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Revised epicenters for large historical earthquakes in Baffin Bay

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ABSTRACT

Accurate epicentral locations can provide information about fault orientations and seismotectonic processes in the regions in which the earthquakes occur. Since 1933 there have been five earthquakes of magnitude 6.0 of greater, including one of magnitude 7.3, beneath Baffin Bay. Current earthquake catalogs generally place these earthquakes at locations published in the International Seismological Summary (ISS) bulletins. However, the epicenters for two of these events appear to have been fixed at the epicenters of previous events and all are based on an outdated model of the Earth's interior. In this study, the five largest Baffin Bay earthquakes have been relocated using a modern Earth model and path corrections (determined in this study) for the stations that recorded the events. Several epicenters were changed by tens of km, although all still fall within the boundaries of the Baffin Bay seismic zone. This paper discusses the relocation of these events and tabulates all arrival time and station correction data used in the procedure.

RÉSUMÉ

Des épicentres précises peuvent nous fournir de l'information sur les orientations des failles et des processus séismotectoniques dans les régions où des tremblements de terre se produisent. Depuis 1933 cinq tremblements de terre de magnitude 6,0 ou supérieur, parmi lesquels il y en a eu un de magnitude 7,3, se sont produits dessous la baie de Baffin. Des catalogues récentes de séismicité indiquent d'habitude que ces tremblements de terre se sont produits aux épicentres publiés dans les bulletins du "International Seismological Summary" (ISS). Il parait qu'on a fixé les épicentres de deux de ces séismes aux épicentres des séismes précédants et qu'on a utilisé une modèle ancienne de l'intérieur de la Terre pour calculer tous les épicentres. Dans cette étude, j'ai recalculé les épicentres des 5 plus grands tremblements de terre de la baie de Baffin utilisant une modèle récente de la Terre et les corrections de trajet (que j'ai calculées) pour les stations qui ont enregistré ces séismes. Quelques épicentres ont changé par des dizaines de km mais ils restent dans la zone séismique de la baie de Baffin. Cet article-ci décrit la détermination des nouvelles épicentres de ces séismes et fournit toutes les données de temps d'arrivé et corrections de trajet utilisées dans l'étude.

INTRODUCTION

The 20 November 1933 Baffin Bay earthquake (Ms 7.3) is the largest instrumentally recorded earthquake to occur in eastern Canada and one of the largest passive margin earthquakes worldwide. It is also the largest known event north of the Arctic Circle. Subsequent to 1933 there have been four large earthquakes in Baffin Bay: 31 August 1934 (Ms 6.5), 1 January 1945 (Ms 6.5), 10 July 1947 (Ms 6.0) and 2 May 1957 (Ms 6.4). It has been suggested (for example, Qamar, 1974) that most of these events are aftershocks of the 1933 earthquake. These earthquakes received very little attention at the time they occurred, presumably because of their remote location. Only the 1933 event has received much attention in subsequent years. Current earthquake catalogs tend to place these events at the epicenters originally calculated by the International Seismological Summary (ISS), two of which (1934 and 1947) appear to be fixed at the epicenters of previous events (1933 and 1945 respectively).

Although large earthquakes in northern Canada pose less threat to the Canadian population than their southern counterparts, current seismicity maps [Fig. 1, or Anglin *et al.*, 1990] show the Baffin Bay region to be very active seismically and current hazard estimates [Basham *et al.*, 1997] rank the region very high in terms of seismic hazard. Additionally, understanding earthquakes along the northeastern passive margin, may provide insight into the southeastern margin where large earthquakes are less frequent but are potentially more threatening to the population.

Accurate epicentral locations can help delineate fault orientations and may improve our understanding of regional seismotectonic processes. In recent years, our knowledge of the Earth's velocity structure has improved considerably as has our computing capability. Thus, recomputing the epicenters of historical earthquakes is a worthwhile exercise. In this paper, the relocation of the five aforementioned Baffin Bay earthquakes is discussed, and all arrival times and station corrections used in the relocations are tabulated. The goal is not to make sweeping conclusions about the regional seismotectonics on the basis of a few epicenters, but rather to provide accurate epicentral locations that may be used in subsequent seismicity or seismotectonic studies of the region.

RELOCATION METHOD

The epicenters were relocated using the iterative least-squares method of Weichert and Newton [1970]. Teleseismic P arrival times reported in the appropriate International Seismological Summary (ISS) catalogs were used. Most of the original seismograms are no longer available. Those seen by the author [Bent, 1998] have very clear P arrivals, consistent with the reported arrival times (assuming the clock corrections are correct). Theoretical travel times were based on the Preliminary Reference Earth Model or PREM [Dziewonski and Anderson, 1981], which is based on nearly two million observations and

includes the effects of anelastic dispersion and anisotropy. Stations with travel times residuals of more than 60 seconds were initially rejected. With subsequent iterations stations with residuals greater than 10, 6 and 4 seconds were eliminated. This process should eliminate misidentified phases and readings from stations with poorly constrained clock corrections.

Station corrections were determined from the travel time residuals of these partially revised epicenters. Depending on the number of observations, the corrections were based on an individual station or on the region in which the station was located. Individual and regional corrections were calculated for all stations. Note that only residuals from the final iteration were used in the calculations. Whether the station or regional correction was selected for the next step depended on a number of factors. Regional corrections were used for any stations not retained in the final iteration for any events (in most cases, this criterion applied only to stations that reported an arrival time for just one of the events). If there were at least four residuals for a station, the individual station correction was always preferred. If there was only one data point for a station, the regional correction was selected. If there were two or three residuals, the regional correction was used unless both the station and regional corrections had the same sign and the standard deviation was lower for the station correction, in which case the individual station correction was preferred. There are a few exceptions. Only an individual station correction was calculated for Honolulu, which was not near enough to any other stations for a regional correction to be meaningful. No corrections were calculated for Resolute (northern Canada) or Terre Adelie (Antarctica) because each reported only one P arrival time and there were no nearby stations. A complete list of station corrections may be found in the Appendix. For the most part, corrections were negative at stations in eastern North America and Asia and positive at stations in western North America and Europe. The station corrections are qualitatively similar to those determined by Cassidy and Bent [1993] in a study of historical earthquakes in northwestern Canada.

The final locations were determined by subtracting the station corrections from the original ISS arrival times and re-running the inversion program using the same station elimination process previously discussed. The station corrections did not significantly affect the final epicenters. The 1947 epicenter moved 5 km when the station corrections were included. For the other four events the difference was less. Note that I am comparing the results of the two inversions, not the ISS and final locations. For all five earthquakes there were slight decreases in the origin time and epicentral uncertainties and the number of stations rejected was slightly less when the station corrections were included. The number of observations retained for the final solution ranged from 78% of the original number (1933 earthquake) to 90% (1957 earthquake). Tables 1 through 5 summarize the residuals, arrival times and station corrections for each earthquake, and Figures 2 through 6 show the residuals plotted on the focal sphere.

The relocation program was run assuming a depth of 10 km since Bent [1998] obtained

a well constrained hypocentral depth of 10 km for the 1933 earthquake by modeling the waveforms. The other earthquakes were assumed to occur at the same depth. To test the effects of depth on the epicentral parameters, the relocation code was run at depths of 5, 10 and 15 km for the 1933 and 1947 earthquakes. The epicenter of the 1933 earthquake was changed by less than 0.01° in both latitude and longitude when the depth was changed. The effect on origin time was more pronounced, but less than 1 sec. The 1947 epicenter was the least well constrained of the the five, and the effect of depth is more pronounced by still minor. Increasing the depth had very little effect; decreasing the depth moved the epicenter by 0.08° in latitude and longitude, but well within the uncertainty obtained from the relocation assuming a 10 km depth. The effects on the origin time were comparable to the 1933 earthquake. Thus, unless the earthquakes depths, are considerably different from 10 km, they will not have a significant impact on the epicenters.

EPICENTERS

The 1933 earthquake received considerably more attention than the other Baffin Bay earthquakes, presumably because of its size. In addition to the standard routine locations (ISS, Bureau Central International de Séismologie (BCIS), Jesuit Seismological Association (JSA), United States Coast and Geodetic Survey (USCGS), Gutenberg and Richter, 1954), there were several studies involving the relocation of this earthquake (Rajko and Linden, 1935; Lee, 1937; Qamar, 1974). For the 1934-1957 earthquakes, the standard locations also exist, but only the Qamar [1974] study attempted to relocate these events. He used the joint hypocenter determination (JHD) method and the Herrin [1968] Earth model to relocate earthquakes in the Baffin Bay-Baffin Island region using the 1963 Baffin Island earthquake (approximately 200 km from the 1933 Baffin Bay epicenter) as the calibration event.

Figure 7 shows the various epicenters, summarized in Table 1, determined for the 1933 Baffin Bay earthquake. Although there are a few outliers, most of these epicenters lie within an area roughly 20 km (north-south) by 100 km (east-west). The epicenter determined in this study lies near the center of the cluster of previous estimates. The revised epicenter is 33 km southeast of the ISS location (Table 2, Fig. 8a).

The ISS location for the 1934 earthquake is identical to their epicenter for the 1933 event, suggesting that it was assumed rather than calculated. The revised epicenter moves this event 51 km southward (Fig. 8a, Table 3) and 26 km from the 1933 earthquake.

The revised epicenter for the 1945 earthquake (Fig. 8a, Table 4) is very close to but slightly (8 km) to the south of the ISS epicenter. It also lies near the revised epicenter for the 1934 earthquake.

The ISS appears to have pegged the 1947 earthquake to the 1945 epicenter. This event

was the smallest of the five earthquakes and there are considerably fewer P arrival times reported for it, and thus the uncertainty is higher than for the other events. My location (Fig. 8a, Table 5) places this event very close to the 1933 epicenter or 18 km west and slightly north of the ISS epicenter for the 1947 event.

Both the original ISS location and my revised epicenter place the 1957 earthquake approximate 140 km to the southeast of the other events as does the Qamar [1974] study. The revised location is 10 km to the southwest of the ISS epicenter (Fig. 8a, Table 6).

Figure 8b shows the epicenters determined in this study as well as those of Qamar [1974]. One of the most striking features of the plot is that his epicenters are consistently to the north of mine. The difference is probably not related to the choice of Earth models since there is no systematic trend in the distance between the epicenters. The bias may be related to his choice of calibration event (1963 Baffin Island), which does not have a well constrained epicenter (Penney, unpublished student work term report). At the same time, there is no compelling evidence that his choice of epicenter for the 1963 earthquake is wrong. It is not clear whether the difference in crustal structure between the calibration event (continental crust) and the Baffin Bay earthquakes (oceanic crust) would have biased the locations. Another difference between the two studies is the assumed depth-10 km for this study; surface for Qamar [1974]. However, as discussed previously, depth appears to have only a minor effect on epicenters calculated from teleseismic data.

DISCUSSION AND CONCLUSIONS

Historical seismic activity is not uniformly distributed throughout Baffin Bay but is concentrated in northwestern Baffin Bay on the Baffin Island side of the 2000 m bathymetric contour (Basham *et al.*, 1977; Fig. 1 here). The seismicity (Fig. 1) trends in a roughly northwest to north-northwest direction. There is no clear correlation between the seismicity and any known geologic structures or geophysical anomalies.

After relocation using the PREM velocity model and modern location methods, the epicenters of the five largest earthquakes in Baffin Bay were revised by 8 to 51 km although all still lie within the cluster of seismicity that defines the seismic zone. The earliest and largest of the events, the 1933 Ms 7.3 earthquake, is the furthest north. If, as Qamar [1974] has suggested, the other events are aftershocks of the 1933 earthquake, this might be an indication of southward rupture. However, care must be taken not to over interpret the data as the number of events studied is small and a sequential north to south migration of epicenters is not noted in the events subsequent to 1933.

The later events are not offset at a constant azimuth relative to the 1933 earthquake. The preferred epicenters for the 1934 and 1947 earthquakes are roughly southwest of the 1933 earthquake although the uncertainty in the 1947 epicenter is such that it could be

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in any direction relative to the 1933 earthquake; the 1945 and 1957 events are offset to the southeast. The 1957 earthquake is sufficiently separated from the other events that it probably should not be considered an aftershock of the 1933 earthquake. If all five earthquakes are considered as a group, they suggest a northwest-southeast seismicity pattern similar to what is observed in Baffin Bay. However, if the 1957 earthquake, which occurred considerably to the southeast of the others, is excluded, there is no clear trend seen in the relative locations of the other four events.

