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Title: Vertical Crustal Movement in Maine

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1. INTRODUCTION

This report describes the procedures and results of a study of vertical crustal motion in Maine through the analysis of repeated first order level data. The study was supported by the Maine Geological Survey and was carried out in the Department of Civil Engineering, University of Maine, Orono. All level data were furnished by the National Geodetic Survey.

The data are presented in two distinct ways, Appendix B includes profile plots of all first order level lines in Maine for which repeated observations are available. These plots are useful in detecting relative movement in a local area or a fault zone. All the data have been combined to create a vertical velocity surface shown in Figure 2. This second type of analysis is useful in detecting regional trends but masks local discontinuties. The profiles and the velocity surface in combination provide perhaps the best picture of vertical crustal motions.

2. DATA ANALYSIS

2.1 The Bangor to Calais Line

A preliminary study focused on the first order level line from Bangor to Calais following the Maine Central Railroad through Ellsworth and Machias. First established in 1927 by the U.S. Coast and Geodetic Survey (now the National Geodetic Survey, NGS), the line was completely resurveyed in 1942 and 1966, while the eastern fifty kilometers from Machias to Calais was resurveyed in 1953.

Large amounts of re-leveling data associated with this line, combined with its location in a potentially active area, made the Bangor to Calais line particularly attractive for study. Repeated geodetic leveling of this type represents perhaps the best single source of quantitative information on relative vertical crustal motion.

The 1942, 1953, and 1966 level data are presented in Appendix A, Table A6. Field data fromthe 1927 surveywere not included because there were very few bench marks in common between it and the 1966 (base) data. Table A6 gives the relative elevations of bench marks common to the three dates of survey. The 1966 survey has been selected as a base year. Bench mark V8 in Bangor has been assigned to the elevation of 10.9400 meters in 1966 and 1942. Elevations of other bench marks in the line have been computed using observed, unadjusted differences in elevation between adjacent bench marks for each epoch. The delta elevation column in Table A6 shows the divergence in observed elevation of each bench mark common to the two epochs. The 1953 survey data has been incorporated into Table A6 by assigning bench mark V92 in Machias an elevation of 32.1747 meters in both 1953 and 1966. It must be emphasized that the elevations shown are relative and will indicate only relative motion between adjacent bench marks. This is the only kind of information that can be directly extracted from level data of this sort without tide gage data and the related eustatic variation in sea level.

Figure B6 of Appendix B is a graphic representation of the same data given in Table A6, Appendix A. The horizontal line represents the base line 1966 data while the other lines are plotted as

divergences from the 1966 data. The terrain is shown at a reduced scale. Bench marks 24+06 at 188.29 (km) and 73+81.4 at 214.38 (km) have extremely high divergences of 623.0 (mm) and 718.0 (mm) respectively, and are not shown to scale.

2.2 Analysis of the State Net

Figure 1 shows the first order level network for Maine. The network was divided into 10 segments to be analyzed in the same manner as the line from Bangor to Calais. Segments can be listed using their endpoints as:

1) Fort Kent to Calais
2) Ashland via Clayton Lake to the Canadian Border
3) Jackman via Brownville Jct. to Danforth
4) Milo via Lagrange to Bangor
5) Bangor via Machias to Calais
6) Machias via Eastport to Calais
7) Danville to Bangor
8) Maine-New Hampshire Border to Danville
9) Danville to Portland
10) Portland to Maine-New Hampshire Border

Data for these lines were made available by the National Geodetic Survey (NGS). Profiles of the type generated for the Bangor to Calais line were plotted for all the segments. These profiles are included in Appendix B. The level data and respective delta elevations are presented in Appendix A.

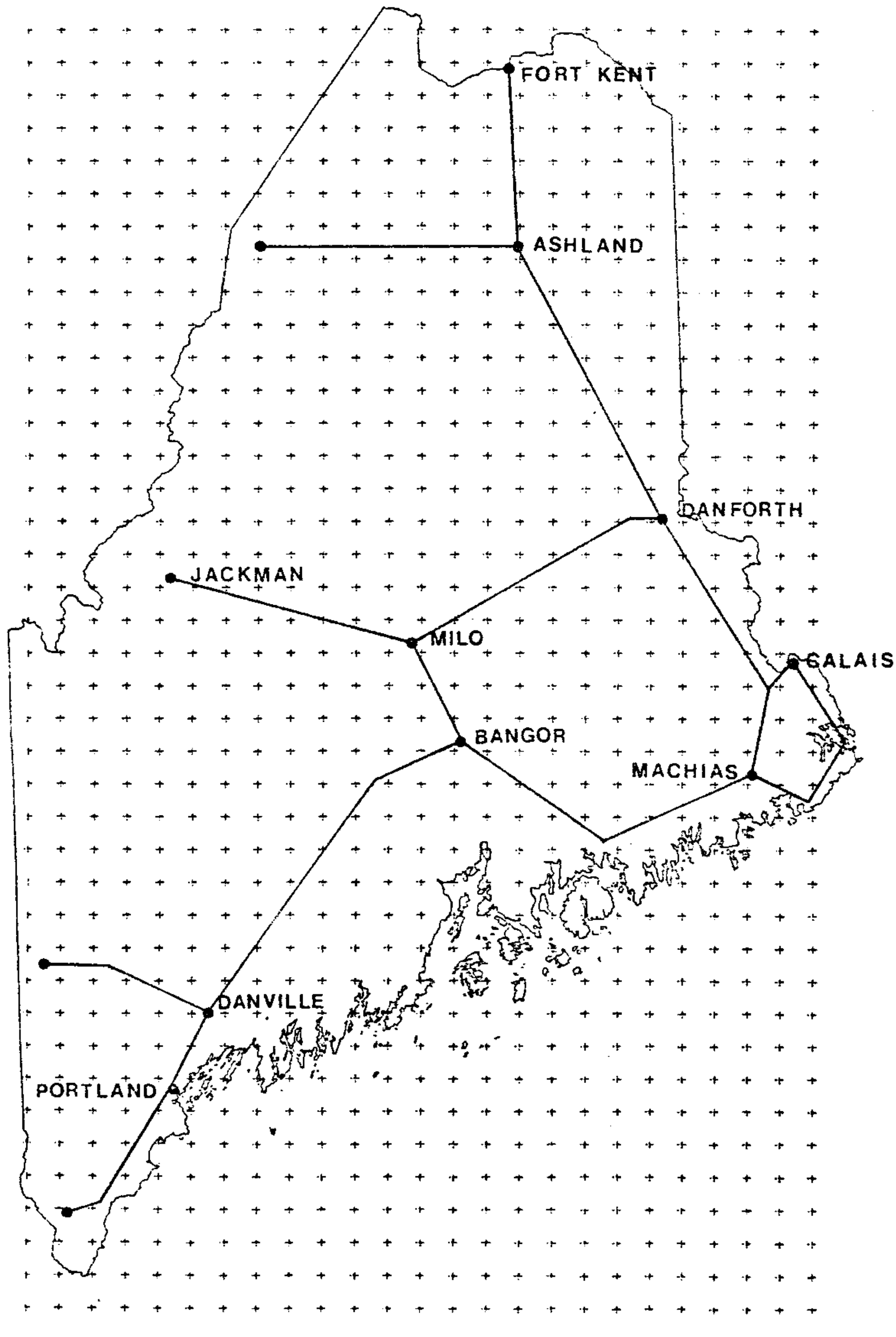

Figure 1. First order level network in Maine

Analysis of the profiles generated from the ten-segment net indicated a study of regional deformation would be appropriate. A number of methods were investigated to form a velocity surface from the scattered repeated level data (Vanicek and Christodulidis, 1974; Holdahl, 1978) and a variation of Holdahl's method 5 was selected.

2.3 Vertical Velocity Surface Model

The elevation of bench mark a at time t_i is given by

$$h_{a,i} = h_{a,o} + V(x_a,y_a)(t_i - t_o) \quad (2.1)$$

where:

$h_{a,i}$ = elevation of bench mark a at time t_i

$h_{a,o}$ = elevation of bench mark a at time t_o

V = vertical velocity

x_a,y_a = plane coordinates of bench mark a

t = time

The velocity function $V(x_a,y_a)$ is assumed to be independent of time and can be expressed as a polynomial power series in the x, y plane coordinates

$$V(x_a,y_a) = \sum_{i,j=o}^{n} C_{ij}\, x_a^{\,i}\, y_a^{\,i} \quad (2.2)$$

The difference in elevation between two bench marks, a and b, at time t_i can now be written

$$\Delta h_{b,a,i} = (h_{b,i} - h_{a,i}) + v_{b,a,i} \tag{2.3}$$

where:

$\Delta h_{b,a,i}$ = observed difference in elevation of time t_i

$h_{a,i}$ and $h_{b,i}$ are as defined in equation (2.1)

$v_{b,a,i}$ = a residual

The unknown parameters in equation (2.3) are the elevations of bench marks a and b at time t_o and the coefficients of the polynomial. Equation (2.3) in expanded form is

$$\begin{aligned} \Delta h_{b-a,i} = {} & (h_{b,o} - h_{a,o}) + c_1(x_b - x_a)(t_i - t_o) + c_2(y_b - y_a)(t_i - t_o) \\ & + c_3(x_b^2 - x_a^2)(t_i - t_o) + c_4(y_b^2 - y_a^2)(t_i - t_o) \\ & + c_5(x_b y_b - x_a y_a)(t_i - t_o) + \ldots + v_{b-a,i} \end{aligned} \tag{2.4}$$

and is linear in the parameters.

