the shorter periods.

2. Amplitudes far larger than those of any other phase in the same period range for continental paths.

3. Approximately equal amplitudes on all components at the beginning of the phase but greater amplitudes on the transverse horizontal component after a few cycles.

4. A velocity of about 3.5 km/sec. for the beginning. This figure may vary slightly over different paths. It is very close to the shear wave velocity in the upper 15 km of continental crust (Katz 1954).

5. Reverse dispersion, i.e., the shorter periods have the higher group velocities. The periods increase to about 10-15 seconds. The dispersion is not as regular as is the case with Rayleigh waves over oceanic paths.

6. Occasional appearance superposed on the classical long period Love waves.

7. A duration far longer than might be expected for the short period branch of classical Love waves.

8. Occurrence only when the entire path is continental. The insertion of a 100-kilometer segment of oceanic crustal structure is sufficient to prevent the occurrence of L_g on the seismogram.

This sensitivity of L_g to horizontal variations of the crustal column forms the basis of this paper. The capacity to distinguish between areas of continental structure and areas of non-continental structure is limited only by the geographical distribution of suitable epicenters and recording stations.

PROCEDURE

The Arctic was chosen for the first application of the method because it includes several interesting localities of uncertain structure and because of the availability of seismograms with Arctic paths. The collection includes records from the following stations: College, Sitka, Resolute Bay, Palisades, Scoresby Sund, Ivigtut, Copenhagen, Uppsala, Lund and the Berkeley group. At these stations, records from the following instruments were used: College - Wenner EW, Benioff short period Z, McComb-Romberg NS and EW; Sitka - Wenner NS and EW; Resolute Bay - Sprengnether NS, EW, Z, Columbia Z; Palisades - Columbia NS, EW, Z, Benioff long and short period NS, EW, Z; Scoresby Sund - Galitzin-Wilip NS, EW, Z; Ivigtut - Wiechert NS, EW, Grenet Z; Lund - Wiechert NE-SW, NW-SE; Berkeley - Galitzin NS, EW, Z; Fresno - Sprengnether NS, EW, Z.

Table 1 lists all the paths studied. Each path is designated by a letter which indicates the recording station and a number which indicates the particular shock as listed at that station. With this system the same shock recorded at different stations will have more than one path symbol, e. g. the shock of 12 February 1951 has path symbols P7 to Palisades, C28 to College, and K6 to Sitka.

All records were carefully examined for L_g and the velocity of the commencement of the phase was calculated. When considerable energy was recorded at the time for L_g but the distinctive characteristics of L_g, primarily the high frequencies, were absent, the path was labeled doubtful. No attempt was made to study variations in velocity, primarily because many of the records do not show good high frequency beginnings. Furthermore, many of the velocities printed here may be approximate, because of the possibility of errors in epicentral location. This is especially true for the shorter paths, e. g. the Alaskan peninsula shocks to College where a small error would be a significant portion of the path.

Some difficulties encountered in application of the method are:

1. The location of many epicenters near shore and offshore, prohibiting their use in exploration of other segments of the path since L_g excitation is always in doubt. This difficulty may be eliminated by the use of two or more recording stations spanning the segment in question. The station nearer the epicenter then determines the degree of L_g excitation and the farther one the effect of the intervening segment on the phase.

2. The effect at the source on L_g excitation, especially the depth of the shock. There are variations in L_g excitation for shocks listed as normal depth.

3. The discrimination of various types of instruments against parts of the frequency spectrum of L_g.

4. The effect of mountainous terrain on L_g. Although this is not thoroughly understood at present, there is meager evidence available which indicates that L_g will travel a considerable distance through a mountainous region such as the Rocky Mountains (path C-72, Fig. 3).

5. Azimuthal effects at the source. No qualitative data are available on this at present.

It is then apparent that although the presence of L_g is indisputable proof of continental structure* along the entire path, the absence of L_g, particularly the high frequencies, cannot be used without caution to deduce the existence of a segment of non-continental structure along the path. In short, the presence of L_g is sufficient proof of continental structure along the entire path. The absence of L_g is necessary but not sufficient proof of the presence of a segment of non-oontinental structure.

* Continental structure as used here refers to a silicic crust having a thickness of about 35 km as determined by seismic refractions and near earthquake data, although the L_g wave guide need be no larger than about 15 km, for the short period oscillations.

RESULTS

Figures 4 and 5 are maps of the Arctic regions with the great circle paths from epicenter to recording station superimposed. Solid lines indicate that no L_g was recorded, crossed lines that L_g was recorded, and dashed lines that the presence of L_g on the record is doubtful.

It is evident from the figures that the water-covered areas of the Canadian archipelago, Baffin Bay and Davis Strait overlie continental structure, although in the case of the latter, no good data are available for the southern part of the strait where it joins with the North Atlantic Ocean, nor is there conclusive evidence for the small deep areas of Baffin Bay. The results are in agreement with geologic interpretations of the area (Eardley, 1951, p. 538). There is a good L_g path across Greenland extending about 2 degrees off the northeast coast into shallow water. Because of the nature of the L_g phase, this is not likely to shed any light on the current theories of the elevation (Nye 1952, p. 529) of the rock floor of Greenland other than to indicate that whatever the elevation of its surface, the crustal column beneath is continental.

Path G1 to Copenhagen traverses the broad continental shelf underlying the Barents Sea clearly indicating continental structure.