Bent [1998] studied the 1933 earthquake in detail. Her focal mechanism determined by detailed waveform modeling consisted of a large strike-slip subevent followed by two smaller oblique-thrust subevents (Fig. 9). The strike-slip subevent had one near north-south and one near east-west nodal plane. The oblique-thrust subevents also had a near north-south nodal plane, with the second nodal plane oriented in a northeast-southwest direction. A preliminary focal mechanism for the 1934 (Fig. 9) earthquake was virtually identical to that of the 1933 strike-slip subevent. The 1957 earthquake also appears to be a predominantly strike-slip event but with a more significant thrust component and with a somewhat different orientation (Fig. 9). The nodal planes for the 1957 event imply that the fault plane is oriented in either a northwest-southeast or northeast-southwest direction. Well constrained focal mechanisms could not be determined for the 1945 and 1947 earthquakes. The relative locations of the earthquakes suggest, but do not prove, that the north-south nodal plane is more likely to be the fault plane of the 1933 earthquake.

In summary, the five largest Baffin Bay earthquakes have been relocated using an iterative least-squares method. The epicenters moved from 8 to 51 km from their original ISS locations. Uncertainties in the revised locations are on the order of 5 km for four of the events and slightly larger (20 km) for the smallest event. While the revised epicenters do not delineate a single fault plane that could have been responsible for all five events, they are also not inconsistent with the regional seismicity or with the focal mechanisms of the events.

REFERENCES

Anglin, F. M., R. J. Wetmiller, R. B. Horner, G. C. Rogers and J. A. Drysdale (1990). Seismicity map of Canada, *Canadian Geophys. Atlas*, Map 15, scale 1 : 10000000.

Basham, P. W., D. A. Forsyth and R. J. Wetmiller (1977). The seismicity of northern Canada, *Can. J. Earth Sci.*, **14**, 1646-1667.

Basham, P., S. Halchuk, D. Weichert and J. Adams (1997). New seismic hazard assessment for Canada, *Seism. Res. Lett.*, **68**, 722-726.

Bent, A. L. (1998). The 1933 Ms 7.3 Baffin Bay earthquake: Strike-slip faulting along the Northeastern Canadian passive margin, *Bull. Seism. Soc. Am.*, (in prep.).

Cassidy, J. F. and A. L. Bent (1993). Source parameters of the 29 May and 5 June, 1940 Richardson Mountains, Yukon Territory, earthquakes, *Bull. Seism. Soc. Am.*, **83**, 636-659.

Dziewonski, A. M. and D. L. Anderson (1981). Preliminary reference Earth model, *Phys. Earth Planet. Int.*, **25**, 297-356.

Gutenberg, B. and C. F. Richter (1954). *Seismicity of the Earth and Related Phenomena*, Princeton University Press, Princeton, New Jersey, 310 pp.

Herrin, E. (chairman) (1968). Seismological tables for P phases, *Bull. Seism. Soc. Am.*, **58**, 1193-1219.

Lee, A. W. (1937). On the travel times of seismic waves from the Baffin Bay earthquake of November 20, 1933, *Meteorol. Office Geophys. Mem. No. 74*, London, 21 pp.

Qamar, A. (1974). Seismicity of the Baffin Bay region, *Bull. Seism. Soc. Am.*, **64**, 87-98.

Rajko, N. and N. Linden (1935). On the earthquake of 20 XI 1933 in the Baffin Bay and on the distribution of epicentres in the Arctic, *Acad. Sci. USSR Institute of Seism. Pub. No. 61*, 1-8 (in Russian).

Weichert, D. H. and J. C. Newton (1970). Epicentre determination from first arrival times at Canadian stations, *Seismology Series of the Earth Physics Branch no. 59*, Ottawa, 16 pp.

TABLE 1
EPICENTERS FOR THE 1933 BAFFIN BAY EARTHQUAKE
FROM VARIOUS SOURCES

Source	Latitude (°N)	Longitude (°W)
ISS	73.3	70.7
BCIS	75.0	65.0
JSA	72.0	70.0
USCGS	73.0	69.0
Rajko and Linden (1935)	73.3	72.0
Lee (1937)	73.3	70.2
Gutenberg and Richter (1954)	73	70 3/4
Qamar (1974)	73.23	70.02
this study	73.07	70.01

TABLE 2
P ARRIVAL TIMES, RESIDUALS and EPICENTER FOR 1933 EARTHQUAKE

ISS: OT   19331120   2321:38.0
              LAT. 73.3°
              LON. -70.7°

REVISED: OT   19331120   2321:35.7 ± 0.2 s
              LAT. 73.07° ± 4.5 km
              LON. -70.01° ± 3.7 km
              OBSERVATIONS RETAINED. 150 of 193 reported phases

for this and subsequent Tables:

P time is the arrival time of the first P phase as reported in the ISS bulletin, UT is used
Corr. Is the station correction (as discussed in the text); it should be subtracted from the P time before relocation
Res. Is the final travel time residual assuming the PREM model [Dziewonski and Anderson, 1981]

Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Ottawa	28	189	232723	-1.4	-0.19
Sitka	30	273	232743	+2.0	-0.60
Toronto	30	194	232742	-0.7	+0.94
Buffalo	31	193	232748	-0.4	-0.10
Weston	31	182	232750	-0.5	+0.30
Edinburgh	31	87	232757	+0.8	+2.23
Madison	31	208	232756	-0.6	+2.66
Ann Arbor	32	200	232800	-0.6	+3.75
Fordham	32	186	232804	-0.8	+0.82
Durham	33	86	232805	+0.8	-2.62
Bozeman	33	238	232814	-0.4	+1.02
Pittsburgh	33	194	232810	-1.6	+1.31
Stonyhurst	33	88	232815	+2.7	+0.76
Bidston	33	89	232814	+0.8	-0.23
Uppsala	34	65	232814	-1.6	-0.39
Victoria	34	253	232818	-0.4	+1.19
Woodstock	34	190	232819	+0.5	+0.18

Table 2 continued

Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Georgetown	34	190	232821	0.0	-1.17
Oxford	35	89	232833	+1.7	+0.79
Cheltenham	36	192	232829	0.0	-1.34
Florissant	36	208	232833	-0.8	-0.04
Copenhagen	36	73	232835	-0.1	+0.20
Kew	36	88	232834	+0.8	-1.95
St. Louis	36	208	232833	-1.9	-0.19
Pulkovo	37	56	232844	-0.9	+0.44
Hamburg	37	77	232846	+0.3	+0.28
De Bilt	37	82	232845	+0.7	+0.28
Denver	37	227	232852	+0.7	+3.56
Uccle	38	84	232850	0.0	-1.83
Göttingen	39	79	232859	+0.2	-1.03
Potsdam	39	75	232902	+0.2	+0.77
Paris	39	87	232901	-0.1	-1.06
Columbia	40	195	232905	+0.2	-0.96
Little Rock	40	209	232907	0.0	-2.59
Leipzig	40	77	232910	+0.2	+2.61
Jof Bayern	41	78	232916	+0.2	+2.25
Karlsruhe	41	82	232919	+1.5	+2.53
Cheb	41	77	232916	-0.7	+0.23
Strasbourg	41	81	232916	+0.7	-1.29
Stuttgart	41	81	232919	-0.4	+0.79
Prague	41	76	232922	+0.1	+0.56
Neuchatel	42	84	232925	-1.2	-0.20
Zurich	42	83	232926	-1.7	+0.19
Kucino	42	53	232931	-0.9	+2.31
Ukiah	42	247	232931	+0.8	+0.39
Clermont-Ferrand	42	89	232926	+0.1	-0.46
Denton	42	215	232928	+0.7	-0.97
Tinemaha	43	241	232934	+0.2	-1.30
Chur	43	74	232934	+0.5	-0.10
Berkeley	43	246	232938	+0.6	+0.03
San Francisco	44	246	232938	+0.5	-1.01
Vienna	44	75	232939	-0.7	+0.55
Bagneres-Bigorre	44	93	232940	+0.1	+0.57
Haiwee	44	240	232942	+0.5	-0.05
Coimbra	44	103	232938	+0.6	-3.21
Pavia	44	83	232948	+0.1	+2.96
Graz	44	77	232945	-0.7	+0.10
Mount Hamilton	44	245	232941	+1.2	-0.28

Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Palo Alto	44	245	232941	+0.5	-0.17
Piacenza	45	83	232948	+0.1	+0.86
Treviso	45	80	232950	+0.8	+0.84
Padua	45	81	232951	+0.1	+1.35
Budapest	45	73	232951	+0.4	-0.07
Venice	45	80	232950	+0.1	-0.49
Trieste	45	79	232950	+0.1	-1.76
Toledo	45	99	232954	+0.6	+0.42
Ljubljana	45	78	232950	+0.3	-1.29
Mount Wilson	46	239	232956	+0.9	-1.07
Zagreb	46	77	232955	+0.3	-1.20
Pasadena	46	240	232957	+0.6	-0.56
Riverside	46	239	232955	-0.2	-1.35
Santa Barbara	46	241	232959	+0.7	+0.44
Tucson	46	230	232957	+0.7	-0.58
Barcelona	46	92	233000	+0.6	+3.43
Ebro	46	94	232958	+0.8	+0.66
Firenze	46	82	232958	+0.1	-1.96
Prato	46	82	233000	+0.4	+0.83
La Jolla	47	238	233009	+0.5	+3.80
Belgrade	48	73	233013	+0.2	-0.13
Malaga	48	101	233015	+0.9	-1.00
Algiers	50	94	233014	-1.1	-1.25
Benvenuto	50	80	233027	+0.1	+0.26
Carloforte	50	87	233026	+0.1	-0.44
Bari	50	79	233029	+0.1	-2.31
Simferopol	52	62	233039	+0.4	-1.48
Sevastopol	52	62	233041	+0.4	-0.66
Yalta	52	62	233044	+1.1	-0.37
Theodosia	52	61	233045	+0.4	+2.58
Messina	53	81	233045	+0.1	-3.79
Catania	53	82	233054	+0.1	+1.46
San Juan	55	176	233102	-0.4	-1.82
Port-au-Prince	55	183	233102	-0.1	-0.68
Otomari	58	334	233133	-0.2	+3.10
Fort de France	59	170	233134	-0.1	+2.84
Baku	60	50	233140	+2.3	-0.77
Alma Ata	62	43	233156	+1.3	+2.12
Sapporo	62	335	233156	-0.2	+0.72
Ksara	62	65	233158	+1.2	-0.61

Table 2 continued

Table 2 continued

Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Tashkent	63	34	233200	+0.8	+1.37
Vladivostok	63	342	233201	-1.3	+0.39
Andizhan	64	31	233205	+1.1	-0.88
Aomori	64	335	233213	-0.2	+2.56
Helwan	65	70	233213	-2.4	+1.29
Akita	66	335	233217	-0.2	-1.00
Mizusawa	66	334	233222	-0.2	+1.11
Sendai	67	334	233225	-0.2	-1.63
Peking	67	355	233228	-0.3	+0.46
Fukushima	67	334	233229	-0.2	-1.10
Heizyo	68	347	233230	-0.2	-1.14
Dairen	68	350	233233	-0.3	-0.38
Wazima	68	337	233233	-0.2	-2.11
Inchon	69	346	233240	-1.5	+0.86
Kumagoya	69	335	233243	-0.2	+2.09
Honolulu	69	275	233241	+1.7	-2.06
Keizyo	69	347	233242	-0.2	+2.24
Nagano	70	343	233238	-0.2	-0.64
Tokyo	70	335	233244	-0.2	+0.55
Toyo'oka	70	339	233247	-0.2	-0.96
Nagoya	70	337	233248	-0.2	-0.74
Hikone	70	337	233248	-0.2	-0.62
Osaka	71	338	233253	-0.2	+0.32
Kobe	71	338	233251	-1.3	-0.74
Taikyu	71	344	233249	-0.2	-0.49
Susaki	71	335	233249	-0.2	-1.29
Sumoto	72	339	233255	-1.0	+0.69
Kochi	72	340	233300	-0.2	-0.68
Wakayama	72	338	233256	-0.2	+0.45
Hatidyozime	72	334	233259	-0.2	+0.04
Muroto Misaki	73	339	233303	-0.2	+0.91
Fukuoka	73	342	233303	-0.2	+0.67
Shimizu	73	340	233306	-0.2	+0.37
Nagasaki	74	343	233307	0.0	-0.76
Dehra Dun	75	28	233310	-0.5	-3.24
Nanking	75	352	233315	-0.7	-0.14
Zi-ka-wei	76	350	233322	-0.3	+2.10
Agra	78	29	233331	-0.5	-0.16
Titizima	78	331	233330	+1.3	-1.57
Nake	78	343	233331	-0.2	-1.77