A least squares solution was used to solve the velocity surface model.

The resulting surface coefficients and equation (2.2) were used to generate point velocities. Figure 2 represents a vertical velocity contour map generated from point velocities. A fifth degree polynomial was used to fit the data. Bench mark V8 in Bangor was given a velocity of 0 mm/year, thus making the velocity values, statewide, relative to Bangor.

This method requires all bench marks in a locality to take on the same velocity and any localized deformation between bench mark segments will be smoothed out in the final surface.

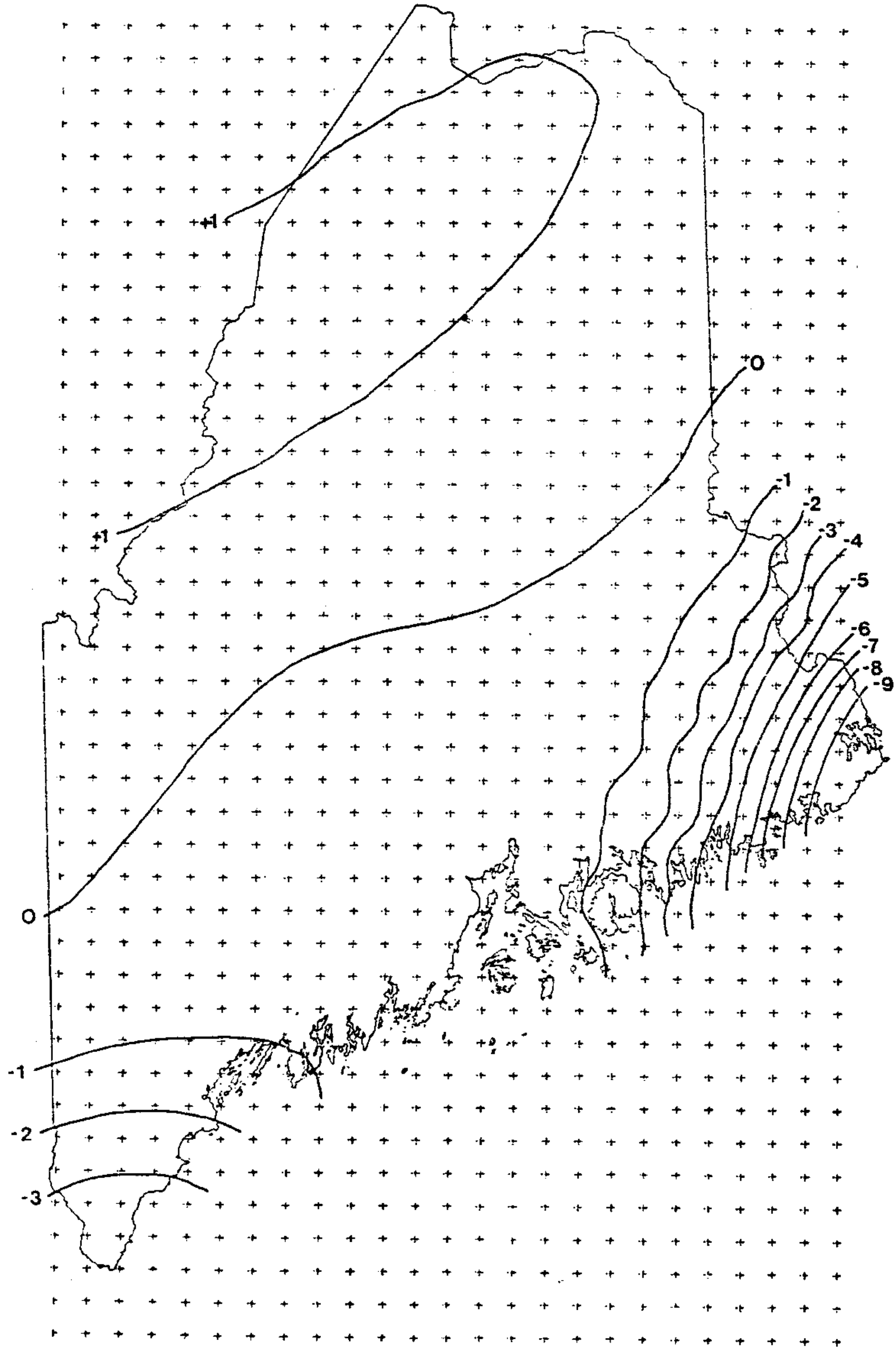

Figure 2. Relative vertical velocity surface (mm/yr)

2.4 Evaluation of Surface Residuals

Observed velocity differences between adjacent bench marks were compared to predicted velocity differences to test the fit of the velocity surface. The resulting root mean square (RMS) errors in relative velocity are tabulated by line in Table 1.

TABLE 1

RMS Errors in Relative Bench Mark Velocities in mm/year

Line	Location	RMS error mm/yr
1	Portland (south) to N.H. Border	0.21
2	Maine-N.H. Border to Danville	0.69
3	Danville to Portland	0.35
4	Danville to Bangor	0.78
5	Milo via Lagrange to Bangor	11.49
6	Bangor to Calais	3.08
7	Machias via Eastport to Calais	2.27
8	Jackman via Brownville Jct. to Danforth	2.36
9	Fort Kent to Calais	1.11
10	Asland via Clayton Lake to Canadian Border	0.46

As expected, the velocity surface does not fit uniformly well throughout the state. With the exception of line 5 between Milo and Bangor, the largest velocity residuals are in the eastern portion of the state where the surface predicts the largest velocities. These residuals can be attributed to random and uncorrected systematic errors in the survey data and to errors in the velocity model.

Profile plots indicate vertical motions that are local in extent on several of the lines. These movements are masked by the velocity surface model but contribute to the residuals.

In both the eastern and southernmost portions of the state, the velocity residuals are significantly smaller than the indicated velocities, indicating that regional trends do exist in the data. In the central and northern regions of the state, the residuals are of the same order of magnitude as the velocities, and the + 1 mm/yr line shown in Northern Maine in Figure 2 is probably not significant.

3. DISCUSSION

The data in Appendix A and the profiles in Appendix B indicate substantial changes in observed height differences within the approximately fifty years of record. The vertical velocity surface indicates a downward relative velocity of up to 9 mm/year in the eastern portion of the state. Four possible explanations for these results are:

a. Accumulation of random errors

b. Incorrectly modeled systematic errors

c. Local movement or instability of individual bench marks

d. Crustal warping or faulting

Accumulation of Random Error. The random error inherent in any surveying measurement propagates through the level line as a function of the square root of the length of the line. Based on past

experience the NGS estimates that the random error in a first order level line will be 1.5 $\sqrt{L}$ mm for lines observed between 1917 and 1955 and 1.0 $\sqrt{L}$ mm for lines observed after 1955 where L is the length of the line in KM. If the line from Bangor to Calais is considered a closed loop (Bangor-Calais-Bangor) the expected random error would be 1.5 $\sqrt{450}$ = 32. mm. This is substantially less than 175 mm divergence and therefore another cause is indicated.

Systematic Errors. There is a considerable amount of geodetic literature devoted to the study of systematic errors or effects in level lines. These effects are believed to accumulate in proportion to the length of the level line and are due to incorrect compensation for atmospheric refraction and settling of the level instrument and rods among other things. A detailed analysis of the Maine leveling data to isolate systematic effects has not been made at this time. However, it is extremely doubtful that systematic errors can account for a significant portion of the total divergence observed on this line.

Instability of Bench Marks. Instability of individual bench marks may account for some of the "spikes" in the data shown in Appendix A and B, but cannot account for the trend of motion indicated.

Crustal Warping or Faulting. Much of the elevation differences indicated by both the profiles and the velocity surface must be caused by vertical motion of the earth's crust. Analysis of eustatic

sea level change, upward growth of salt marshes, and the ongoing submergence of historic structures indicates a pattern of subsidence in eastern Maine. This reinforces the evidence supplied by survey data.

The pattern of regional deformation in eastern Maine shown in Figure 2 agrees with the absolute vertical crustal velocity map of the Maritime Provinces of Canada (Lambert & Vanicek, 1979) if Bangor is assigned a velocity of + 2 mm/yr.

4. CONCLUSIONS

The conclusions of this study can be summarized as follows:

a. The easternmost portion of Maine is subsiding at a rate of up to 9 mm/year relative to Bangor. A significant portion of this motion appears to be of a regional nature and can be modeled by a velocity surface. However, some of the motion is compensated locally and is best shown on profiles.

b. There is relative subsidence of up to 3 mm/year occurring in southern Maine.

c. The interior and northern portion of the state are stable vertically.