In no case is L_g recorded for paths that traverse the Arctic Ocean basin proper. This evidence is highly favorable to a crustal structure other than continental for the Arctic Ocean basin. To supplement this information, records exhibiting Rayleigh wave dispersion across the Arctic Ocean were examined. In such a study it is highly advantageous to choose a path which has as small a continental segment and as large an oceanic segment as possible. College, Alaska is, at present, the best station from this point of view. However, current instrumentation there is poor for this purpose as the only long period instrument measures the EW or primarily transverse component of ground motion for most Arctic quakes. However, one set of records is available for which NS and EW long period instruments were recording. The dispersion curve of this quake, path C-74, as well as some points from waves tentatively identified as the Rayleigh type on the EW component for paths C-24 and C-10, are shown in Figure 6. Corrections have been made from the curve of Brilliant and Ewing (1954) for the land travel in Alaska and the Alaskan continental shelf. Although there is considerable scatter, note that the curve falls below the oceanic curve of Press and Ewing (1950 p. 275) but above the continental curve of Brilliant and Ewing

(1954 p. 149). This apparently indicates a structure of intermediate nature for the Arctic Ocean basin, but the Rayleigh wave data are so poor that a final decision is not warranted here. Furthermore, recent sounding data in the Arctic by Crary et al. (1952) show that considerable changes need to be made in the map of Emery on which the continental corrections are based. Most certainly, however, the Arctic basin is not underlain by a continental column of rocks. Its identification with the oceanic column of the Atlantic and Pacific or with some intermediate structure awaits evidence which is not readily available at present. Eardley (1951 p. 538) has interpreted a continental structure underlying the Arctic Ocean from geological evidence. Such evidence, he admits, is quite scanty. Gutenberg (1941 p. 27) from PP/P ratios found the Arctic Ocean floor to be similar to that of the Pacific, although Byerly, Mei, and Romney (1949 p. 269) and Mei (1943 p. 149) have pointed out that supplemental studies on directionality of the source are desirable.

No L_g phases were recorded for any of the paths crossing the Greenland Sea-Norwegian Sea area in the vicinity of Jan Mayen, with the possible exception of a doubtful one at Resolute Bay. Although the Jan Mayen shocks are sometimes thought to be of slightly greater than normal depth, additional evidence for paths G-5 and S-19 favors a non-continental structure for this area.

No L_gs were recorded from the North Atlantic shocks.

The shocks along the Alaskan peninsula and the Aleutian arc exhibit a very consistent set of data. Beginning with the easternmost shock on the peninsula and continuing clockwise in azimuth around College to path C-9 it is apparent that most shocks made the L_g phase. Two did not but they are far enough from shore to be inefficient in L_g excitation. Path C-9 which is approximately on the margin of the deep part of the Bering Sea made a doubtful L_g. The remainder of the shocks to the west whose paths cross the deep Bering Sea did not make L_g at College. The consistency of the results indicates with certainty that the crustal structure of the deep Bering Sea is markedly different from that of the continent.

The large group of Japanese, Kurile and Kamchatka shocks failed to produce an L_g at College. However, the complicated nature of the path does not permit any specific conclusions to be drawn since most of the paths cross either the Pacific Ocean or the Okhotsk Sea in addition to the Bering Sea.

Most of the shocks whose paths cross the Bering Strait did not make an L_g at College. However, one shock, C-68 did, although the very high frequencies are missing. In an effort to isolate the reason for the missing L_gs, shocks corresponding to paths C-28, L-1 and G-9, and C-32, L-2 and G-10 were examined at Copenhagen and Lund. Neither made an L_g at College. The former made a very doubtful L_g at both European stations, the latter made a weak one. This evidence tends to place the reason for the missing L_g at College on inefficient excitation at the source rather than on a structural anomaly at the Bering Strait. Furthermore, for shock C-68 which did send an L_g to College, Uppsala also reports L_g in its station bulletin. On the other hand, for shock C-67, Uppsala does not report L_g, and neither is it recorded at College. The conclusion, then, is that continental structure is continuous, at least across the narrow part of the Bering Strait. This is in agreement with the geologic interpretations of the area (Eardley 1951, p. 532).

There is an excellent correlation between water depth and areas through which L_g will not propagate. In no case is there L_g propagation beneath water deeper than 1000 fathoms for any great distance. The possibility that the absence of L_g over these paths might be due to the water column rather than the underlying rocks is ruled out because, although it is present on all three components, L_g is primarily a shear wave polarized horizontally. This component of motion could not be affected by the water. Thus it appears that water depths actually reflect changes of the crustal column. Indeed, geophysical methods of any sort have yet to detect an area where continental structure underlies oceanic depths.

SUMMARY

The L_g surface wave phase was used to distinguish areas of continental crustal structure from areas of non-continental structure in the Arctic regions. Water-covered areas of continental structure include the Canadian archipelago, parts of Baffin Bay and Davis Strait, the shallow parts of the Bering Sea and of the Greenland Sea, the Barents Sea and Bering Strait. Areas of non-continental structure include the Arctic Ocean, Beaufort Sea, Greenland Sea, Norwegian Sea and the deep Bering Sea. Nowhere is continental structure detected beneath oceanic depths.