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Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Taihoku	82	350	233356	0.0	+2.01
Hong Kong	85	356	233407	-0.3	-2.05
Bombay	85	35	233410	-0.5	+1.12
Huancayo	85	185	233410	+1.5	-0.77
Phu-Lein	86	3	233415	0.0	-0.96
La Paz	89	178	233430	-0.9	-0.60
Manila	92	349	233443	0.0	-1.63
Sucre	92	176	233440	-0.1	-3.39
Kodaikanal	94	32	233454	-0.5	+0.14
Riverview	136	309	234054	-2.1	+0.28
Perth	139	353	234100	-2.1	+0.29
Melbourne	140	315	234100	-2.1	-1.60

Table 2 continued

TABLE 3
P ARRIVAL TIMES, RESIDUALS and EPICENTER FOR 1934 EARTHQUAKE

ISS: OT   19340831   0502:52.0
               LAT. 73.3°
               LON. -70.7°

REVISED: OT   19340831   0502:49.3 ± 0.2 s
               LAT. 72.85° ± 5.5 km
               LON. -70.30° ± 4.1 km
               OBS. 104 of 127

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Ivigtut	15	133	050604	-8.3	+0.4
Reykjavik	19	93	050714	+2.8	-0.5
Ottawa	28	188	050835	-1.4	+0.2
Sitka	30	273	050856	+2.0	+1.4
Toronto	30	193	050851	-0.7	-1.7
Ann Arbor	31	199	050906	-0.6	-1.9
Chicago	32	205	050914	-0.6	-1.2
Durham	33	86	050926	+0.8	+3.8
Pittsburgh	33	194	050920	-1.6	-0.3
Bozeman	33	238	050922	-0.4	-3.0
Stonyhurst	33	87	050928	+2.7	-0.7
Bidston	34	88	050929	+0.8	+0.3
Uppsala	34	65	050929	-1.6	-0.5
Victoria	34	253	050926	-0.4	-3.2
Georgetown	34	189	050935	0.0	+1.2
Helsinki	36	59	050946	-0.8	+1.4
Oxford	36	88	050946	+1.7	-0.7
Cheltenham	35	191	050944	0.0	+2.0
Copenhagen	36	73	050950	-0.1	+0.3
Florissant	36	208	050945	-0.8	+0.3
Kew	36	87	050950	+0.8	-0.4
St. Louis	36	207	050945	-1.9	+0.2
Pulkovo	37	55	050957	-0.9	-1.9
De Bilt	37	82	050959	+0.7	-0.4
Hamburg	37	77	051000	+0.3	-0.5
Denver	37	227	051002	+0.7	+1.7
Uccle	38	84	051005	0.0	-1.4

Table 3 continued

Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Columbia	39	194	051020	+0.2	+2.3
Leipzig	40	76	051023	+0.2	+0.8
Jena	40	77	051022	+0.2	-1.1
Karlsruhe	41	81	051032	+1.5	+0.9
Strasbourg	41	82	051032	+0.7	+0.1
Stuttgart	41	81	051034	-0.4	+1.1
Prague	42	75	051035	+0.1	-1.2
Basel	42	83	051037	-0.7	-0.8
Neuchatel	42	84	051039	-1.2	-0.8
Zurich	42	82	051041	-1.7	+0.6
Ukiah	42	247	051042	+0.8	-0.9
Tinemaha	43	241	051047	+0.2	-0.5
Berkeley	43	246	051051	+0.6	+0.7
Mt. Hamilton	44	245	051053	+1.2	-0.6
Palo Alto	44	245	051056	+0.5	+2.6
Vienna	44	75	051055	-0.7	+1.8
Pavia	44	83	051058	+0.1	-1.6
Treviso	45	80	051103	+0.8	-0.8
Budapest	45	73	051106	+0.4	+0.1
Venice	45	80	051102	+0.1	-3.1
Ljubljana	45	78	051108	+0.3	+2.0
Trieste	45	78	051108	+0.1	+1.6
Toledo	45	99	051106	+0.6	-1.7
Mt. Wilson	46	239	051109	+0.9	-0.3
Sverdlovsk	46	35	051111	-2.0	-0.8
Zagreb	46	76	051109	+0.3	-1.9
Pasadena	46	239	051109	+0.6	-0.8
Riverside	46	238	051109	-0.2	+0.5
Tucson	46	230	051112	+0.7	+2.4
Santa Barbara	46	241	051110	+0.7	-0.8
La Jolla	47	238	051115	+0.5	-2.4
Belgrade	48	73	051128	+0.2	+0.1
Alicante	48	96	051129	+2.1	+0.6
San Fernando	48	103	051129	+0.6	+1.4
Cartuja	48	100	051133	+2.3	+3.1
Rome	48	82	051134	+0.1	+3.2
Almeria	49	99	051132	+0.6	-1.2
Simferopol	52	61	051154	+0.4	-1.5
Theodosia	52	60	051157	+0.4	-0.4
Yalta	52	61	051200	+1.1	+0.6

Station	Δ (deg)	Az. (deg)	P time (hhmmss)	Corr. (sec)	Res. (sec)
San Juan	55	175	051223	-0.4	-1.0
Baku	60	50	051256	+2.3	+0.1
Tashkent	63	33	051314	+0.8	+0.2
Ksara	63	64	051314	+1.2	+0.6
Vladivostok	63	342	051315	-1.3	-0.5
Andizhan	64	31	051322	+1.1	+0.9
Helwan	65	70	051326	-2.4	-0.4
Mizusawa	66	334	051336	-0.2	+0.4
Peking	67	355	051342	-0.3	-0.5
Oiwake	69	335	051357	-0.2	+1.9
Inchon	69	346	051353	-1.5	-1.0
Honolulu	69	274	051358	+1.7	+1.7
Tokyo	70	334	051401	-0.2	+2.9
Nagoya	71	337	051400	-0.2	-3.4
Kameyana	71	337	051406	-0.2	+0.4
Kobe	71	338	051407	-1.3	+0.6
Husan	72	343	051410	-0.2	+1.3
Sumoto	72	338	051408	-1.0	-1.0
Kochi	73	339	051416	-0.2	+0.6
Shimonoseki	72	342	051415	-0.2	+0.5
Nagasaki	74	342	051423	0.0	+0.5
Miyazaki	74	341	051426	-0.2	-0.2
Nanking	75	352	051430	-0.7	+0.0
Agra	78	29	051443	-0.5	-3.1
Hong Kong	85	356	051524	-0.3	+0.2
Huancayo	85	185	051525	+1.5	+0.7
Hyderbad	88	30	051534	-0.5	-2.4
La Paz	89	178	051542	-0.9	-1.2
Manila	92	349	051600	0.0	+0.8
Sucre	92	175	051557	-0.1	+0.9
Kodaikanal	95	32	051616	-0.5	+2.5

<div align="center">Table 3 continued</div>

TABLE 4
P ARRIVAL TIMES, RESIDUALS and EPICENTER FOR 1945 EARTHQUAKE

ISS: OT   19450101   0120:42.0
          LAT. 73.00°
          LON. -69.60°

REVISED: OT   19450101   0120:46.6 ± 0.3 s
          LAT. 72.93° ± 6.8 km
          LON. -69.55° ± 4.7 km
          OBS. 62 of 75

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Seven Falls	26	182	012620	-0.7	+3.1
Saskatoon	26	237	012620	-0.4	+0.4
Shawinigan Falls	27	185	012621	-0.7	-1.4
Ottawa	28	189	012633	-1.4	-0.1
Harvard	31	183	012659	-0.8	+0.8
State College	32	192	012713	-0.8	-2.3
Rapid City	33	227	012720	-0.4	+0.4
Philadelphia	33	188	012722	-0.8	+0.6
Butte	33	240	012724	-0.5	+1.1
Grand Coulee	33	249	012722	-0.3	-0.5
Uppsala	34	65	012725	-1.6	+0.2
Georgetown	34	190	012731	0.0	-1.2
Copenhagen	36	73	012744	-0.1	-1.0
Florissant	36	208	012743	-0.8	-0.5
St. Louis	36	208	012745	-1.9	+1.3
Uccle	38	84	012803	0.0	+1.2
Salt Lake City	38	236	012805	+0.5	+0.2
Paris	39	88	012814	-0.1	+2.0
Columbia	39	195	012814	+0.2	-2.1
Jena	40	78	012817	+0.2	-1.5
Collmberg	40	76	012817	+0.2	-2.2
Strasbourg	41	83	012827	+0.7	-0.3
Shasta	41	248	012826	+0.5	-2.1
Prague	41	76	012833	+0.1	+1.4
Basel	42	84	012834	-0.7	+0.8

Table 4 continued

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Clermont-Ferrand	42	89	012836	+0.1	-0.4
Neuchatel	42	83	012835	-1.2	-0.2
Zurich	42	83	012835	-1.7	-0.9
Moscow	42	53	012840	-0.6	+0.8
Ukiah	43	248	012842	+0.8	-0.2
Overton	43	237	012843	+0.1	+0.2
Chur	43	82	012844	+0.5	-0.2
Pierce Ferry	43	236	012846	+0.8	+0.2
Tinemaha	43	241	012847	+0.2	+0.3
Boulder City	43	237	012848	+0.3	-0.1
Spring Hill	43	204	012852	0.0	+3.5
Berkeley	43	246	012848	+0.6	-1.5
Santa Clara	44	246	012855	+0.5	+2.3
Haiwee	44	241	012853	+0.5	-0.4
Lisbon	45	105	012859	+0.6	-1.3
Toledo	45	99	012902	+0.6	-1.3
Mt. Wilson	46	240	012909	+0.9	+0.6
Pasadena	46	240	012909	+0.6	+0.1
Riverside	46	239	012907	-0.2	-0.7
Tucson	46	231	012908	+0.7	-0.7
Sverdlovsk	46	36	012908	-2.0	+0.4
Santa Barbara	46	242	012910	+0.7	+0.1
Palomar	46	238	012912	-0.8	+0.4
La Jolla	47	239	012916	+0.5	-0.5
Cartuja	48	100	012926	+2.3	+0.4
Malaga	48	101	012926	+0.9	+0.2
Sofia	51	72	012938	+0.3	+3.2
San Juan	55	176	013016	-0.4	+2.2
Ksara	62	65	013109	+1.2	-0.2
Tashkent	63	34	013110	+0.8	+0.1
Vladivostok	63	343	013113	-1.3	+0.3
Andizhan	64	32	013117	+1.1	-0.2
Helwan	65	70	013121	-2.4	-1.2
Bogota	68	185	013146	-0.1	-0.6
New Delhi	76	30	013233	-0.5	-0.2
Huancayo	85	186	013318	+1.5	-2.1
La Paz	89	179	013338	-0.9	-0.9

TABLE 5
P ARRIVAL TIMES, RESIDUALS and EPICENTER FOR 1947 EARTHQUAKE

ISS: OT   19470710   1048:46.0
           LAT. 73.00°
           LON. -69.60°

REVISED: OT   19470710   1048:51.3 ± 0.8 s
           LAT. 73.05° ± 20.2 km
           LON. -70.12° ± 10.8 km
           OBS. 30 of 38