APPENDIX A

Level Data

Table A1 - Portland (South) to N.H. Border

STA	DIST (km)	EL 1966 (m)	EL 1923 (m)	DIV (mm)
L5	0.00	4.811	4.811	0.00
N5	8.50	5.246	5.242	3.60
B104	16.30	4.955	4.948	6.50
Q5	19.10	9.068	9.057	11.20
U5	30.60	37.179	37.160	19.10
V5	34.60	23.913	23.893	20.71
Z5	46.80	35.617	35.591	26.11
A6	50.70	57.854	57.821	32.30
B6	53.30	54.262	54.220	42.31
C6	56.50	44.774	44.743	31.31

Table A2. Maine-N.H. Border to Danville

STA	DIST (km)	EL 1978 (m)	EL 1922 (m)	DIV (mm)
T1	0.00	212.173	212.173	0.00
Y3	8.26	208.267	208.279	-11.96
A4	17.02	201.299	201.318	-18.43
B4	20.14	197.517	197.522	- 4.93
F4	26.66	210.272	210.281	- 8.87
H4	32.90	226.460	226.447	12.45
L4	40.74	169.201	169.197	4.26
S4	60.98	126.779	126.782	- 2.76
R4	61.57	116.688	116.690	- 1.79
V4	71.31	100.587	100.618	-30.46
X4	81.88	92.717	92.695	22.03
Y4	86.52	77.646	77.643	2.93

Table A3. Danville to Portland

STA	DIST (km)	EL 1966 (m)	EL 1955 (m)	DIV (mm)	EL 1922 (m)	DIV (mm)
85	0.00	56.548			56.548	0.00
C5	14.00	46.021			46.043	-21.51
D5	19.00	30.367			30.385	-18.51
F5	25.00	28.020			28.043	-22.90
H5	31.00	17.671			17.719	-47.61
J5	38.00	14.575			14.601	-25.30
K5	42.00	33.441			33.464	-22.90
Tidal1	51.00	4.422	4.422	0.00		
Tidal42	51.10	4.227	4.234	- 7.60		
Tidal27	51.20	3.331	3.350	-19.30		
Tidal30	51.30	4.471	4.466	4.90	4.505	-34.00
Tidal31	51.40	4.481	4.476	4.10	4.512	-31.40
Tidal33	52.00	3.992	3.986	5.50		
C121	54.00	4.830	4.822	8.00		

Table A4. Danville to Bangor

STA	DIST (km)	EL 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
B5	0.00	56.548					56.548	0.00
Z15	8.91	69.039					69.060	-20.90
204(USGS)	11.07	63.302					63.323	-20.51
Y15	11.41	63.862					63.871	- 9.51
X15	14.48	57.474					57.480	- 6.30
W15	16.60	64.055					64.055	- 0.40
228(USGS)	21.65	77.456					77.278	178.39
T15	24.59	75.058					75.073	-14.60
257(USGS)	26.68	82.876					82.964	-87.60
S15	28.65	96.547					96.397	149.49
293(USGS)	29.53	89.228					89.228	0.09
Q15	35.30	89.546					89.464	82.20
P15	39.74	83.103					82.961	141.80
L15	48.68	68.725					68.740	-15.00
K15	51.51	67.525					67.563	-38.30
J15	54.24	72.104					72.130	-25.21

Table A4 Continued

STA	DIST (km)	El 1966 (m)	EL 1958 (m)	DIV (mm)	El 1953 (m)	DIV (mm)	EL 1927 (mm)	DIV (mm)
H15	57.78	96.351					96.374	-22.90
F15	63.92	83.533					83.557	-23.80
X14	95.90	42.352					42.362	-10.01
K1(USGS)	99.03	34.621	34.621	0.00			34.669	-48.40
J128	100.79	50.617	50.617	- 0.40				
K128	101.64	29.660	29.663	- 3.10				
L128	102.95	37.235	37.234	0.79				
K2(USGS)	103.97	43.295	43.313	-17.50			43.277	18.20
M128	105.68	32.015	32.013	1.69				
A128	106.94	37.819	37.820	- 1.01				
B128	107.54	41.117	41.117	0.00				
V14	109.94	48.569	48.551	18.20			48.489	80.09
F128	111.77	48.871	48.872	- 1.30				
K3(USGS)	112.35	48.670	48.667	3.31			48.712	-42.19
G128	113.96	48.305	48.307	- 1.89				

Table A4. Continued

STA	DIST (km)	EL 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
U14	114.95	47.704	47.708	- 4.59			47.763	-59.20
N128	116.90	39.811	39.816	- 5.10				
E128	117.30	35.542	35.549	- 6.50				
H129	118.73	63.512	63.520	- 7.90				
J129	120.06	41.327	41.337	-10.50				
K129	120.95	51.566	51.575	- 9.09				
K5(USGS)	122.51	58.071	58.078	- 7.20				
L129	122.80	41.684	41.691	- 7.00				
T14	124.14	52.063					51.974	88.70
N129	124.74	42.257	42.261	- 4.50				
K6(USGS)	126.80	49.089	49.098	- 9.00			49.163	-74.20
W129	128.59	48.601	48.570	30.30				
S14	131.68	62.468	62.422	46.60			62.296	172.10
Y128	132.46	83.617	83.623	- 5.71				
R14	133.81	73.393	73.402	- 9.29			73.358	34.70

Table A4 Continued

STA	DIST (km)	EL 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
CARP	134.24	85.792	85.801	- 8.50				
P129	136.54	75.635	75.660	-25.30				
Q129	137.80	63.098	63.107	- 8.91				
PICK	138.48	91.580	91.577	2.41				
PICKRM2	138.51	92.598	92.598	- 0.09				
PICKRM1	138.54	92.623	92.638	-14.69				
R129	140.19	57.704	57.712	- 8.00				
P14	143.17	65.418	65.423	- 4.81			65.421	- 3.01
D129	143.36	68.664	68.673	- 8.61				
G129	143.76	64.362	64.364	- 1.39				
M129	145.57	90.557	90.566	- 9.09				
S129	147.33	74.482	74.491	- 8.39				
U129	149.18	90.402	90.408	- 6.50				
T129	150.11	72.271	72.282	-10.91				
V129	151.57	80.877	80.889	-12.21				

Table A4 Continued

STA	DIST (km)	El 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
M14	153.39	57.416					57.497	-81.89
W129	153.97	72.829	72.837	- 7.90				
X129	155.92	72.069	72.078	- 8.70				
Y129	156.75	67.727	67.742	-15.30				
L14	157.86	61.480	61.497	-16.69			61.574	-93.00
NEWPRM1	158.26	64.346	64.361	-14.89				
NEWPORT	158.28	64.180	64.195	-15.70				
NEWPRM2	158.30	64.096	64.108	-12.30				
E130	158.62	59.673	59.686	-12.30				
K14	159.62	61.590	61.601	-11.29			61.661	-71.40
B130	160.06	63.361	63.384	-23.10				
A130	160.93	58.348	58.364	-15.81				
C130	162.22	74.286	74.296	- 9.70				
HSTYRM1	162.82	83.065	83.079	-13.70				

Table A4 Continued

STA	DIST (km)	EL 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
HASTY	162.85	83.506	83.507	- 1.39				
HSTYRM2	162.88	83.525	83.535	-10.19				
HSTYAZI	163.18	81.012	81.021	- 8.91				
F130	164.41	75.483	75.497	-14.21				
J14	165.28	71.630	71.641	-11.20			71.703	-73.09
D130	166.32	73.510	73.518	- 7.71				
H14	167.82	75.181					75.128	52.40
G14	171.47	76.306			76.306	0.00	76.375	-68.41
W115	173.06	70.952			70.954	- 1.82		
V115	174.36	70.377			70.380	- 3.31		
F14	175.49	71.263			71.260	- 2.90	71.210	52.80
X115	175.65	70.005			70.008	- 3.60		
U115	176.78	68.132			68.139	- 6.30		
T115	178.69	62.102			62.107	- 4.50		

Table A4 Continued

STA	DIST (km)	EL 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
S115	179.80	54.832			54.834	- 2.41		
E14	179.89	56.781			56.783	- 2.30	56.808	-27.50
R115	181.88	48.024	48.013	10.91	48.030	- 6.10		
D14	181.93	47.023			47.036	-12.41	47.042	-18.40
L118	182.44	44.068			44.070	- 1.71		
S111	183.95	40.514			40.519	- 4.61		
C14	185.72	41.709			41.710	- 1.42	41.770	-60.71
K113	187.51	51.690			51.696	- 6.21		
B14	189.02	47.745			47.749	- 4.32	47.794	-48.51
J113	190.42	44.261			44.263	- 2.01		
A14	191.85	47.079			46.973	105.59	46.903	175.40
H113	193.83	42.433			42.434	- 0.31		
HERAZI	196.68	69.356	69.310	46.10				
HERRM2	196.84	75.518	75.477	41.31				
HERMON	196.87	77.111	77.069	42.30				

Table A4 Continued

STA	DIST (km)	EL 1966 (m)	EL 1958 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
HERRI	196.90	76.864	76.823	40.80				
G113	197.17	40.134	40.104	29.71	40.133	0.99		
N.M.JCT	198.80	47.969	47.935	33.89	47.968	1.08		
A9	200.56	44.421	44.397	34.39	44.414	6.59		
L132	201.69	44.493	44.458	34.81				
G132	202.93	39.674	39.661	12.60				

Table A5 - Milo via Lagrange to Bangor

STA	DIST (km)	EL 1978 (m)	EL 1953 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
U114	0.00	89.813	89.813	0.00		
W114	0.20	88.750	88.750	0.44		
V114	0.40	87.613	87.620	-6.47		
T13	8.08	94.068	94.059	8.24	94.068	0.00
A114	9.61	97.898	97.890	7.89		
B114	10.61	96.317	96.310	7.05		
D114	12.48	93.107	93.098	9.49		
C114	14.21	85.879	85.875	4.50		
V13	14.77	85.210	85.191	19.74	85.153	56.90
H83	17.67	66.125	66.094	30.76		
G91	43.71	41.927	41.910	17.58		
G9	50.03	41.449	41.426	22.55	41.497	-48.19
D9	64.81	45.010			45.052	-41.35