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TABLE I

MASTER LIST OF SHOCKS USED IN ARCTIC STUDY

BERKELEY GROUP (B)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical loc.	Depth	Mag.	in km	Lg	Lg Vel. in km/sec	Comp	Remarks
B1	22-4-51	12 36 16	76°N	73°W	Baffin Bay			4500	Yes	3.5	Z	Mineral - poor data for Lg
								4810	Yes	3.45	Z	Mt. Hamilton - poor data for Lg
B2	6-6-51	16 10 52	71 1/2N	8°W	Jan Mayen	60	7		No			Mineral
									No			Fresno

TABLE I

MASTER LIST OF SHOCKS USED IN ARCTIC STUDY

(COLLEGE - C)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	LgVel in km/sec	Comp.	Remarks
C1	2-2-50	23 33 38	22N	100 1/2E	S. Ynnan Prov. China		6 3/4		No			
C2	3-2-50	16 45 29*	54N	162W	Aleutians			1440	Yes	3. 23	E	Excellent Lg - Long Period Preceding
C3	4-2-50	02 07 53*	54N	162W	Aleutians			1440	Yes	3. 27	E	Same as above
C4	7-2-50	10 37 22	46N	152E	Kurile Isl.				No			
C5	18-2-50	14 39 30	54N	164W	Aleutians			1500	Yes	3. 26	E	
C6	27-3-50	13 04 04	53 1/2N	173E	Aleutians				No			
C7	4-4-50	18 44 10	52N	101E	Border USSR & Outer Mongolia		6 1/2		No			S. P. Benioff only
C8	5-4-50	01 17 15	52N	177W	Aleutians				No			S. P. Benioff only
C9	26-4-50	12 18 28	53N	170W	Aleutians	60			Possibly		Z, E	No H. F.
C10	5-6-50	11 16 12	87N	45E	No. Polar Region				No			Good dispersed train of surface waves
C11	27-6-50	15 41 54	45 1/2N	140E	Off Hokkaido		6 1/2		No			

TABLE I (Cont'd)

(COLLEGE - 2)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/sec	Comp.	Remarks
C12	9-7-50	16 09 55	36N	72E	Pakistan				No			
C13	12-7-50	11 09 15	53N	166W	Aleutians		6 1/4	1400	Yes	3.48	E	
C14	14-7-50	12 06 45	52N	171W	Aleutians				No			
C15	8-8-50	05 12 00	55N	134 1/2W	S. E. Alaska			1250	Possibly		E	Not a good Lg
C16	15-8-50	14 09 30 Aftershocks	28 1/2N	97E	CBI Border		8 1/2		No			
C17	22-8-50	07 40 07	53N	160E	Off Kamchatka	Deeper than normal			No			
C18	2-9-50	02 47 23	52 1/2N	169W	Aleutians	100	6 3/4	1820	Yes	3.52	E	
C19	10-9-50	03 21 20	35N	140 E	Near Honshu		6 3/4		No			
C20	16-9-50	21 58 15	52 1/2N	178E	Aleutians	100	6.6	2180	No			
C21	28-9-50	21 47 01	54 1/2N	134 1/2W	Qu. Charlotte Isl.			5900	Possibly		E	
C22	5-11-50	17 37 25	33N	134 1/2E	Off Shikoku, Japan				No			
C23	22-11-50	10 16 26*	51N	176W	Aleutians				No			
C24	9-1-51	16 00 24	81N	122E	Arctic Ocean		6 3/4-6 1/2		No			Good dispersed train of surface waves

TABLE I (Cont'd)

(COLLEGE - 3)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/ sec.	Comp	Remarks
C25	15-1-51	01 50 36 02 29 46	51N	178 1/2E	Aleutians				No			
C26	18-1-51	21 15 50	52N	177W	Aleutians				No			
C27	24-1-51	07 17 01	33N	115 3/4	California		6		No			
C28	12-2-51	17 22 02	66N	136E	Siberia				No			
C29	5-3-51	14 46 00	53N	163W	S. of Alaska Pen.				No			
C30	5-3-51	20 11 45	29N	128E	Ryukyu Isl.	150	7		No			
C31	19-3-51	20 28 55	57N	160E	Kamchatka				No			
C32	14-4-51	13 32 59	61N	136E	Siberia				No			
C33	22-4-51	12 36 16	76N	73W	Baffin Bay			2790	Doubtful	3. 27	E	Weak
C34	29-4-51	07 35 46	80 1/2N	121E	Arctic Ocean				No			Good dispersed train of surface waves
C35	25-4-51	21 59 35	81N	121E	Arctic Ocean				No			
C37	10-3-51	19 44 52 19 47 14	51N	180W	Aleutians	60			No			
C38	5-6-51	16 57 47	30N	132E	Kyushu	100	6 3/4-7		No			
C39	6-6-51	16 10 52	71 1/2N	8W	Jan Mayen	60	7	4640	Doubtful	3. 34	E	No H. F.

TABLE I (Cont'd)

(COLLEGE - 4)

No	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in Km	Lg	Lg Vel. in km/ sec.	Comp.	Remarks
C40	9-7-51	01 30 28	32 1/2N	139E	Off Honshu, Japan				No			
C41	14-7-51	07 18 12	47N	154 1/2E	Kuriles				No			
C42	19-7-51	20 41 25 21 07 07	51 1/2N	177 1/2W	Aleutians	60	6		No			
C43	22-7-51	09 01 02	51N	178 1/2W	Aleutians	60			No			
C44	26-7-51	10 00 00	41N	143E	Hokkaido	600	6 1/4		No			
C45	28-7-51	23 04 33	37N	143E	Honshu		6		No			
C46	11-8-51	09 54 20	55N	163E	Off Kamchatka				No			
C47	13-8-51	18 33 40	43N	32 1/2E	Black Sea		6 1/2		No			
C48	24-8-51	14 21 15	47N	151E	Kuriles		6 1/2		No			
C49	12-9-51	15 10 18	45 1/2N	151E	Kuriles				No			
C50	1-10-51	10 11 40	55N	166W	Aleutians			1480	Yes	3.57	E	
C51	15-10-51	21 01 57	33N	134E	Shikoku				No			
C52	18-10-51	08 26 23	42N	142E	Hokkaido	100	6 3/4		No			
C53	21-10-51	22 07 55	44 1/2N	151E	Kuriles				No			
C54	6-11-51	16 40 02	47N	154E	Kuriles		7 1/4		No			