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Scoresby Sund	15	76	105212	-7.1	-2.1
Kirkland Lake	25	196	105420	-0.7	+3.1
Seven Falls	26	181	105426	-0.7	+3.3
Saskatoon	26	237	105425	-0.4	+1.4
Shawinigan Falls	27	184	105425	-0.7	-3.1
Ottawa	28	189	105438	-1.4	-0.7
Harvard	31	182	105503	-0.8	-0.9
Weston	31	182	105504	-0.5	-1.3
Grand Coulee	33	248	105527	-0.3	+0.8
St. Louis	36	207	105547	-1.9	-1.6
Paris	39	87	105618	-0.1	0.0
Strasbourg	41	83	105635	+0.7	+1.8
Shasta	41	247	105630	+0.5	-1.9
Stuttgart	41	81	105632	-0.4	-2.2
Overton	43	236	105647	+0.1	+0.1
Pierce Ferry	43	236	105650	+0.8	0.0
Tinemaha	43	241	105651	+0.2	+0.3
Boulder City	43	236	105652	+0.3	-0.2
Haiwee	44	240	105658	+0.5	+0.6
Mt. Wilson	46	239	105713	+0.9	0.5
Pasadena	46	239	105713	+0.6	+0.1
Riverside	46	238	105712	-0.2	+0.3
Tucson	46	230	105712	+0.7	-1.0
Palomar	46	238	105715	-0.8	-0.7
La Jolla	47	238	105721	+0.5	+0.4
Alicante	48	96	105731	+2.1	+0.9

Table 5 continued

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Malaga	48	101	105731	+0.9	-0.9
Almeria	49	99	105739	+0.6	+4.0
Helwan	65	70	105928	-2.4	+0.4
Huancayo	85	185	110123	+1.5	-1.4

TABLE 6
P ARRIVAL TIMES, RESIDUALS and EPICENTER FOR 1957 EARTHQUAKE

ISS: OT   19570502   0355:35.5
          LAT. 72.04°
          LON. -67.65°

REVISED: OT   19570502   0355:37.3 ± 0.1 s
          LAT. 71.97° ± 2.3 km
          LON. -67.84° ± 1.8 km
          OBS. 145 of 162

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Scoresby Sund	15	74	035856	-7.1	+0.4
Reykjavik	18	92	035955	+2.8	+1.0
Kirkland Lake	25	200	040055	-0.7	-0.6
Seven Falls	25	185	040100	-0.7	+0.6
Ottawa	27	192	040117	-1.4	+0.4
Halifax	27	173	040123	-0.7	+0.5
Kiruna	28	54	040127	-0.8	+0.2
College	28	297	040128	+1.8	-1.7
Banff	30	251	040140	-0.4	-0.8
Buffalo	30	196	040142	-0.4	-0.3
Weston	30	185	040143	-0.5	+0.5
Sodankyla	30	51	040144	-0.8	+0.4
Sitka	31	277	040151	+2.0	-1.3
Palisades	31	189	040155	-0.8	-0.2
Cleveland	31	200	040157	-0.6	+0.6
Hungry Horse	32	247	040159	-0.4	-0.1
Rathfarnham	32	92	040201	+0.8	-1.8
Chicago	32	209	040201	-0.6	+1.3
Durham	32	89	040205	+0.8	+0.4
Pittsburgh	32	198	040202	-1.6	-1.0
Rapid City	33	231	040210	-0.4	+1.4
Morgantown	33	197	040212	0.0	+0.3
Bozeman	33	242	040214	-0.4	-1.2
Butte	33	243	040213	-0.5	-1.1

Table 6 continued

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Horseshoe Bay	33	258	040215	-0.4	0.0
Uppsala	34	65	040216	-1.6	+0.6
Washington D. C.	33	193	040216	0.0	-0.1
Victoria	34	257	040221	-0.4	-1.0
Seattle	35	255	040226	-0.4	+0.2
Kew	35	88	040232	+0.8	-0.7
Helsinki	35	60	040231	-0.8	-0.4
Copenhagen	36	74	040235	-0.1	+0.8
Tiksi	36	351	040240	-1.0	+1.6
Witteveen	36	81	040241	0.0	+0.5
De Bilt	36	83	040243	+0.7	+0.5
Corvallis	38	254	040254	-0.4	+1.9
Salt Lake City	38	239	040255	+0.5	-0.3
Paris	39	88	040259	-0.1	-0.1
Fayetteville	38	215	040257	0.0	-1.6
Columbia	39	198	040301	+0.2	+0.2
Jena	40	78	040306	+0.2	-1.1
Bermuda	40	176	040309	-0.1	0.0
Karlsruhe	40	82	040314	+1.5	-0.5
Strasbourg	40	83	040315	+0.7	-0.2
Cheb	40	78	040313	-0.7	-1.5
Eureka	40	243	040315	+0.7	+0.2
Stuttgart	41	82	040317	-0.4	+0.7
Tubingen	41	82	040318	+0.2	-0.4
Besancon	41	76	040320	+0.1	+0.2
Prague	41	76	040320	+0.1	-0.6
Messtetten	41	83	040321	+0.2	+0.3
Warsaw	41	69	040321	+0.2	0.0
Shasta	41	251	040319	+0.5	-1.5
Mineral	41	250	040321	+0.5	-0.2
Clermont-Ferrand	41	90	040323	+0.1	-0.4
Reno	41	247	040323	+0.7	-0.3
Neuchatel	42	85	040324	-1.2	+1.2
Raciborz	42	73	040329	-0.7	+0.1
Moscow	43	54	040331	-0.6	-0.6
Lubbock	43	224	040332	+0.7	0.0
Krakow	43	72	040333	+0.2	-1.2
Ukiah	43	251	040335	+0.8	+0.5
Tinemaha	43	244	040339	+0.2	+1.0

Table 6 continued

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Boulder City	43	240	040339	+0.3	+0.3
Bratislava	44	75	040340	-0.7	-0.1
Berkeley	44	249	040342	+0.6	+0.5
L'vov	44	68	040345	-0.9	+0.5
Santa Clara	44	248	040344	+0.5	-0.6
Monaco	45	87	040349	+0.1	0.0
Isabella	45	244	040350	+0.5	+0.7
Woody	45	244	040350	+0.5	+0.2
Trieste	45	80	040349	+0.1	-1.4
King Ranch	45	245	040355	+0.5	+0.4
Hayfield	46	240	040359	+0.5	+1.3
Tucson	46	234	040359	+0.7	+0.6
Riverside	46	242	040400	-0.2	+1.4
Pasadena	46	243	040401	+0.6	+1.0
Magadan	46	334	040400	-1.0	+0.8
Palomar	46	241	040403	-0.8	+0.6
Sverdlovsk	47	36	040403	-2.0	+0.6
Barrett	47	240	040408	+0.5	+0.6
Alicante	47	98	040409	+2.1	-1.2
Cartuja	47	101	040411	+2.3	-0.4
Malaga	47	102	040413	+0.9	+1.7
Iassy	48	67	040412	+0.3	-0.3
Belgrade	48	74	040413	+0.2	+0.3
Rome	48	83	040413	+0.1	-1.4
Almeria	48	100	040412	+0.6	-2.8
Chihuahua	48	227	040415	-1.3	-0.2
Bucharest	49	70	040428	+0.3	-0.5
Algiers	50	95	040428	-1.1	+1.2
Relizane	50	98	040429	+0.6	-0.8
Petropavlovsk	51	326	040438	+1.0	-0.2
Simferopol	51	63	040442	+0.4	-0.2
Yalta	52	63	040446	+1.1	0.0
Messina	52	82	040449	+0.1	+1.7
San Juan	54	178	040458	-0.4	+0.3
Kabansk	56	4	040516	-1.0	+0.6
Makhachkala	57	53	040520	+1.3	-1.6
Tblisi	57	55	040525	+1.3	-0.6
Fort de France	57	172	040524	-0.1	-1.0
Kyakhta	58	4	040527	-1.0	-0.4

Table 6 continued

Station	Δ (deg.)	Az. (deg.)	P time (hhmmss)	Corr. (sec)	Res. (sec)
Kirovabad	59	54	040535	+1.3	-0.3
Yerevan	59	56	040535	+1.3	-0.1
St. Vincent	59	173	040535	-0.1	-0.8
Goris	60	55	040542	+0.4	0.0
Baku	60	51	040545	+2.3	+0.8
Ksara	62	66	040600	+1.2	+0.2
Frunze	62	30	040601	+1.3	0.0
Kizyl-Arvat	62	47	040603	+1.3	+2.1
Tashkent	63	35	040603	+0.8	-1.4
Tananarive	63	98	040606	-0.1	+0.1
Balboa Heights	63	193	040606	-0.1	-0.1
Namaugan	64	33	040611	+1.3	+1.1
Ashkabad	64	45	040610	+1.1	-1.8
Changchun	64	350	040610	-0.3	-0.4
Vladivostok	64	344	040611	-1.3	0.0
M'bour	65	124	040616	-0.1	+0.3
Bayram-Ali	65	42	040619	+1.0	+0.9
Peking	68	357	040638	-0.3	+1.1
Matsushiro	70	338	040649	-0.2	-0.4
Quetta	73	40	040709	-0.5	+0.7
Lahore	73	33	040709	-0.5	+0.5
Nanking	76	354	040724	-0.7	0.0
Shillong	82	18	040755	-0.5	0.0
Huancayo	84	187	040810	+1.5	+1.2
Hong Kong	86	358	040817	-0.3	+0.1
Poona	86	36	040817	-0.5	-0.4
La Paz	88	180	040830	-0.9	+2.6
Baguio City	92	352	040843	0.0	-1.3
Lwiro	94	84	040856	-0.1	0.0
Brisbane	130	310	041448	+0.1	+2.3
Wellington	137	281	041457	-2.1	-1.9
Melbourne	141	316	041502	-2.1	-4.0

FIGURE CAPTIONS

Figure 1. Seismicity beneath and near Baffin Bay. Circles indicate epicenters of earthquakes of magnitude less than 6.0. Larger earthquakes are represented by stars. Symbol size is proportional to magnitude. Earthquakes of magnitude 5.0 and greater are plotted for the period 1900-1996, magnitudes 4.0-4.9 for 1960-1996, magnitudes 3.0-3.9 for 1970-1996 and magnitudes 2.0-2.9 for 1980-1996. Epicenters are from the Canadian Earthquake Epicenter File (CEEF). The 2000 m bathymetry contour is shown by the dashed line. Communities (triangles) are shown for geographic reference.

Figure 2. Travel time residuals after relocation of the 1933 Baffin Bay earthquake. The symbol size is proportional to the residual. Points are plotted on the focal sphere (lower hemisphere projection).

Figure 3. Travel time residuals for the 1934 Baffin Bay earthquake. See Fig. 2 for explanation.

Figure 4. Travel time residuals for the 1945 Baffin Bay earthquake. See Fig. 2 for explanation.

Figure 5. Travel time residuals for the 1947 Baffin Bay earthquake. See Fig. 2 for explanation.

Figure 6. Travel time residuals for the 1957 Baffin Bay earthquake. See Fig. 2 for explanation.

Figure 7. Epicenters for the 1933 Baffin Bay earthquake determined by various sources.

Figure 8. A) Revised and original ISS locations for the five largest Baffin Bay earthquakes. The uncertainty of the revised location is indicated by the ellipse. B) Revised and Qamar [1974] epicenters for the five largest Baffin Bay earthquakes. Qamar [1974] rated his locations A, B, C, D; the error ellipses are plotted using the median value in km for the appropriate rating.