Table A6 - Bangor to Calais

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
V8	0.00	10.940			10.940	0.00
U8	0.48	12.102			12.076	25.90
K89	1.56	22.602			22.611	-9.19
M89	6.47	39.007			38.986	20.90
N89	7.94	25.902			25.905	-2.38
Q89	11.99	43.295			43.293	2.00
R8	12.95	51.482			51.486	-3.89
QB	14.77	75.408			75.413	-5.69
R89	16.52	71.195			71.207	-12.50
P8	17.32	60.992			61.005	-13.29
T89	19.42	71.622			71.637	-15.40
U89	20.97	72.200			72.212	-12.59
NB	22.51	77.419			77.447	-27.30
V89	22.94	74.039			74.061	-22.00
W89	24.45	83.497			83.517	-20.78

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
X89	24.84	79.548			79.567	-18.91
Y89	26.21	66.185			66.202	-17.90
Z89	27.93	55.606			55.630	-24.29
LB	28.05	54.272			54.296	-24.00
A90	29.36	58.776			58.801	-24.80
K8	30.92	70.972			70.993	-21.50
B90	32.51	82.925			82.943	-17.59
C90	34.15	83.288			83.304	-15.88
J8	34.90	83.304			83.289	15.11
D90	35.77	79.332			79.350	-18.01
HB	37.30	73.885			73.899	-14.98
E90	39.03	75.493			75.500	-6.39
F90	40.46	54.114			54.134	-19.59
G8	41.22	51.518			51.479	39.11
G90	42.15	45.349			45.339	10.50
J90	45.36	38.776			38.768	7.61

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
K90	46.64	41.145			41.141	3.31
E8	47.36	34.358			34.356	1.60
Z88	48.42	45.672			45.667	5.71
L90	49.44	42.093			42.092	0.40
C8	52.41	60.170			60.176	-6.00
M90	54.29	33.950			33.952	-1.39
B8	55.20	21.488			21.492	-4.39
N90	56.42	30.594			30.605	-11.09
A8	59.63	27.703			27.709	-5.40
Q90	61.45	21.540			31.542	-1.50
R90	63.00	22.809			22.827	-18.19
Z7	63.62	21.917			21.985	-68.19
S90	63.81	21.501			21.520	-19.39
C1(USGS)	64.89	22.829			22.850	-21.90
T90	67.04	19.257			19.278	-20.80
U90	67.50	22.498			22.518	-19.99
V90	68.89	22.030			22.053	-22.80
X7	70.36	13.901			13.924	-22.70
W90	71.42	28.187			28.224	-37.09

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
W7	72.60	40.842			40.875	-33.10
X90	74.43	58.093			58.123	-29.50
V7	75.90	57.845			57.882	-36.90
Y90	77.63	46.162			46.188	-25.89
Z90	79.36	58.143			58.169	-26.00
J91	79.53	60.744			60.773	-29.50
A91	79.90	71.527			71.557	-29.39
D91	82.16	81.275			81.304	-29.50
C91	85.63	85.176			85.208	-32.90
R88	87.22	67.790			67.828	-38.10
S7	88.77	51.046			51.085	-39.49
Q88	90.46	48.757			48.790	-33.29
R7	93.68	27.375			27.411	-36.10
P88	97.12	29.025			29.031	-6.29
N88	98.97	32.981			33.018	-36.61
P7	101.86	16.619			16.623	-4.09

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
S88	104.75	32.701			32.734	-32.79
T88	105.85	34.204			34.237	-33.20
V88	110.46	20.781			20.814	-32.68
K7	113.90	28.017			28.029	-11.69
W88	117.06	23.798			23.828	-29.89
J7	118.30	20.480			20.465	15.50
Y88	119.85	18.280			18.318	-37.99
37(USGS)	122.21	11.408			11.454	-45.50
Y93	123.81	23.192			23.206	-14.40
68(USGS)	126.28	20.760			20.801	-41.09
Z93	127.41	21.473			21.490	-17.68
A94	129.43	32.258			32.303	-44.39
S94	130.73	31.660			31.706	-45.90
58(USGS)	132.49	17.738			17.783	-44.89
T94	134.27	27.493			27.534	-40.59
U94	135.40	26.573			69.625	-51.50

Table A6 Continued

STA	DIST (km)	El 1966 (m)	El 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
V94	136.09	29.961			29.999	-37.69
129(USGS)	137.40	39.471			39.518	-46.49
X94	139.57	38.163			38.218	-54.69
R94	140.84	22.098			22.145	-47.00
57(USGS)	143.01	17.439			17.492	-53.50
Q94	144.79	24.315			24.389	-73.68
P94	146.08	36.582			36.655	-73.00
71(USGS)	148.31	21.611			21.664	-53.50
N94	149.87	3.696			3.747	-51.40
M94	151.49	4.390			4.448	-57.30
L94	153.26	6.359			6.414	-54.90
K94	154.60	4.285			4.339	-53.60
EM(MIT)	156.34	13.412			13.468	-56.50
44(USGS)	156.38	13.387			13.443	-56.30
J94	156.83	15.091			15.153	-62.10
H94	158.37	14.383			14.443	-59.10

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
52+83	158.64	15.094			15.152	-58.00
G94	159.94	15.870			15.929	-59.50
F94	161.11	32.919			32.979	-60.20
E94	162.45	30.255			30.314	-59.10
X6	163.74	32.717			32.629	87.51
D94	163.77	32.489			32.546	-56.70
B94	167.71	26.376			26.442	-66.21
Z92	169.24	28.847			28.914	-66.99
5332	169.90	25.058			25.123	-65.29
Y92	170.88	22.449			22.520	-70.98
W92	172.70	32.175	32.175	0.00	32.246	-70.89
V92	174.04	31.630	31.632	-2.20	31.702	-72.19
5510	175.46	33.997	33.995	2.09	34.067	-70.69
U6	175.59	37.396	37.402	-6.20	37.479	-83.19
U92	177.21	60.705	60.704	1.50	60.776	-71.00
T6	177.81	56.389	56.385	3.60	56.458	-69.09
X92	178.47	47.444	47.437	6.50	47.516	-72.69

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	El 1942 (m)	DIV (mm)
T92	180.03	28.291	28.286	5.29	28.363	-71.70
89	180.23	27.218	27.212	5.71	27.290	-71.88
S92	181.52	26.745	26.739	7.10	26.817	-72.19
R92	182.47	28.366	28.361	4.70	28.439	-72.60
Q92	184.08	29.051	29.046	5.10	29.218	-77.79
92(MIT)	184.68	28.063	28.056	6.90	28.136	-73.39
R6	184.90	26.783	26.768	15.20	26.833	-49.50
P92	185.45	28.638	28.634	3.49	28.718	-80.09
N92	187.31	40.761	40.760	1.21	40.845	-83.39
24+06	188.29	44.717	44.716	0.70	44.093	623.31
Q6	188.70	45.667	45.669	-1.30	45.754	-86.88
M96	190.43	41.837	41.839	-2.20	41.931	-93.49
L96	192.23	36.412	36.416	-3.60	36.505	-92.80
06	193.77	41.944	41.955	-11.00	42.053	-108.80
K96	195.21	32.961	32.972	-10.80	33.070	-108.70
J96	196.11	29.330	29.342	-12.50	29.441	-111.21
H96	197.57	28.263	28.249	14.51	28.334	-71.38

Table A6 Continued

STA	DIST (km)	EL 1966 (m)	EL 1953 (m)	DIV (mm)	EL 1942 (m)	DIV (mm)
G96	198.80	27.968	27.983	-15.20	28.092	-123.89
F96	201.04	24.480	24.495	-15.00	24.604	-124.39
87+610	202.77	38.289	38.292	-2.40	38.401	-111.50
E96	203.29	34.744	34.763	-18.71	34.881	-137.19
L6	204.40	35.029	35.043	-13.50	35.142	-112.79
C96	206.67	38.678	38.698	-19.79	38.819	-140.40
B96	208.38	38.210	38.231	-20.89	38.356	-145.98
A96	209.00	41.825	41.847	-21.50	41.969	-143.20
Z91	210.35	43.558	43.591	-32.50	43.718	-159.48
Y91	212.23	48.976	49.003	-26.79	49.123	-146.79
X91	213.87	35.472	35.489	-17.50	35.614	-142.00
73+814	214.38	34.069	34.100	-30.11	33.351	718.40
W91	215.23	30.032	30.064	-31.51	30.189	-156.80
C91	218.99	22.993	23.022	-28.90	23.163	-170.09
K19	219.62	25.501	25.530	-28.31	25.668	-166.99
U91	220.88	22.969	22.999	-30.11	23.139	-169.60

Table A6 Continued

STA	DIST (km)	El 1966 (m)	El 1953 (m)	DIV (mm)	El 1942 (m)	Div (mm)
T91	222.02	16.603	16.634	-30.90	16.780	-176.48
S91	223.33	9.908	9.936	-27.40	10.088	-179.60
G6	224.24	5.939	5.965	-26.40	6.113	-174.80
IR(GSC)	225.02	16.437	16.466	-29.59	16.613	-175.89