TABLE I (Cont'd)

(COLLEGE - 5)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/sec	Comp.	Remarks
C55	8-11-51	13 45 39	54 1/2N	160W	Off Alaska Pen.		6 1/2		No			
C56	12-11-51	08 09 26	47N	154E	Kuriles		6 1/2		No			
C57	15-11-51	19 42 12	52 1/2N	160 1/2E	Kamchatka	60	6 1/4		No			
C58	18-11-51	09 35 43	31N	90 1/2E	E. Tibet		7 1/2		No			
C59	24-11-51	04 30 24	57 1/2N	176 1/2W	Aleutians	60			No			
C60	21-12-51	08 37 28	26 1/2N	100E	Yunnan, China				No			
C61	25-12-51	15 58 28	49N	155 1/2E	Kuriles	60			No			
C62	12-3-52	12 13 10	64N	22W	W. Coast of Iceland				No			
C63	19-3-52	09 04 18	41N	125E	Korea				No			
C64	1-4-52	00 37 41.5	48.0N	113.8W	N.W. Montana			2750	Yes	3.50	E	Weak
C65	19-6-52	12 12 56	23N	100E	S. Yunnan Prov. China		6 1/2		No			
C66	17-8-52	16 02 05	30 1/2N	91 1/2E	Tibet		7 1/4		No			
C67	14-9-52	09 34 10	93 1/2E	34N	Shanghai, China				No			
C68	30-9-52	12 52 00	28 1/2N	102E	China		6 1/2	8030	Yes	3.66	E	No H.F. Also recorded at Uppsala

TABLE I (Cont'd)

(COLLEGE - 6)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg.	Lg Vel. in km/ sec.	Comp.	Remarks
C69	10-10-52	18 47 37	30 1/2N	69E	Cent. Pakistan				No			
C70	8-12-52	15 09 30	23N	99 1/2E	CBI Border				No			
C71	10-12-52	05 58 06	71N	7W	Jan Mayen Isl.				No			Looks slightly deep, perhaps 100 km
C72	23-11-47	09 46 05.5	47°47'N	112°02'W	S. W. Montana			3120	Yes	3.59	N, E	Excellent Lg
C73	28-1-48	15 51.3	38N	68E	Turkistan				No			
C74	18-2-48	20 29.8	82N	43E	Arctic Region		6 3/4		No			
C75	25-5-48	07 11.3	30N	99 1/2E	Siking Prov. China		7 1/4		No			
C76	28-9-48	21 36.6	23N	94E	Burma				No			

TABLE I (Cont'd)

(COPENHAGEN - G)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/sec.	Comp.	Remarks
G1	18-2-48	20 29.8	82N	43E	Arctic Region			3080	Yes	3.68		Excellent Lg
G2	26-4-48	09 32 20	51N	34W	N. Atlantic			3070	No			Good Rayleigh wave dispersion
G3	8-7-48	12 34.6	71N	6W	Near Jan Mayen Land			1920	No			
G4	28-8-48	02 27.8	57N	161E	Kamchatka			7170	No			
G5	2-3-49	06 54.6	72N	3W	Arctic Ocean			2290	No			
G6	19-4-49	15 19.2	48N	154E	Kuriles			7950	No			
G7	27-9-49	15 30 43	60N	149W	S. Alaska			4930	No			
G8	6-6-51	16 10 52	71 1/2N	8W	Jan Mayen	60	7	2600	No			
G9	12-2-51	17 22 02	66N	136E	Siberia			5675	Doubtful	3.27	N	Weak if present
G10	14-4-51	13 32 39	61N	136E	Siberia			6120	Yes	3.38	N, E, Z	No H. F.

TABLE I (Cont'd)

(SITKA - K)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/sec	Comp.	Remarks
K1	2-2-50	23 33 38	22N	100 1/2E	S. Yunnan Prov. China		6 3/4		No			
K2	4-4-50	18 44 10	52N	101E	Border USSR & Outer Mongolia		6 1/2		No			
K3	5-6-50	11 16 12	87N	45E	N. Polar Region				No			
K4	9-7-50	16 09 53	36N	72E	Pakistan				No			
K5	26-8-50	04 39 27	65N	162W	150 mi. NW of Nome		6 1/2		No			
K6	12-2-51	17 22 02	66N	136E	Siberia				No			
K7	14-4-51	13 32 59	61N	136E	Siberia		6 3/4	3650	No			
K8	22-4-51	12 36 16	76N	73W	Baffin Bay			3200	Yes	3.30	N, E	
K9	6-6-51	16 10 52	71 1/2N	8W	Jan Mayen	60	7		No			
K10	13-8-51	18 33 40	43N	32 1/2E	Black Sea		6 1/2		No			
K11	18-11-51	09 26 33 09 35 43	31N	90 1/2E	E. Tibet		7 1/2		No			
K12	21-12-51	08 37 28	26 1/2N	100E	Yunnan, China				No			
K13	31-10-35	18 37 49	46 1/2N	112W	Helena, Mont.			1790	Yes	3.55		Periods less than 4 sec

TABLE I (Cont'd)

(LUND - L)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel in km/ sec.	Comp	Remarks
L1	12-2-51	17 22 02	66N	136E	Siberia			5650	Doubtful	3. 23	NW	Very weak
L2	14-4-51	13 32 59	61N	136E	Siberia			6100	Yes	3. 44	NW, NE	No H. F.