Figure 9. Focal mechanisms determined by Bent [1998] for three of the events relocated in this study. Shaded sections represent compressional quadrants. Two solutions are shown for the 1933 earthquake because it had a complex source; the strike-slip subevent (*left*) was the first and largest subevent.
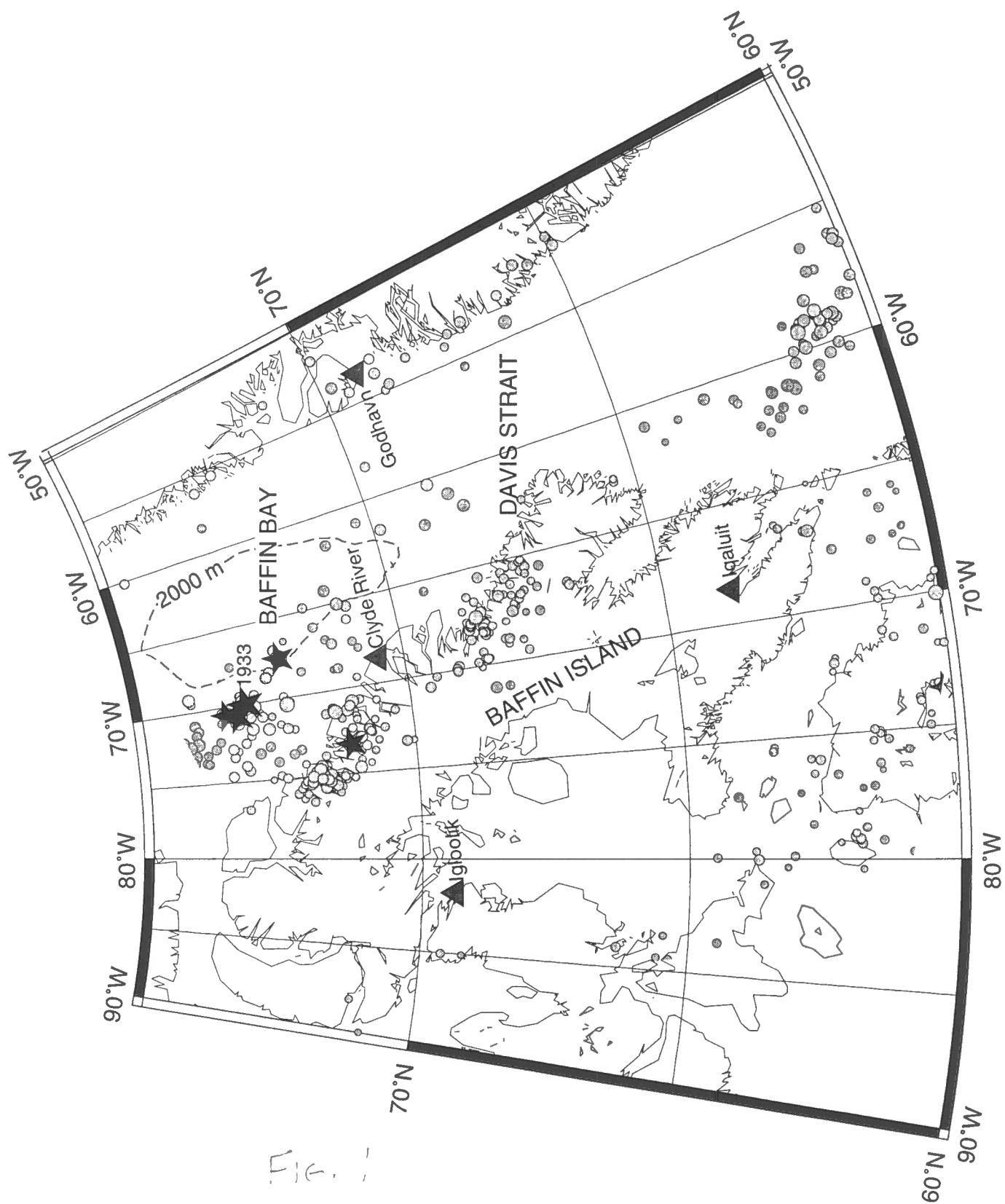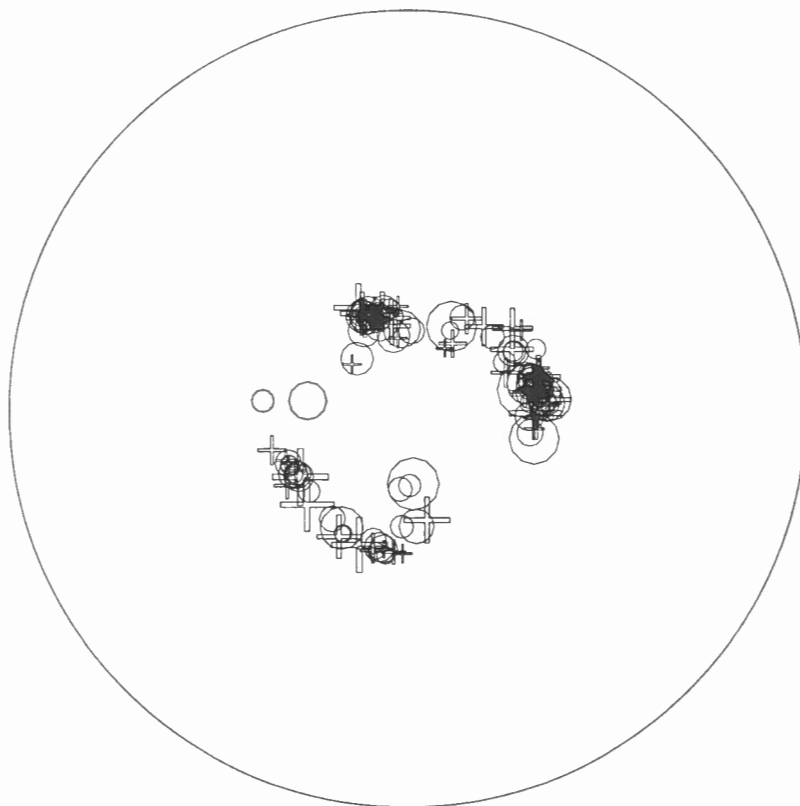
Fig. 1

TRAVEL TIME RESIDUALS
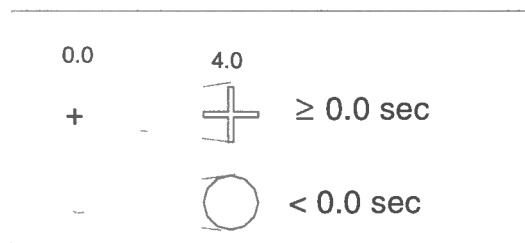1933 BAFFIN BAY EARTHQUAKE
(150 observations)

FIG 2

TRAVEL TIME RESIDUALS
1934 BAFFIN BAY EARTHQUAKE
(104 observations)

FIG. 3

TRAVEL TIME RESIDUALS
1945 BAFFIN BAY EARTHQUAKE
(62 observations)

0.0   4.0

+ $\geq$ 0.0 sec

$<$ 0.0 sec
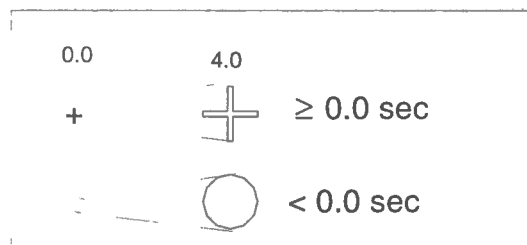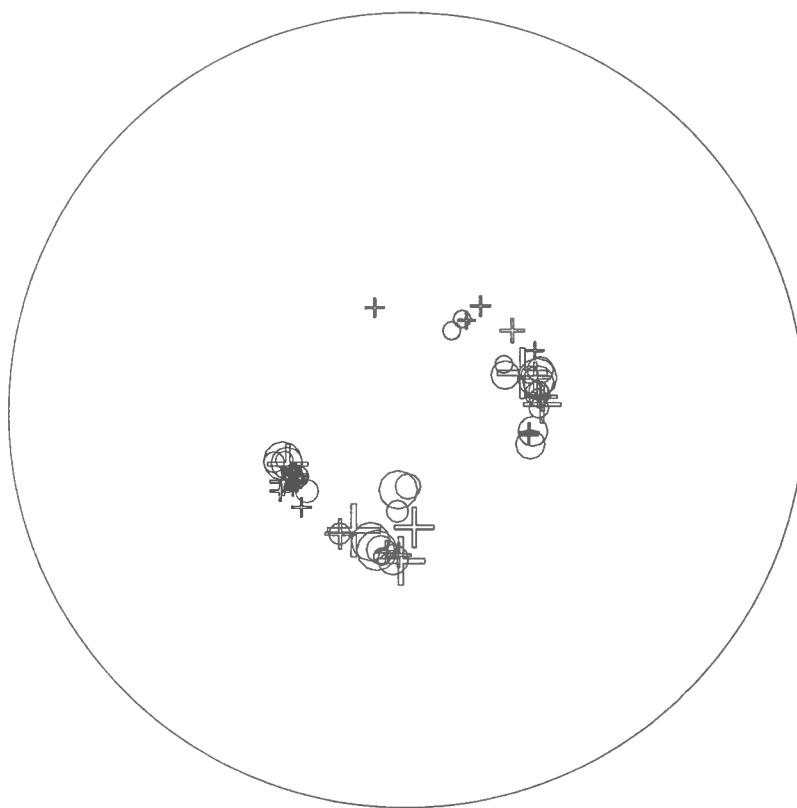
FIG. 4

TRAVEL TIME RESIDUALS
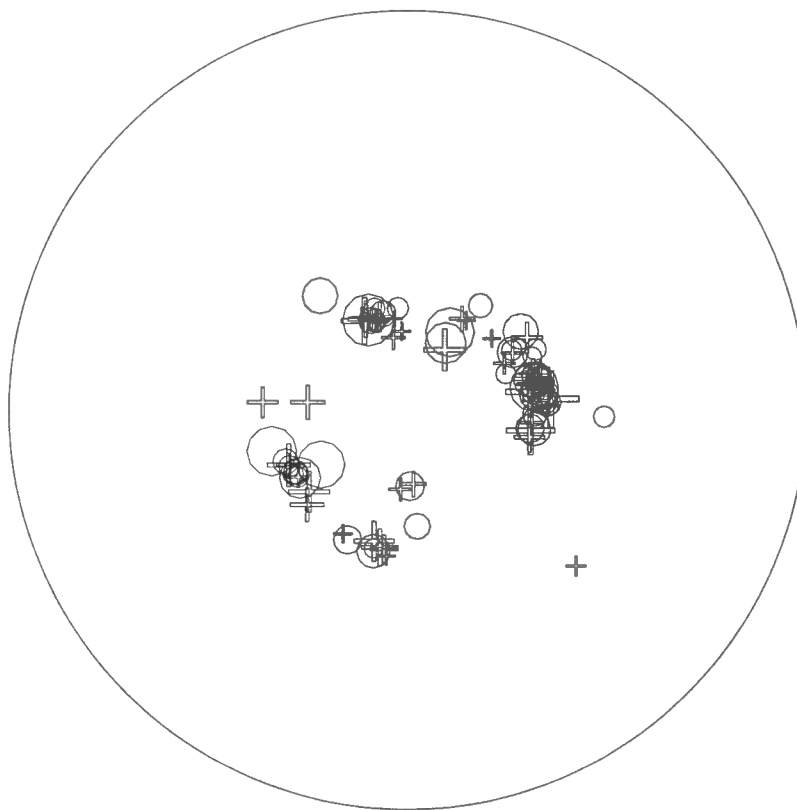1947 BAFFIN BAY EARTHQUAKE
(30 observations)

0.0   4.0

+ $\geq$ 0.0 sec

○ < 0.0 sec

FIG. 5

31
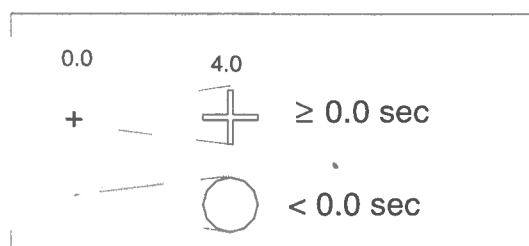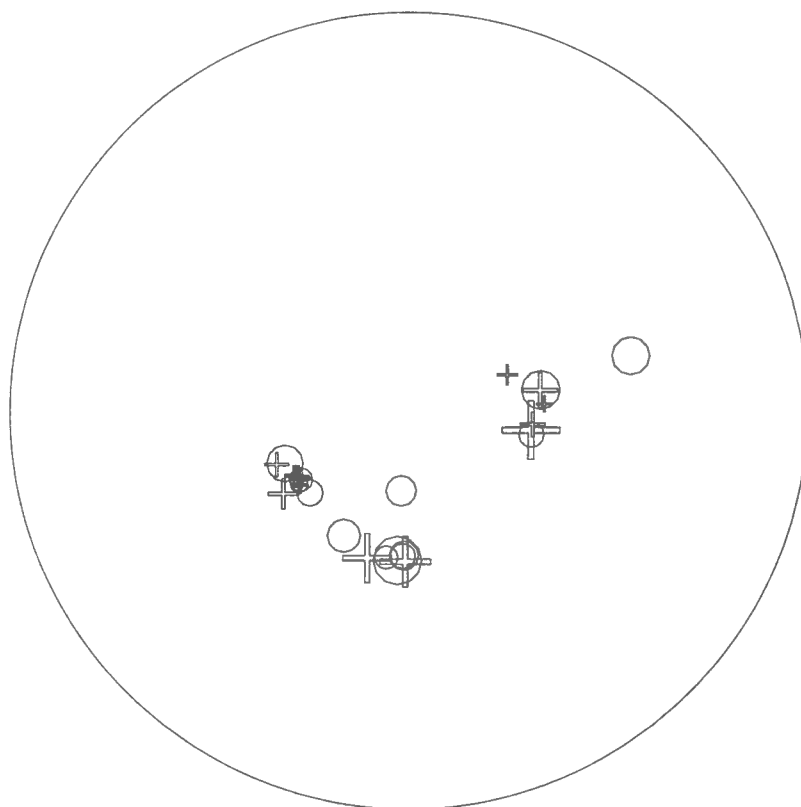
TRAVEL TIME RESIDUALS
1957 BAFFIN BAY EARTHQUAKE
(145 observations)