Table A7 - Machias via Eastport to Calais

STA	DIST (km)	EL 1978 (m)	EL 1935 (m)	DIV (mm)
44USGS	0.00	13.319	13.319	0.00
W68	0.52	17.892	17.898	-5.63
T68	7.73	10.290	10.251	39.08
L68	20.17	6.219	6.124	95.30
J68	22.82	29.788	29.730	57.77
F68	28.49	53.073	53.013	60.04
E68	30.25	53.528	53.472	56.11
W93	34.73	25.833	25.783	50.57
T67	36.74	29.566	29.505	61.22
S67	38.23	20.312	20.257	55.18
N67	45.12	49.567	49.490	77.03
LUBEC2	53.58	12.313	12.405	-91.90
QUODDY1	62.36	12.460	12.541	-80.23
TIDAL2	65.16	7.953	8.039	-85.82
TIDAL3	65.19	11.399	11.484	-85.82
TIDAL4	65.24	12.309	12.388	-78.88

Table A7 Continued

STA	DIST (km)	EL 1978 (m)	EL 1935 (m)	DIV (mm)
J65	88.41	20.540	20.587	-46.39
H65	89.77	27.279	27.324	-44.30
N15USGS	92.89	33.037	33.096	-59.08
C65	100.63	30.603	30.676	-72.86
IBGSC	107.78	16.380	16.465	-84.44

Table A8 - Jackman via Brownville Jct. to Danforth

STA	DIST (km)	EL 1978 (m)	EL 1959 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1935 (m)	DIV (mm)	EL 1916 (m)	DIV (mm)
U	0.00	367.284							367.284	0.00
Y	7.10	355.453							355.490	-37.35
B1	14.74	356.469							356.500	-31.25
N1	76.84	322.814					322.814	0.00	322.842	-28.08
01	76.97	316.025					316.029	-4.39	316.060	-35.16
D33	91.07	317.848					317.854	-5.86		
S33	113.91	132.242					132.302	-60.20		
J34	144.95	98.329					98.384	-54.47		
U114	163.03	89.815			89.815	0.00				
W114	163.23	88.753			88.752	0.75				
V114	163.41	87.616			87.622	-6.21				
PISCATRM1	195.79	51.092	51.092	0.00						
PISCATAZMK	196.12	50.737	50.749	-12.18						
SEBOEIS	197.34	75.039	75.049	-9.35						
SEBRM1	197.37	74.392	74.399	-7.13						
GORRM2	201.09	56.959	56.973	-14.11						

Table A8 Continued

STA	DIST (km)	EL 1978 (m)	EL 1959 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1935 (m)	DIV (mm)	EL 1916 (m)	DIV (mm)
GORDEN	201.12	57.497	57.512	-15.79						
GORAZMK	201.36	58.959	58.970	-11.25						
F136	203.01	50.298	50.310	-12.56						
G136	205.67	54.796	54.809	-12.73						
H136	207.17	52.869	52.883	-13.52						
Q136	210.40	81.088	81.112	-24.05						
V2	237.42	66.188							66.233	-44.89
W2	237.79	66.761							66.829	-67.81
E3	281.81	102.715							102.771	-55.83
J3	300.00	119.494							119.517	-23.74

Table A9 - Fort Kent to Calais

STA	DIST (km)	EL 1978 (m)	EL 1959 (m)	DIV (mm)	EL 1953 (m)	DIV (mm)	EL 1933 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
761BC	0.00	160.711					160.711	0.00		
M10	54.00	187.728								
Z101	97.00	173.288			173.288	0.00			187.728	0.00
B11	99.00	175.254			175.329	-75.53			175.353	-98.88
E11	108.00	168.631							168.713	-81.42
Y11	166.00	176.632							176.773	-140.93
Z11	168.00	172.178	172.178	0.00						
R139	174.00	229.113	229.114	-1.43						
T139	179.00	195.044	195.048	-4.24						
V139	186.00	151.027	151.036	-8.74						
W139	189.00	138.254	138.262	-7.72						
X139	191.00	124.990	124.999	-8.68						
Y139	192.50	130.744	130.761	-17.62						
Z139	194.00	131.753	131.763	-10.03						
B140	198.00	130.586	130.607	-21.74						
E21	201.26	109.790	109.816	-26.60						

Table A9 Continued

STA	DIST (km)	EL 1978 (m)	EL 1959 (m)	DIV (mm)	El 1953 (m)	DIV (mm)	EL 1933 (m)	DIV (mm)	EL 1927 (m)	DIV (mm)
D21	201.35	111.543	111.570	-27.27						
B21	207.00	177.258					177.226	-8.68		
Y20	216.72	132.776					132.779	-3.13		
X20	219.85	165.773					165.781	-8.35		
U20	229.26	175.764					175.773	-8.64		
T20	232.35	152.166					152.171	-5.75		
L20	254.61	139.240					139.256	-15.75		
J3	256.28	119.495					119.515	-19.41		
J20	268.33	119.303					119.338	-34.99		
Y19	301.35	93.870					93.913	-43.23		
G6	348.33	5.878					5.980	-102.36		
IBGSC	348.70	16.376					16.481	-104.92		

Table A10 - Ashland via Clayton Lake to Canadian Border

STA	DIST (km)	EL 1978 (m)	EL 1953 (m)	DIV (mm)
C101	0.00	193.024	193.024	0.00
D101	2.14	220.184	220.190	-5.89
E101	3.51	227.734	227.741	-7.06
F101	4.82	191.091	191.099	-7.71
H101	7.99	215.809	215.838	-28.61
J101	8.89	221.563	221.572	-9.22
K101	10.39	237.545	237.557	-12.13
N101	13.87	245.089	245.132	-42.62
P101	15.39	271.188	271.229	-40.04
Q101	16.68	322.361	322.402	-41.26
R101	18.16	352.889	352.928	-38.82
R23	19.10	378.578	378.794	-216.31
T101	21.98	310.296	310.335	-39.31
R45	97.77	317.354	317.397	-42.97
P110	99.17	336.146	336.190	-43.70