TABLE I (Cont'd)

(PALISADES - P)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/ sec	Comp.	Remarks
P1	19-6-52	12-12-56*	23N	100E	S. Yunnan Prov. China		6 1/2	12950	No			
P2	17-8-52	16 02 05*	30 1/2N	91 1/2E	Eastern Tibet			11950	No			
P3	14-9-52	09 34 10*	34N	93 1/2E	Shanghai Prov.			11600	No			
P4	30-9-52	12 52 00*	28 1/2N	102E	Szechwan Prov. China		6 1/2	12300	No			
P5	27-11-52	07 20 13*	37N	70E	N. Afghanistan			10600	No			Weak at Palisades
P6	8-12-52	15 09 30*	23N	99 1/2E	China-Burma Border			12800	No			
P7	12-2-51	17 22 02	66N	136E	Near Verkhoyanski Mts., Siberia		6 1/2		No			Poor records
P8	14-4-51	13 32 59*	61N	136E	" " "		6 3/4	8350	No			
P9	22-4-51	12 36 16*	76N	73W	Baffin Bay			3900	Yes	3.58	Z	
P10	29-4-51	07 35 46*	80 1/2N	121E	Arctic Ocean			6430	No			
P11	6-6-51	16 10 52	71 1/2N	8W	Jan Mayen	60	7	4900	No			
P12	12-2-53	04 31 16*	65N	133W	Yukon, Canada			4550	Yes	3.57	N	Excellent Lg

TABLE I (Cont'd)

(RESOLUTE BAY - R)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel. in km/sec	Comp.	Remarks
R1	22-4-51	12 36 16	76N	73W	Baffin Bay			610	Yes	3.76		Velocity doubtful
R2	6-6-51	16 10 52	71 1/2N	8W	Jan Mayen	60	7	2600	Doubtful	3.60	Z	Only fair at Resolute. No H. F.
R3	27-9-51	19 24 12	49N	129W	Off Vancouver, B.C.			3200	Yes	3.54	Z	
R4	20-9-51	12 38 40	65N	154W	Central Alaska			2350	Yes	3.46	E	
R5	12-2-51	17 22 02	66N	136E	Siberia		6 1/2		No			

TABLE I (Cont'd)

(SCORESBY SUND - S)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel in km/sec	Comp.	Remarks
S1	1-3-29	07 31 0	50.2N	130.7W	Off Vancouver Island			5440	Doubtful	3.63	E	No H.F. - not a good Lg
S2	4-7-29	04 28 28	63.2N	147.3W	Central Alaska			4550	No			
S3	4-7-29	07 14 18	55.7N	35.5W	N. Atlantic Ocean			1770	No			Good train of dispersed surface waves
S4	4-7-29	07 31 10	55.7N	35.5W	N. Atlantic Ocean			1770	No			Good train of dispersed surface waves
S5	4-7-29	05 56 32	55.7N	35.5W	N. Atlantic Ocean			1770	No			Good train of dispersed surface waves
S6	25-3-32	23 58 39	62.5N	153.3W	Near Anchorage, Alaska			4760	Doubtful	3.53	E	Not a sharp Lg
S7	28-7-34	21 37 04	55N	156.8W	Off Alaska Peninsula			5490	No			
S8	24-9-35	22 12 25	49.3N	129.2W	Off Vancouver Island			5490	Yes	3.32		S.P. missing - L.P. insts. may have missed beginning
S9	22-3-38	15 22 11	57.6N	132.1W	Off. Qu. Charlotte Islands			5270	Yes	3.55	E	S.P. missing

TABLE I (Cont'd)

(SCORESBY SUND - 2)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag	in km	Lg	Lg Vel. in km/sec	Comp.	Remarks
S10	29-5-40	01 57 46	66.6N	135.4W	Near MacKenzie River			3990	Yes	3.42	Z	Excellent - very H. F. some L. P.
S11	30-7-41	01 51.5	60.9N	149.2W	Near Anchorage			4870	No			
S12	28-2-48	01 58 05	53.5N	133W	Qu. Charlotte Islands			5450	No			
S13	27-6-48	21 39.2	56N	158W	S. of Alaska Peninsula			5520	No			
S14	23-8-49	20 24 32	53N	132W	Off Brit. Columbia			5210	Yes	3.52	N	Good Lg
S15	31-10-49	01 39 32	56N	135W	Sitka, Alaska			5000	Yes	3.49	E	Good Lg but not very H. F.
S16	27-3-50	13 04 04	53.5N	173E	Aleutians			6290	No			
S17	6-4-50	21 48 02	49N	129W	Vancouver, B. C.			5530	No			
S18	5-6-50	11 16 16	87N	50E	North Polar Region			2080	No			
S19	20-6-50	14 11 45	74.5N	80E	Jan Mayen			1080	No			Good train of disparsed waves
S20	12-7-50	11 09 15	53N	166W	Aleutians			5990	No			
S21	12-2-51	17 22 02	66N	136E	Siberia				No			
S22	14-4-51	13 32 59	61N	136E	Siberia				No			