0.0   4.0

+   ┼   ≥ 0.0 sec

○   < 0.0 sec

FIG. 6

EPICENTERS DETERMINED FOR
1933 BAFFIN BAY EARTHQUAKE

100 KM

★ this study

△ ISS

◇ JSA

▽ BCIS

✕ USCGS

+ Rajko & Linden 1935

◇ Lee 1937

□ Gutenberg & Richter 1954

◯ Qamar 1974

FIG. 7

33

72°W 70°W 68°W

⊙ 1933, 1934

1947

1933

1945

1934

epicenter: this study

epicenter: ISS

uncertainty: this study

72°N 72°N

1957

km

0   50

72°W 70°W 68°W

FIG. 8a

34

FIG. 8b

FOCAL MECHANISMS:
LARGE HISTORICAL
BAFFIN BAY EARTHQUAKES

Fig. 9

36
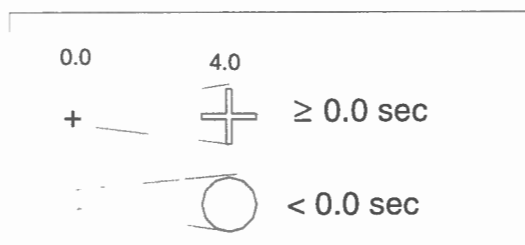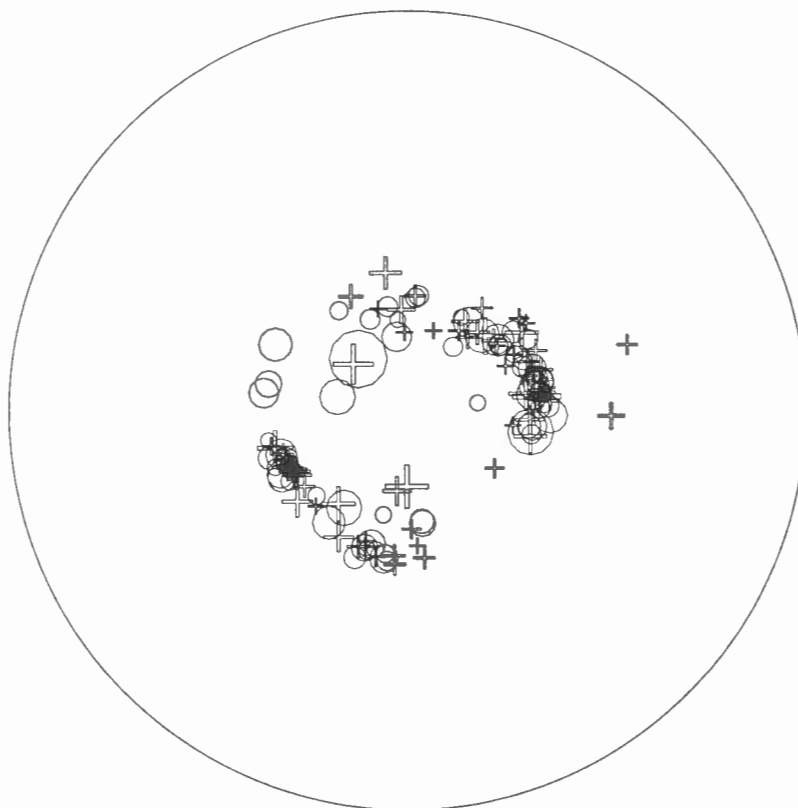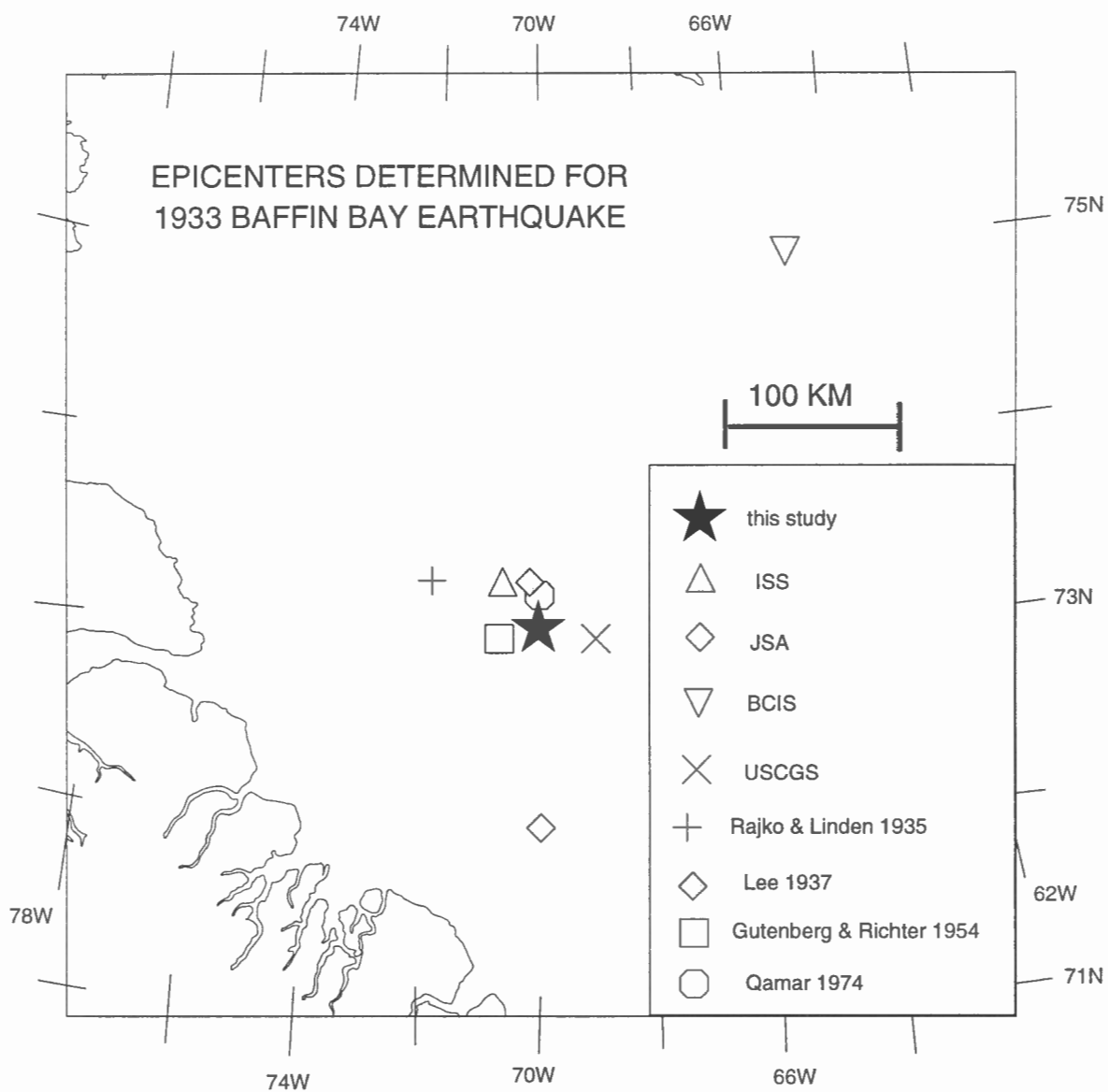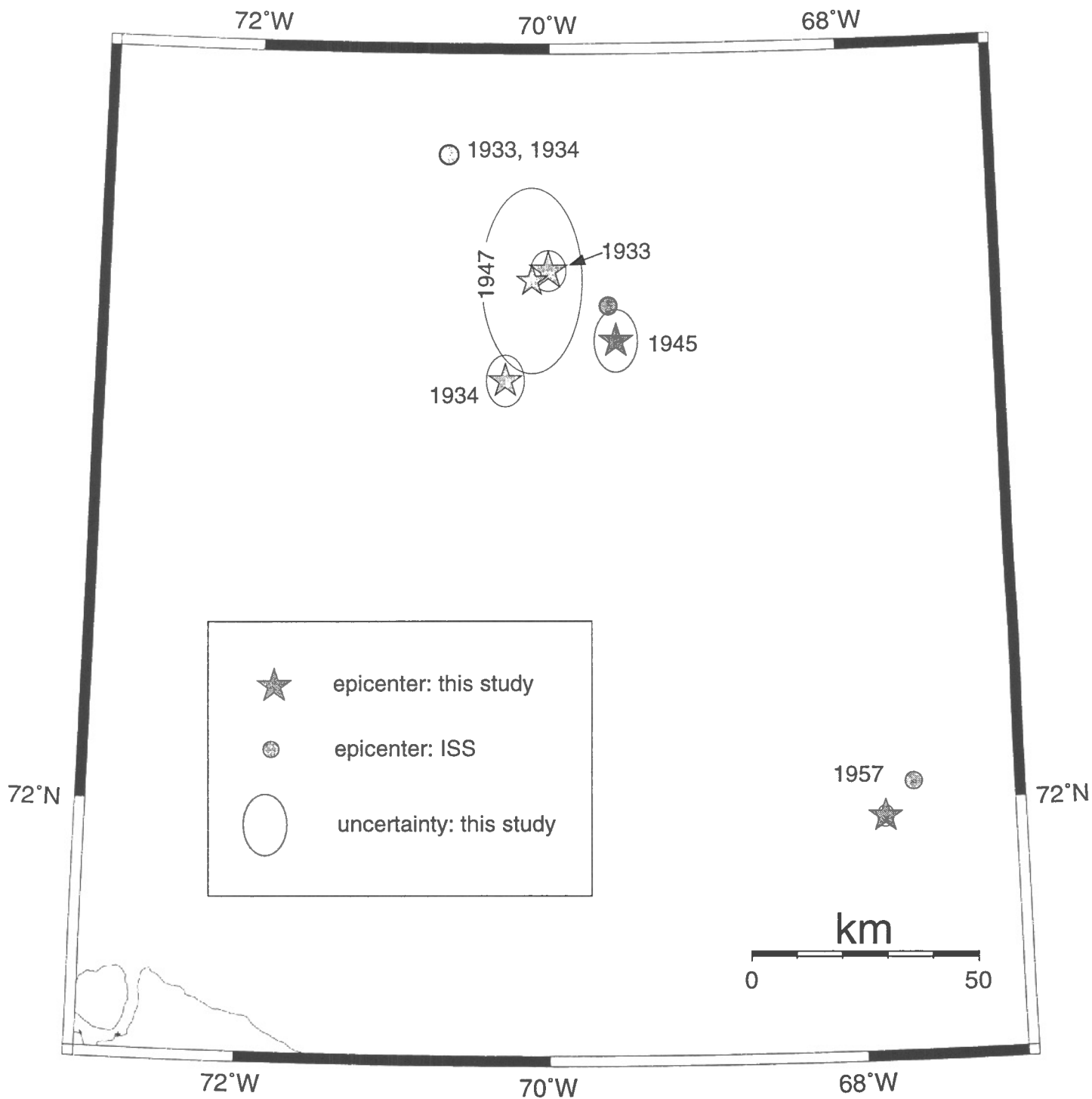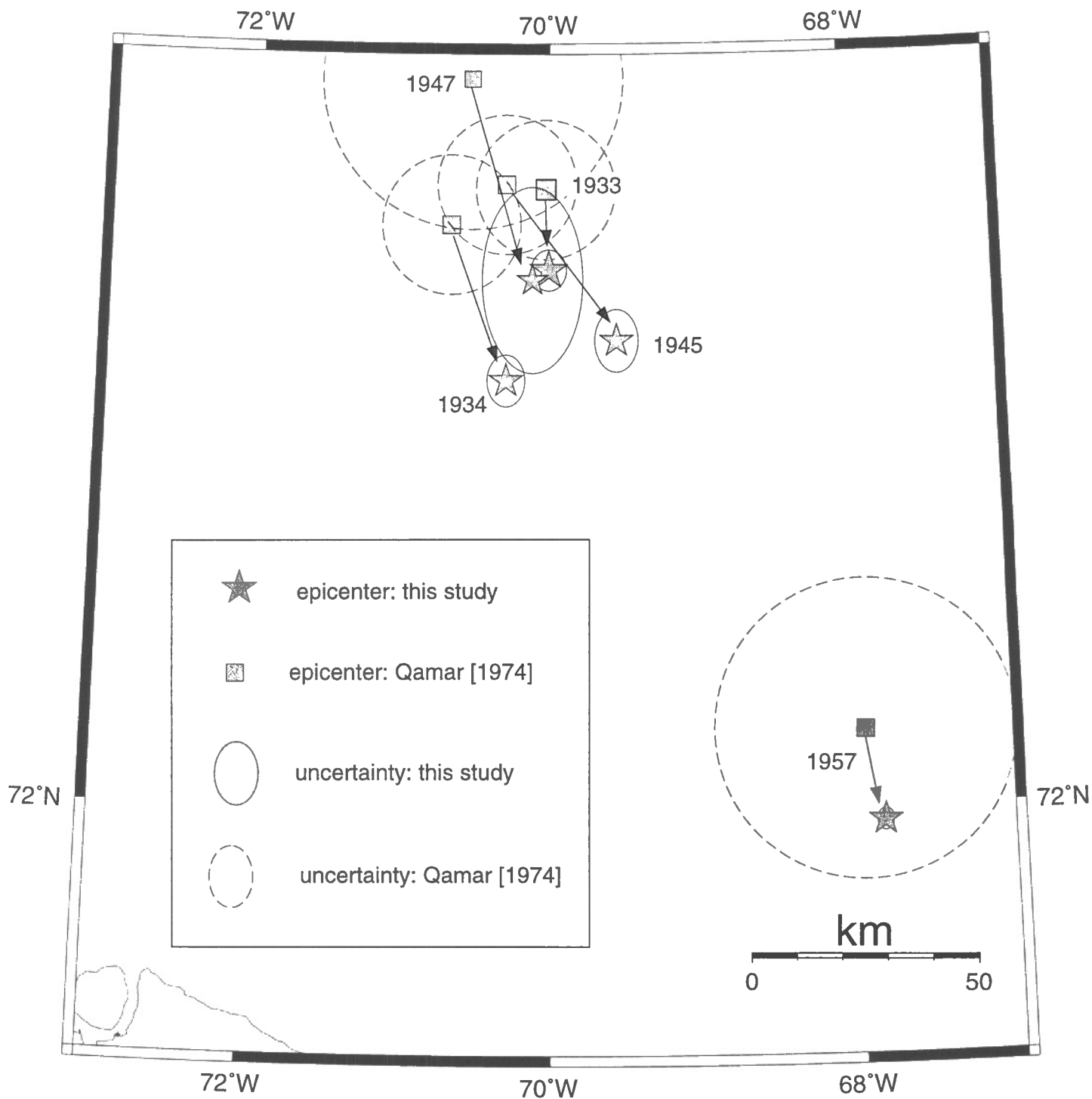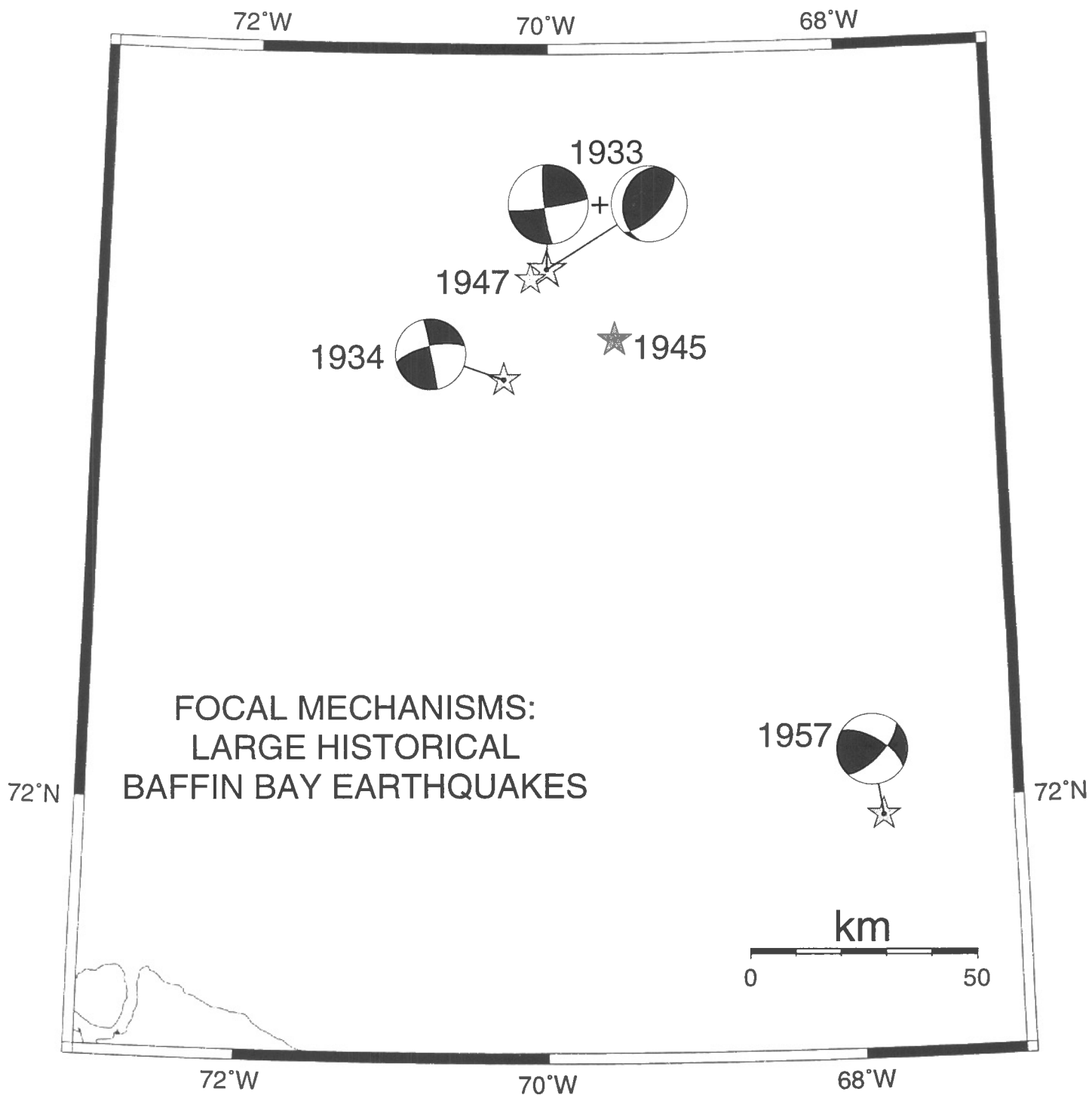
APPENDIX
SUMMARY OF STATION CORRECTIONS