APPENDIX B
Profile Plots

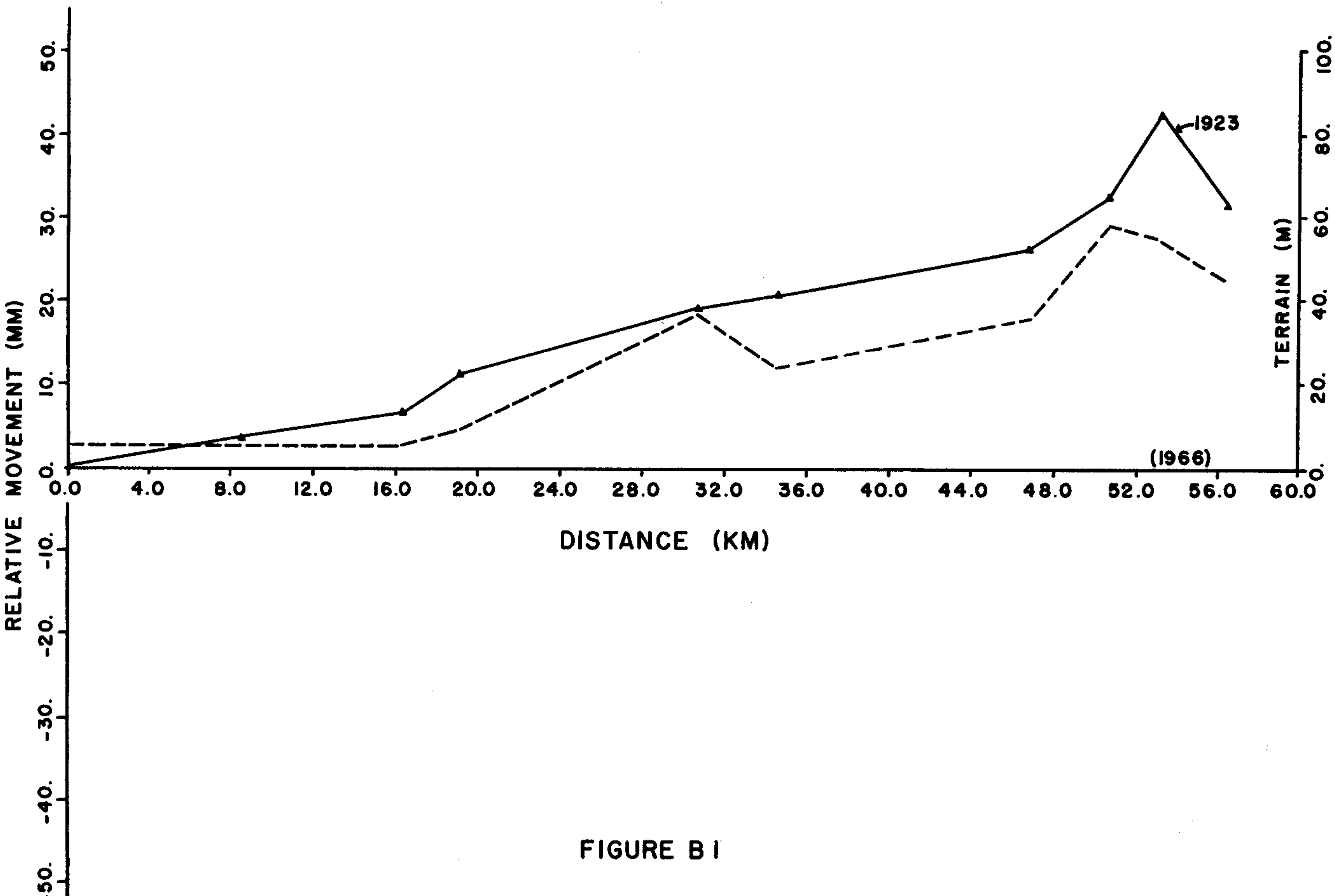

FIGURE B1

PORTLAND (SOUTH) TO MAINE, NEW HAMPSHIRE BORDER

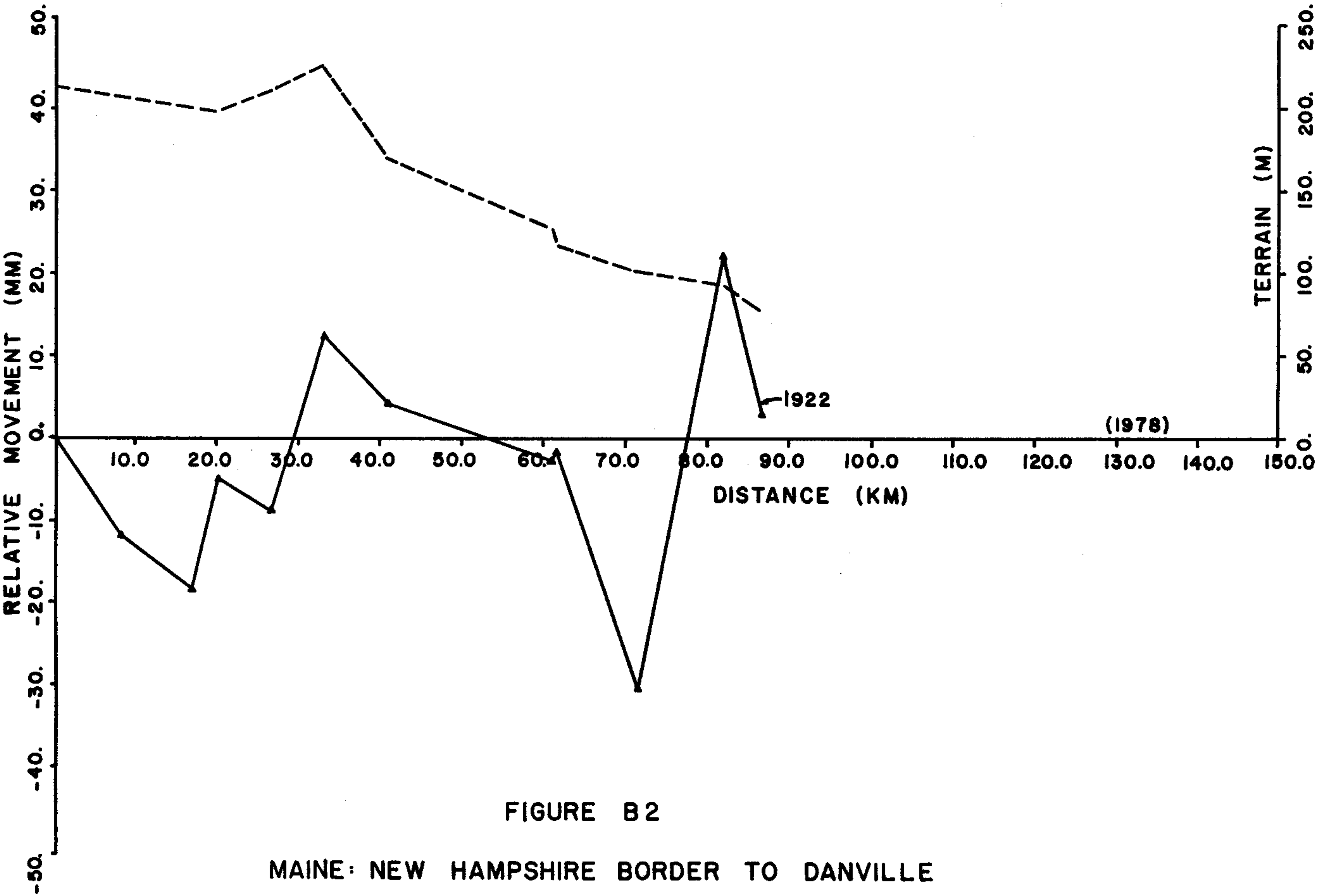

FIGURE B2

MAINE: NEW HAMPSHIRE BORDER TO DANVILLE