TABLE I (Cont'd)

(UPPSALA - U)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Remarks
U1	6-6-51	16 10 52	71 1/2N	8W	Jan Mayen	60	7	2600	No	Poor records for Lg

(IVIGTUT - V)

No.	Date D-M-Y	Hour	Lat.	Long.	Geographical Location	Depth	Mag.	in km	Lg	Lg Vel in km/ sec	Comp.	Remarks
V1	15-4-45	02 35.2	56N	164E	Off Kamchatka			5840	No			
V2	8-11-45	09 05 41	81N	7W	Greenland Sea			2560	Yes	3.73	N	Good H. F.
V3	8-11-45	10 62.5	81N	7W	Greenland Sea			2560	Yes	3.66	N	
V4	12-1-46	20 25.7	59N	147.5W	Gulf of Alaska			4970	No			
V5	1-4-46	12 28.9	54N	164W	Aleutians			6040	No			
V6	16-10-47	02 09 45	64.5N	148.8W	40 mi. S. W. of Fairbanks			4660	Yes	3.68	Z	Good H. F.

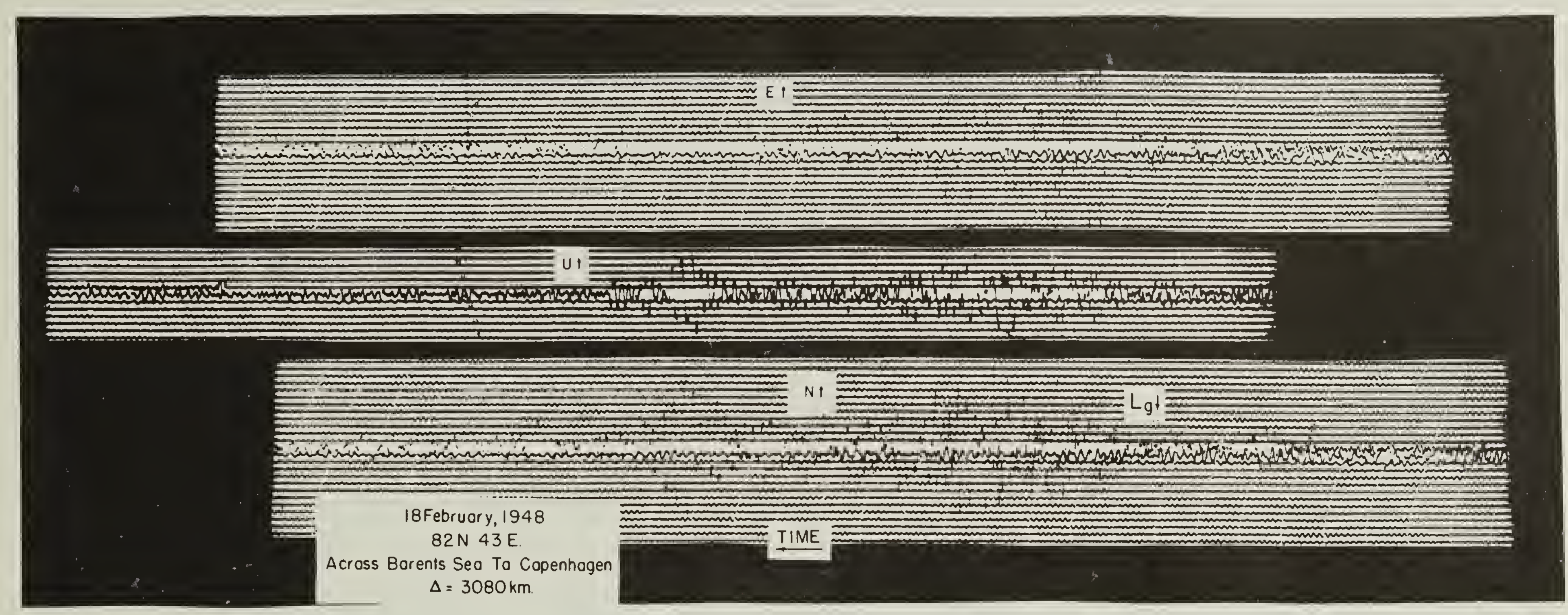

Figure 1. Seismograms: L_g across Barents Sea to Copenhagen

Figure 2. Seismograms: L_g, Aleutians to College, Alaska