Station	Lat	Lon	Corr	Source
Aberdeen	57.17	-2.10	+0.8	R
Adelaide	-34.97	138.71	-2.1	R
Agra	27.13	78.02	-0.5	R
Akita	39.72	140.11	-0.2	R
Algiers	36.77	3.06	-1.1	S
Alicante	38.36	-0.49	+2.1	S
Alma-Ata	43.27	76.95	+1.3	R
Almeria	36.85	-2.46	+0.6	R
Amboina	3.70	128.17	0.0	R
Andizhan	40.76	72.36	+1.1	S
Ann Arbor	42.30	-83.60	-0.6	R
Aomori	40.82	140.78	-0.2	R
Ashkabad	37.95	58.35	+1.1	R
Bagneres-Bigorre	43.07	0.15	+0.1	R
Baguio City	16.41	120.58	0.0	R
Baku	40.38	49.90	+2.3	S
Balboa Heights	8.96	-79.56	-0.1	R
Banff	51.17	-115.56	-0.4	R
Barcelona	41.42	2.15	+0.6	R
Bari	41.13	16.88	+0.1	R
Barrett	32.68	-116.67	+0.5	R
Basel	47.54	7.58	-0.7	R
Batavia	-6.18	106.84	0.0	R
Bayram-Ali	37.60	62.13	+1.0	R
Belgrade	44.82	20.46	+0.2	S
Benvenuto	41.13	14.80	+0.1	R
Bergen	60.39	5.33	-0.8	R
Berkeley	37.87	-122.26	+0.6	S
Bermuda	32.38	-64.68	-0.1	R
Besancon	47.25	5.99	+0.1	R
Bidston	53.40	-3.07	+0.8	S
Bogota	4.59	-73.96	-0.1	R
Bologna	44.49	11.33	+0.1	R
Bombay	18.90	72.82	-0.5	R
Boulder City	35.98	-114.83	+0.3	S
Bozeman	45.60	-111.63	-0.4	R

Station	Lat	Lon	Corr	Source
Bratislava	48.17	17.11	-0.7	R
Brisbane	-27.48	153.03	-2.1	R
Bucharest	44.41	26.10	+0.3	R
Budapest	47.48	19.02	+0.4	S
Buffalo	42.85	-78.64	-0.4	S
Butte	46.01	-112.56	-0.5	S
Calcutta	22.54	88.37	-0.5	R
Camerino	43,13	13.07	+0.1	R
Capetown	-33.95	18.45	-0.1	R
Carloforte	39.14	8.31	+0.1	R
Cartuja	37.19	-3.60	+2.3	S
Catania	37.51	15.10	+0.1	R
Changchun	43.83	125.31	-0.3	R
Chapel Hill	35.89	79.09	0.0	R
Charlottesville	38.03	-78.52	0.0	R
Cheb	50.08	12.38	-0.7	R
Chicago	41.90	-87.63	-0.6	S
Chihuahua	28.64	-106.08	-1.3	R
Christchurch	-43.53	172.63	-2.1	R
Chur	46.85	9.54	+0.5	S
Clermont-Ferrand	45.76	3.10	+0.1	R
Cleveland	41.49	-81.53	-0.6	R
Coimbra	42.21	-8.42	+0.6	R
College	64.90	-147.79	+1.8	R
Collmberg	51.31	13.00	+0.2	R
Colombo	6.90	79.87	-0.5	R
Columbia	34.00	-81.03	+0.2	S
Copenhagen	55.68	12.43	-0.1	S
Corvallis	44.59	-123.30	-0.4	R
Dairen	38.90	121.63	-0.3	R
De Bilt	52.10	5.18	+0.7	S
Dehra Dun	30.32	78.06	-0.5	R
Denton	33.21	-97.14	+0.7	R
Denver	39.79	-105.03	+0.7	R
Durham	54.77	-1.58	+0.8	R
Ebro	40.82	0.49	+0.8	S
Edinburgh	55.92	-3.19	+0.8	R
Eureka	39.48	-115.97	+0.7	R
Fayetteville	36.09	-94.19	0.0	R