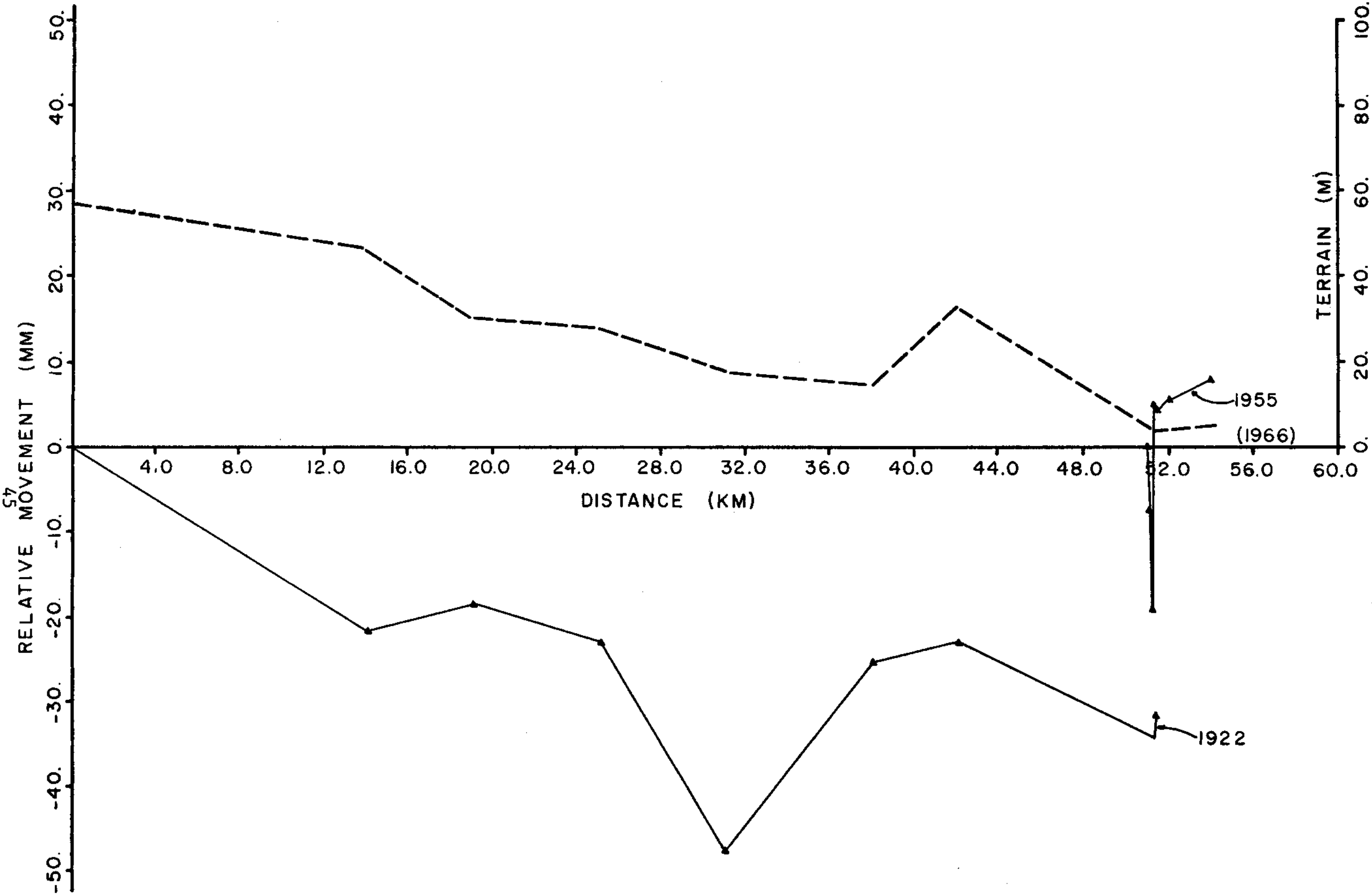

FIGURE B 3

DANVILLE TO PORTLAND

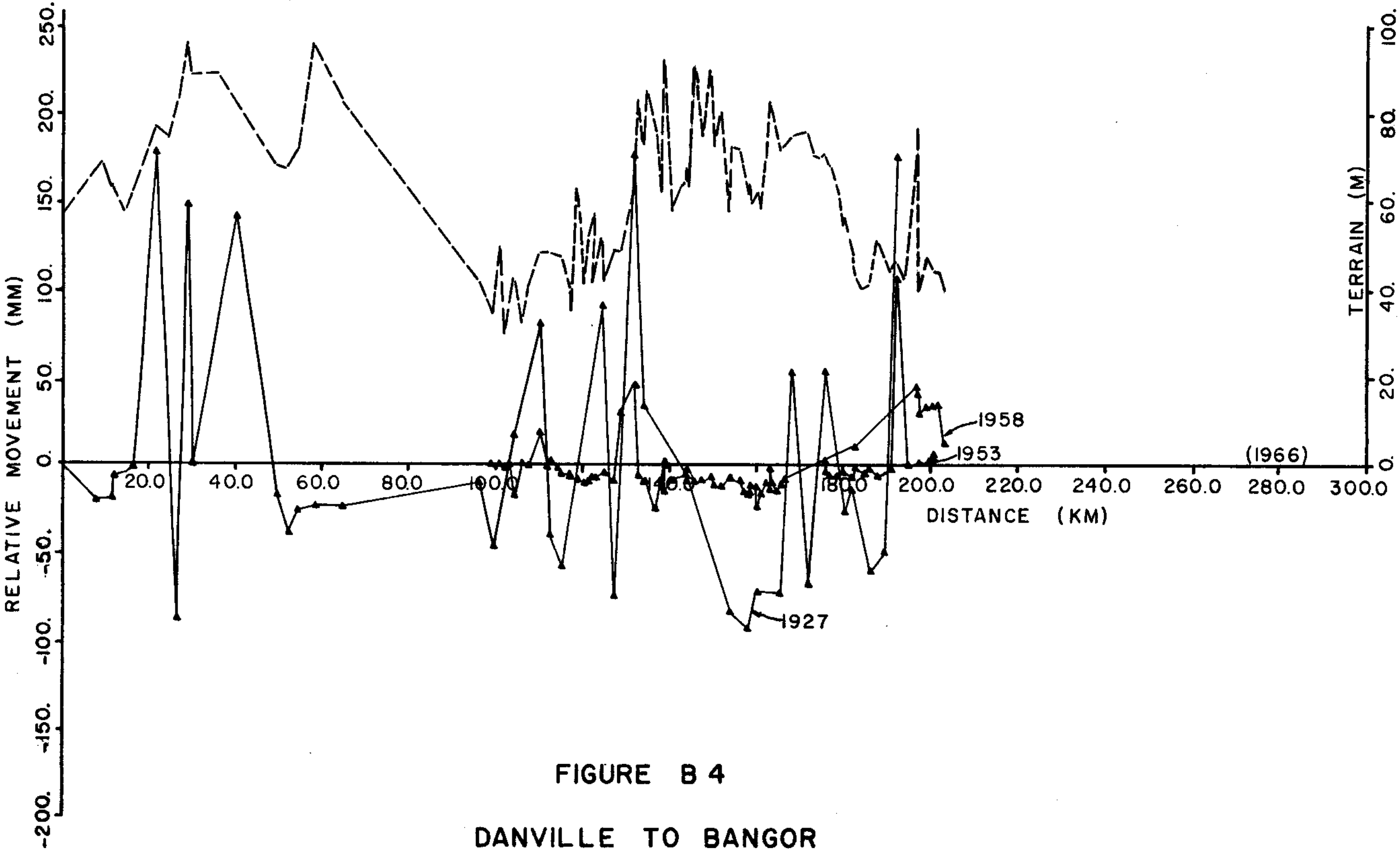

FIGURE B 4

DANVILLE TO BANGOR

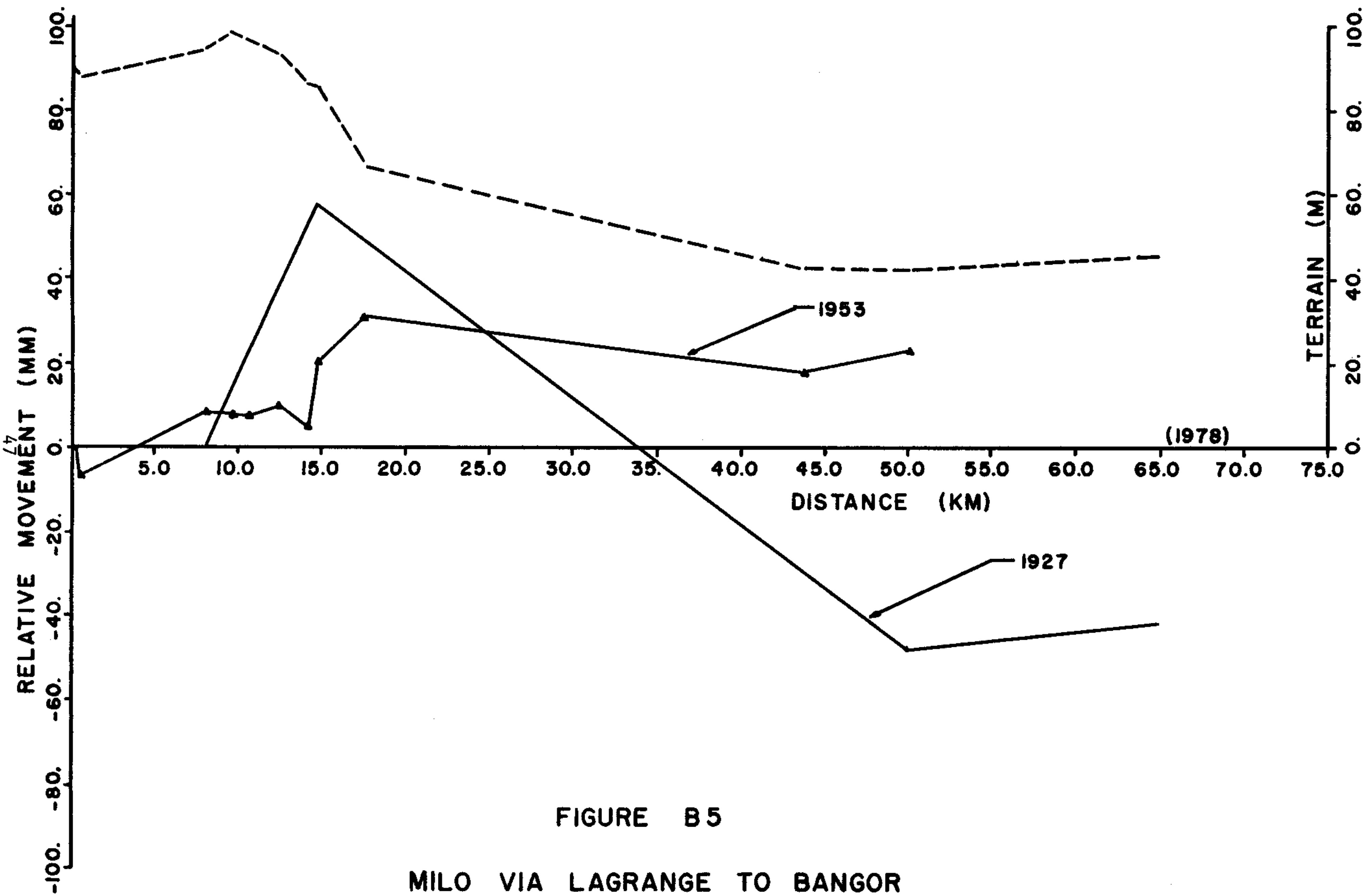

FIGURE B5

MILO VIA LAGRANGE TO BANGOR