Figure 3. Seismograms: L_g, S. W. Montana to College, Alaska

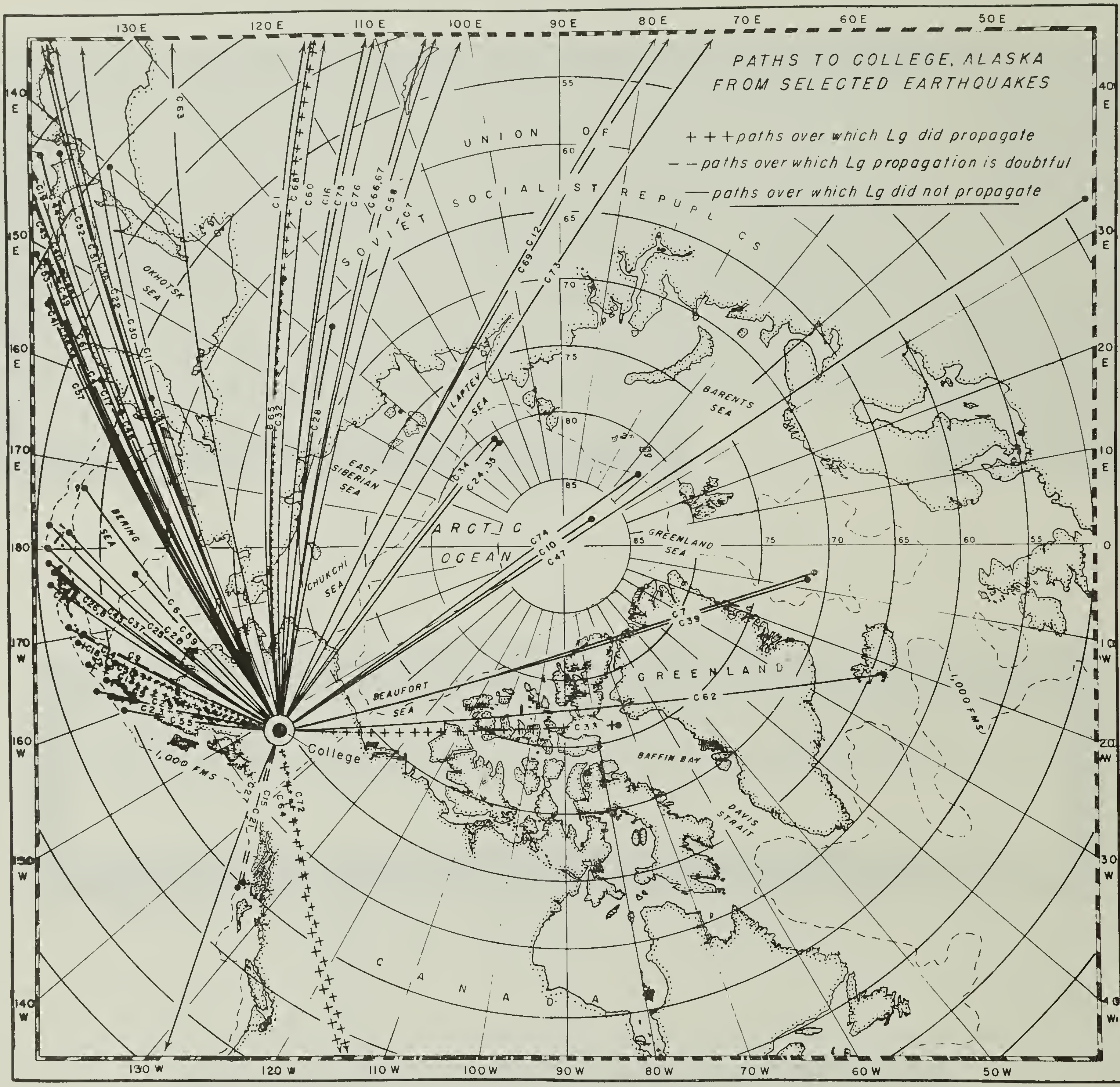

Figure 4. Paths across Arctic regions to College, Alaska

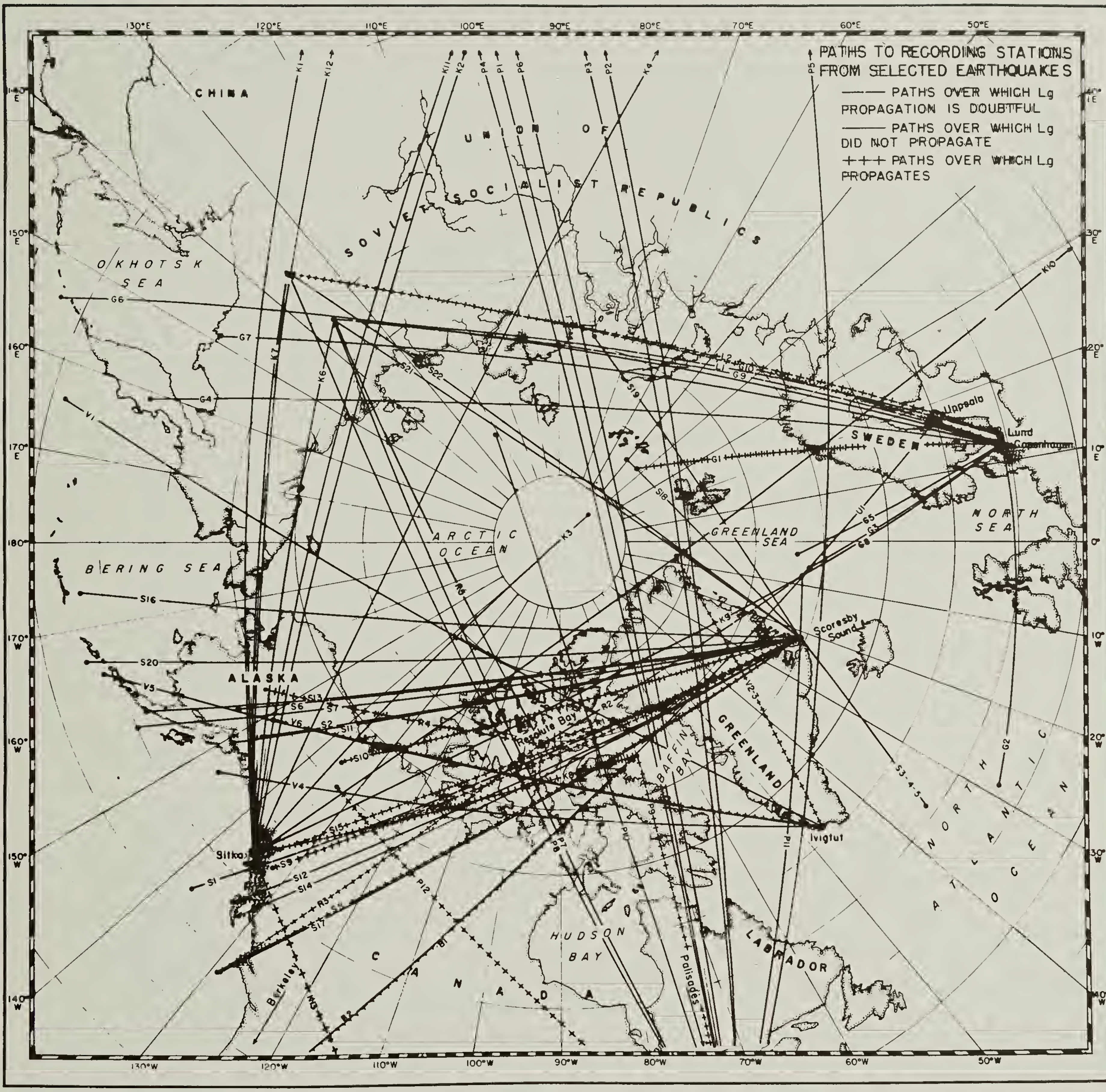

Figure 5. Paths across Arctic regions to all stations except College

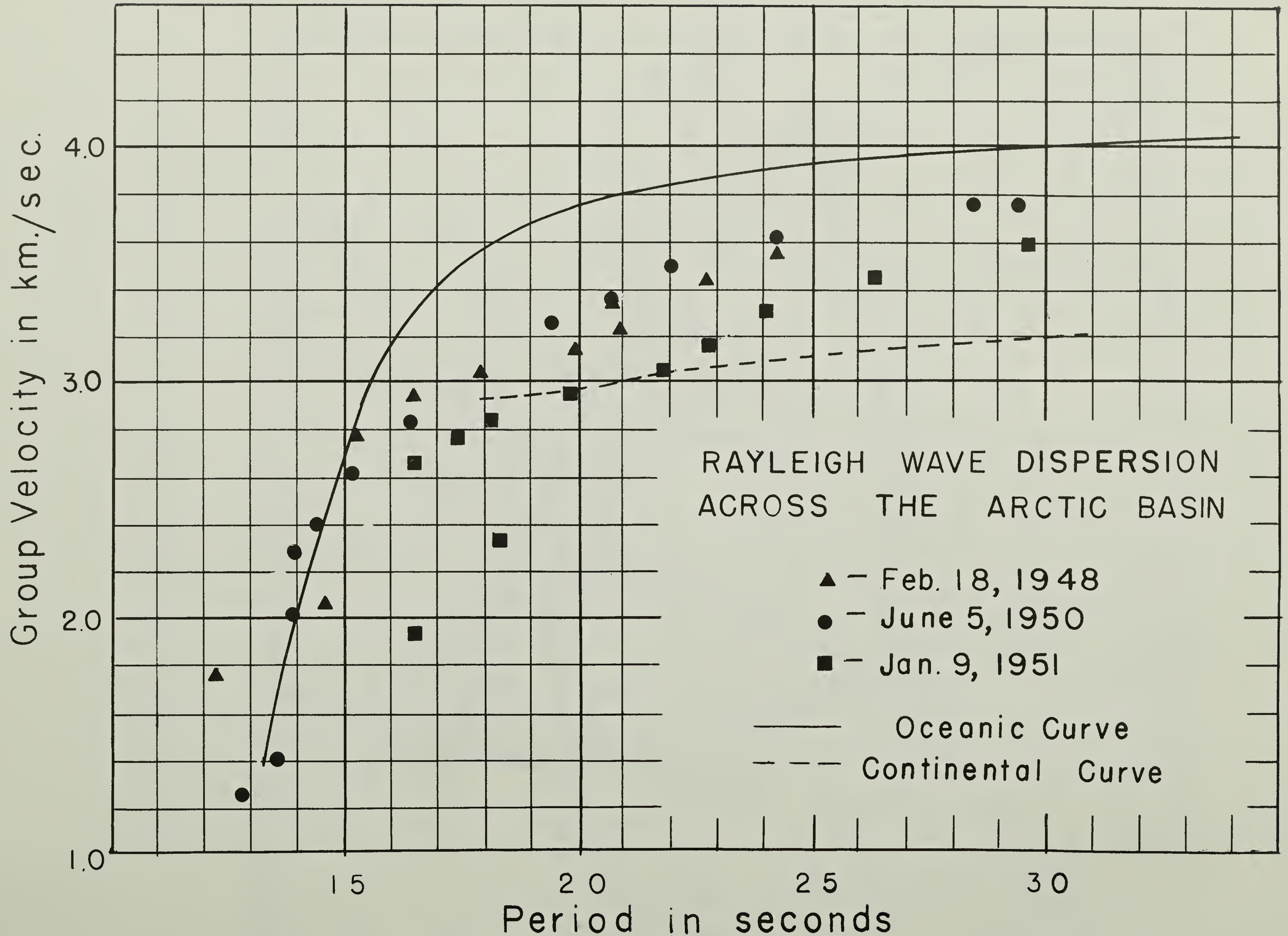

Figure 6. Rayleigh wave dispersion across the Arctic Ocean Basin