Station	Lat	Lon	Corr	Source
Feldberg	47.88	8.02	+0.2	R
Firenze	43.78	11.26	+0.1	R
Florissant	38.80	-90.37	-0.8	S
Fordham	40.86	-73.89	-0.8	R
Fort de France	14.73	-61.16	-0.1	R
Fresno	36.77	-119.80	+0.5	R
Frunze	42.82	74.62	+1.3	R
Fukuoka	33.58	130.38	-0.2	R
Fukushima	37.76	140.48	-0.2	R
Georgetown	38.90	-77.07	0.0	R
Goris	39.50	46.33	+0.4	R
Gottingen	51.55	9.96	+0.2	R
Grand Coulee	47.94	-118.98	-0.3	S
Graz	47.08	15.45	-0.7	R
Grenoble	45.19	5.70	+0.1	R
Grozny	43.35	45.68	-0.9	R
Haiwee	36.14	-117.95	+0.5	S
Halifax	44.63	-63.60	-0.7	R
Hamburg	53.47	9.93	+0.3	S
Harvard	42.51	-71.56	-0.8	R
Hatidyozime	33.10	139.83	-0.2	R
Hayfield	33.71	-115.64	+0.5	R
Heizyo	39.03	125.75	-0.2	R
Helsinki	60.18	24.96	-0.8	R
Helwan	29.86	31.34	-2.4	S
Hikone	35.27	136.25	-0.2	R
Hong Kong	22.31	114.17	-0.3	R
Honolulu	21.32	-158.06	+1.7	S
Horseshoe Bay	49.38	-123.28	-0.4	R
Hungry Horse	48.35	-114.03	-0.4	R
Hsiking	43,92	125.39	-0.3	R
Huancayo	-12.04	-75.32	+1.5	S
Husan	35.10	129.02	-0.2	R
Hyderbad	17.42	78.55	-0.5	R
Iassy	47.19	27.56	+0.3	R
Inchon	37.48	126.63	-1.5	S
Irkutsk	52.27	104.31	-1.0	R
Isabella	35.66	-118.47	+0.5	R
Ivigtut	61.20	-48.18	-8.3	R
Jena	50.95	11.58	+0.2	R

Station	Lat	Lon	Corr	Source
Johannesburg	-26.20	28.03	-0.1	R
Jof	50.31	11.88	+0.2	R
Kabansk	52.05	106.65	-1.0	R
Kameyama	34.86	136.47	-0.2	R
Karenko	23.98	121.60	-0.3	R
Karlsruhe	49.01	8.41	+1.5	S
Keizyo	37.57	126.98	-0.2	R
Kew	51.47	-0.31	+0.8	R
King Ranch	35.33	-119.75	+0.5	R
Kirkland Lake	48.14	-80.03	-0.7	R
Kirovabad	40.65	46.33	+1.3	R
Kiruna	67.84	20.42	-0.8	R
Kobe	34.69	135.18	-1.3	S
Kochi	33.55	133.53	-0.2	R
Kodaikanal	10.23	77.47	-0.5	R
Konigsberg	54.83	20.50	-0.8	R
Kizyl-Arvat	39.20	56.27	+1.3	R
Krakow	50.06	19.94	+0.2	R
Ksara	33.82	75.98	+1.2	S
Kucino	55.75	37.97	-0.9	R
Kumagoya	36.15	139.39	-0.2	R
Kyakhta	50.37	106.74	-1.0	R
Lahore	31.55	74.33	-0.5	R
La Jolla	32.86	-117.25	+0.5	R
La Paz	-16.50	-68.13	-0.9	S
La Plata	-34.91	-57.93	-0.1	R
Leipzig	51.34	12.39	+0.2	R
Lincoln	40.81	-96.70	-0.6	R
Lisbon	38.72	-9.15	+0.6	R
Little Rock	34.78	-92.35	0.0	R
Ljubljana	46.04	14.53	+0.3	R
Lubbock	33.58	-101.87	+0.7	R
L'vov	49.82	24.03	-0.9	R
Lwiro	-2.24	28.80	-0.1	R
Madison	43.37	-89.76	-0.6	R
Magadan	59.55	150.80	-1.0	R
Makhachkala	43.02	47.43	+1.3	R
Malaga	36.73	-4.41	+0.9	S
Manila	14.66	121.08	0.0	R
Matsushiro	36.54	138.21	-0.2	R

Station	Lat	Lon	Corr	Source
M'bour	14.39	-16.95	-0.1	R
Medan	3.58	98.68	0.0	R
Melbourne	-36.83	144.97	-2.1	R
Merida	20.95	-89.62	-1.3	R
Messina	38.20	15.56	+0.1	R
Messtetten	48.18	8.97	+0.2	R
Mineral	40.35	-121.61	+0.5	R
Miyazaki	31.92	131.43	-0.2	R
Mizusawa	39.13	141.13	-0.2	R
Monaco	43.73	7.43	+0.1	R
Montreal	45.50	-73.62	-0.7	R
Morgantown	39.63	-79.95	0.0	R
Moscow	55.74	37.63	-0.6	S
Mt. Hamilton	37.34	-121.64	+1.2	S
Mt. Wilson	34.22	-118.06	+0.9	S
Muroto Misaki	33.25	134.18	-0.2	R
Nagano	36.66	138.20	-0.2	R
Nagasaki	32.73	129.87	0.0	S
Nagoya	35.17	136.97	-0.2	R
Namaugan	40.98	71.67	+1.3	R
Nanking	32.06	118.78	-0.7	S
Naples	40.85	14.26	+0.1	R
Neuchatel	47.00	6.96	-1.2	S
New Delhi	28.68	77.22	-0.5	R
New Kensington	40.56	-79.75	-0.8	R
New Orleans	29.95	-90.12	0.0	R
Oak Ridge	35.91	-84.30	0.0	R
Oiwake	36.33	138.55	-0.2	R
Oropa	45.63	7.98	+0.1	R
Osaka	34.68	135.52	-0.2	R
Otomari	46.65	142.77	-0.2	R
Ottawa	45.39	-75.72	-1.4	S
Overton	36.35	-114.44	+0.1	S
Oxford	37.42	-122.18	+1.7	S
Padova	45.41	11.89	+0.1	R
Palau	7.33	134.48	-0.2	R
Palisades	41.00	-73.91	-0.8	R
Palo Alto	37.42	-122.18	+0.5	R
Palomar	33.35	-116.86	0.0	S
Paris	48.81	2.49	-0.1	S

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Station	Lat	Lon	Corr	Source
Pasadena	34.15	-118.17	+0.6	S
Pavia	45.18	9.17	+0.1	R
Peking	40.04	116.18	-0.3	R
Perth	-31.95	115.84	-2.1	R
Petropavlovsk	53.02	158.65	-1.0	R
Philadelphia	39.96	-75.18	-0.8	R
Phu-Lein	20.81	106.63	0.0	R
Piacenza	45.05	9.67	+0.1	R
Pierce Ferry	36.12	-114.00	+0.8	S
Pittsburgh	40.45	-79.95	-1.6	S
Poona	18.53	73.85	-0.5	R
Port-au-Prince	18.56	-72.34	-0.1	R
Potsdam	52.38	13.07	+0.2	R
Prague	50.07	14.43	+0.1	S
Pratio-Toscano	43.88	14.54	+0.4	S
Pulkovo	59.77	30.32	-0.9	R
Quetta	30.19	66.95	-0.5	R
Raciborz	50.08	18.19	-0.7	R
Rapid City	44.08	-103.21	-0.4	R
Rathfarnham	53.30	-6.28	+0.8	R
Relizane	35.75	0.55	+0.6	R
Reno	39.54	-119.81	+0.7	R
Resolute	74.69	-94.90	0.0	none
Reykjavik	64.14	-21.91	+2.8	S
Riverside	33.99	-117.38	-0.2	S
Riverview	-33.82	151.16	-2.1	R
Rome	41.81	12.70	+0.1	R
Salt Lake City	40.77	-111.85	+0.5	S
San Francisco	37.78	-122.45	+0.5	R
San Fernando	36.46	-6.21	+0.6	R
San Juan	18.38	-66.12	-0.4	S
Santa Barbara	34.44	-119.71	+0.7	S
Santa Clara	37.35	-121.95	+0.5	R
Sapporo	43.06	141.33	-0.2	R
Saskatoon	52.13	-106.63	-0.4	R
Schefferville	54.82	-66.78	-0.7	R
Scoresby Sund	70.48	-21.95	-7.1	S
Seattle	47.66	-122.31	-0.4	R
Sendai	38.26	140.90	-0.2	R
Sevastopol	44.62	33.53	+0.4	R

Station	Lat	Lon	Corr	Source
Seven Falls	47.12	-70.83	-0.7	R
Shasta	40.70	-122.39	+0.5	R
Shawinigan Falls	46.55	-72.76	-0.7	R
Shimonoseki	33.95	130.93	-0.2	R
Shillong	25.57	91.88	-0.5	R
Shimizu	32.78	132.96	-0.2	R
Simferopol	44.95	34.12	+0.4	R
Sitka	57.06	-135.32	+2.0	S
Sochi	43.58	39.72	+0.4	R
Sodankyla	67.37	26.63	-0.8	R
Sofia	42.69	23.33	+0.3	R
Spring Hill	30.69	-88.14	0.0	R
State College	40.80	-77.87	-0.8	R
St. Louis	38.64	-90.24	-1.9	S
Stonyhurst	53.85	-2.47	+2.7	S
Strasbourg	42.58	7.77	+0.7	S
Stuttgart	48.77	9.20	-0.4	S
St. Vincent	13.17	-61.24	-0.1	R
Sucre	-19.05	-65.24	-0.1	R
Sumiainen	62.72	26.15	-1.0	S
Susaki	34.67	138.98	-0.2	R
Suva	-18.15	178.46	-2.1	R
Sverdlovsk	56.81	60.64	-2.0	S
Tacubaya	19.41	-99.19	-1.3	R
Taihoku	25.03	121.52	0.0	R
Taikyu	35.87	128.60	-0.2	R
Tamanrasset	22.79	5.52	-0.1	R
Tananarive	-18.92	47.55	-0.1	R
Taranto	40.48	17.26	+0.1	R
Tashkent	41.33	69.30	+0.8	S
Tblisi	41.72	44.80	+1.3	R
Tchimkent	42.20	69.60	+1.3	R
Terre Adelie	-66.82	141.40	0.0	none
Theodosia	45.02	35.39	+0.4	R
Tiksi	71.63	128.87	-1.0	R
Tinemaha	37.06	-118.23	+0.2	S
Titizima	27.08	142.18	-0.2	R
Tokyo	35.69	139.76	-0.2	R
Toledo	39.88	-4.05	+0.6	R
Toronto	43.67	-79.40	-0.7	R

Station	Lat	Lon	Corr	Source
Toyo'oka	35.53	134.83	-0.2	R
Trenta	39.28	16.32	+0.1	R
Treviso	45.67	12.18	+0.8	S
Trieste	45.71	13.76	+0.1	R
Tubingen	48.53	9.06	+0.2	R
Tucson	32.31	-110.78	+0.7	R
Tunis	36.80	10.13	-0.1	R
Uccle	50.80	4.36	0.0	R
Ukiah	39.14	-123.21	+0.8	S
Uppsala	59.86	17.63	-1.6	S
Venice	45.43	12.33	+0.1	R
Vera Cruz	19.20	-96.14	-1.3	R
Victoria	48.41	-123.32	-0.4	R
Vienna	48.25	16.36	-0.7	R
Vladivostok	43.12	131.89	-1.3	S
Wakayama	34.23	135.17	-0.2	R
Warsaw	52.24	21.0	+0.2	R
Washington	38.89	-77.03	0.0	R
Wazima	37.38	136.90	-0.2	R
Wellington	-41.29	174.77	-2.1	R
Weston	42.38	-71.32	-0.5	S
Witteveen	52.81	6.67	0.0	R
Woodstock	39.33	-76.88	+0.5	R
Woody	35.70	-118.84	+0.5	R
Yalta	44.5	34.17	+1.1	S
Yerevan	40.18	44.50	+1.3	R
Zagreb	45.82	15.98	+0.3	R
Zi-ka-wei	31.18	121.43	-0.3	R
Zurich	47.48	8.39	-1.7	S

Lat.: degrees, North is positive

Lon.: degrees, East is positive

Corr.: station correction in seconds to be subtracted from P arrival time

Source: S = calculated from data from single station only

R = calculated from regional data