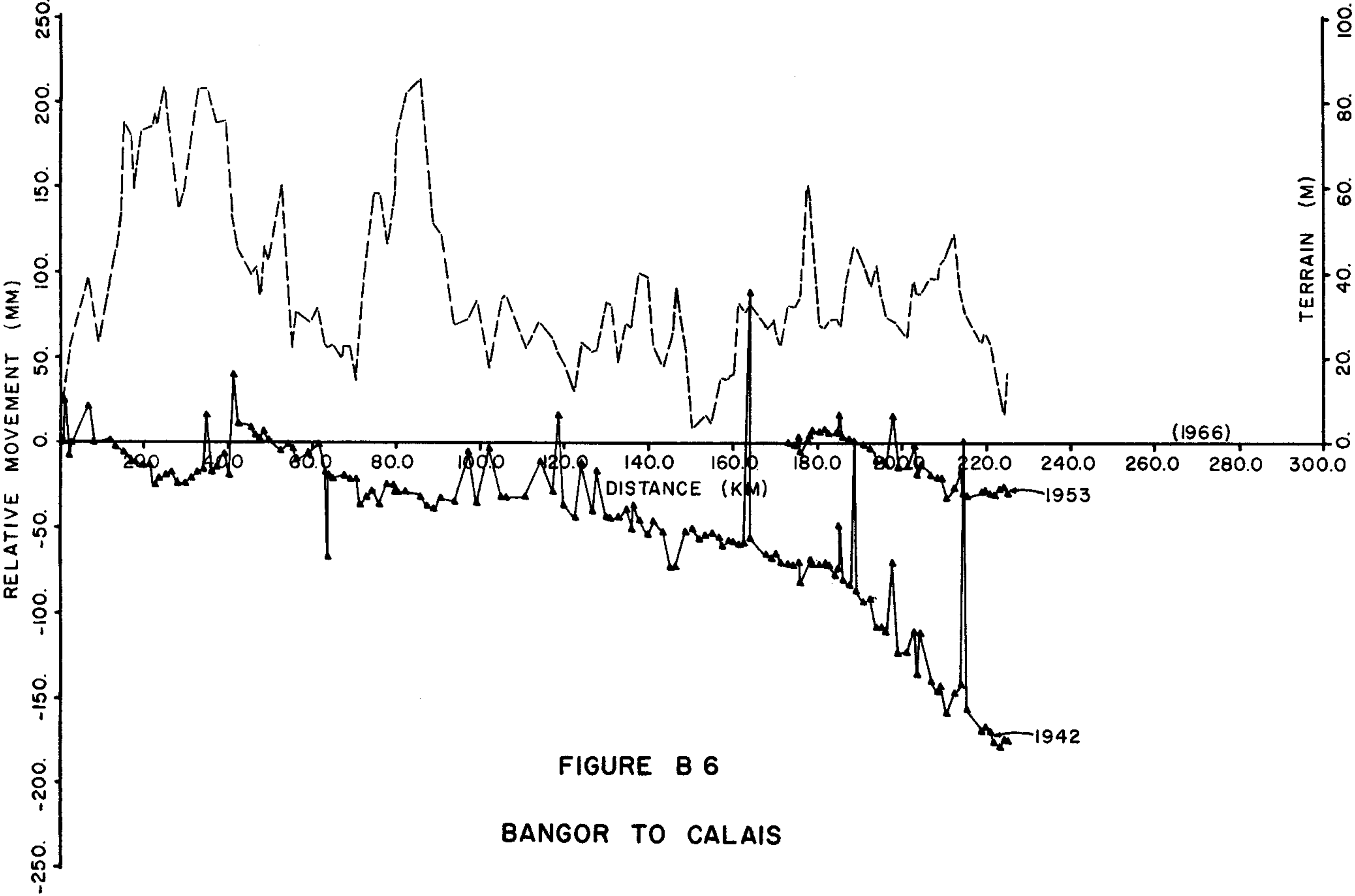

FIGURE B 6

BANGOR TO CALAIS

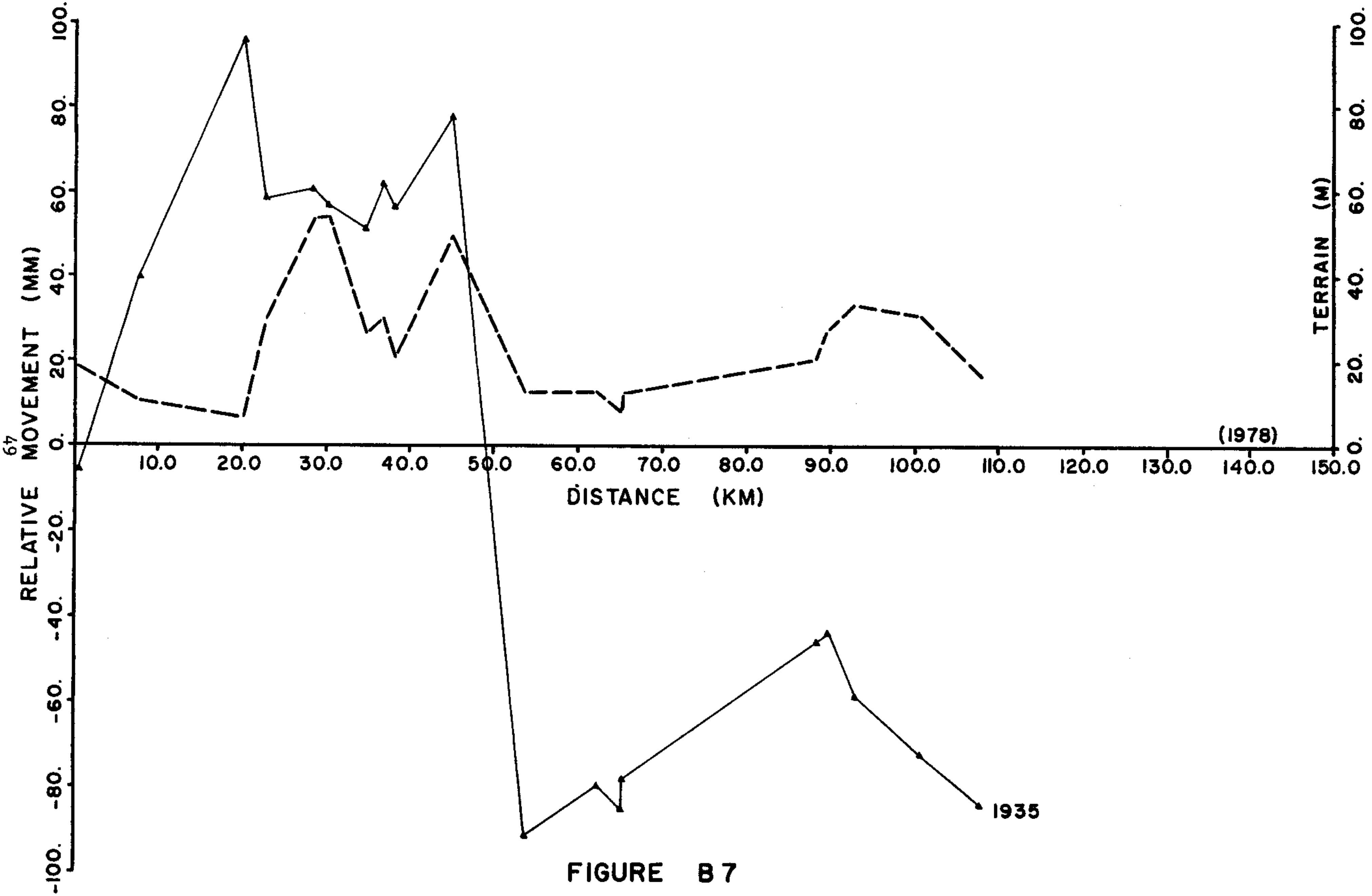

FIGURE B 7

MACHIAS VIA EASTPORT TO CALAIS

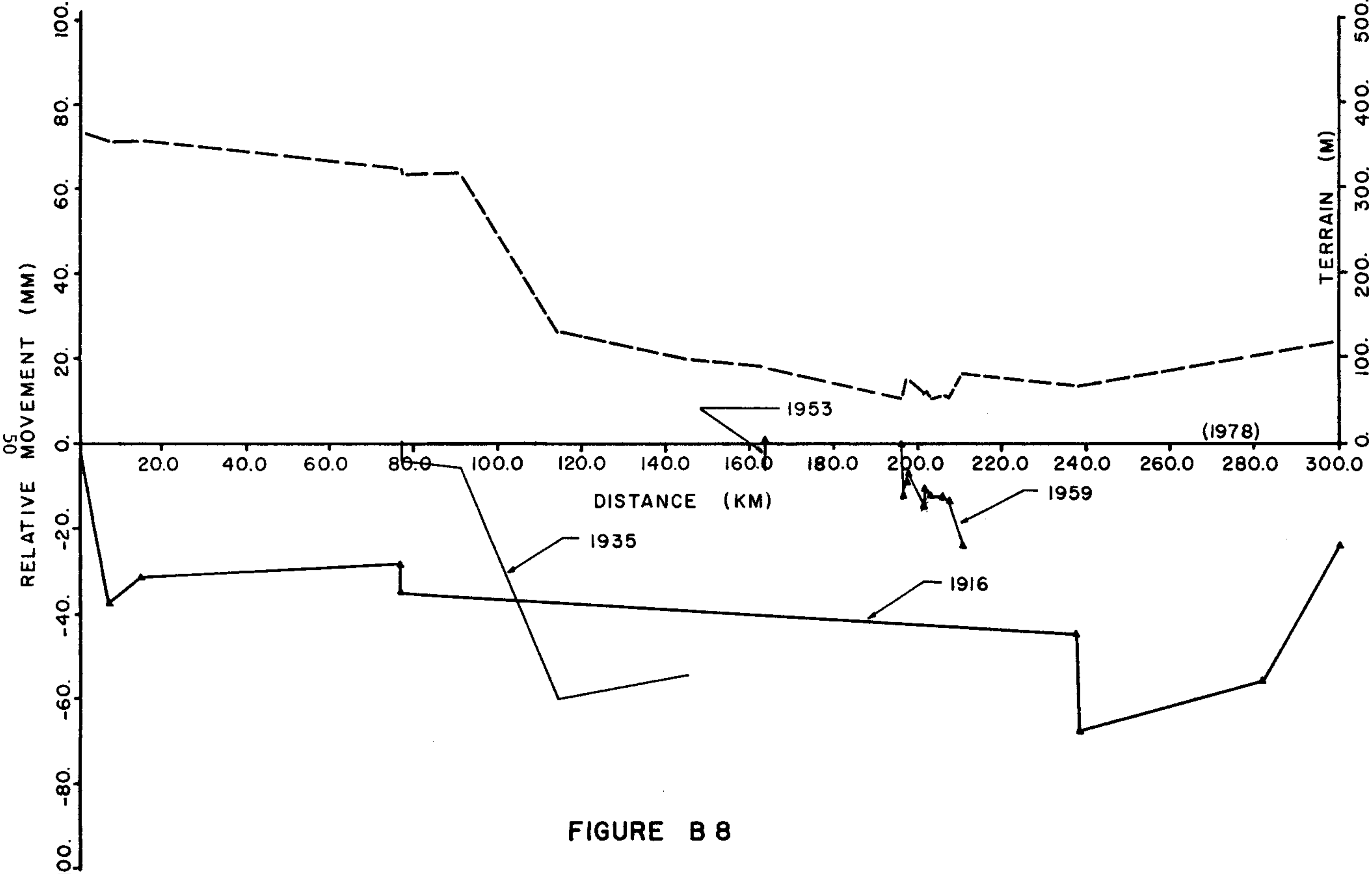

FIGURE B 8

JACKMAN VIA BROWNVILLE JCT TO DANFORTH

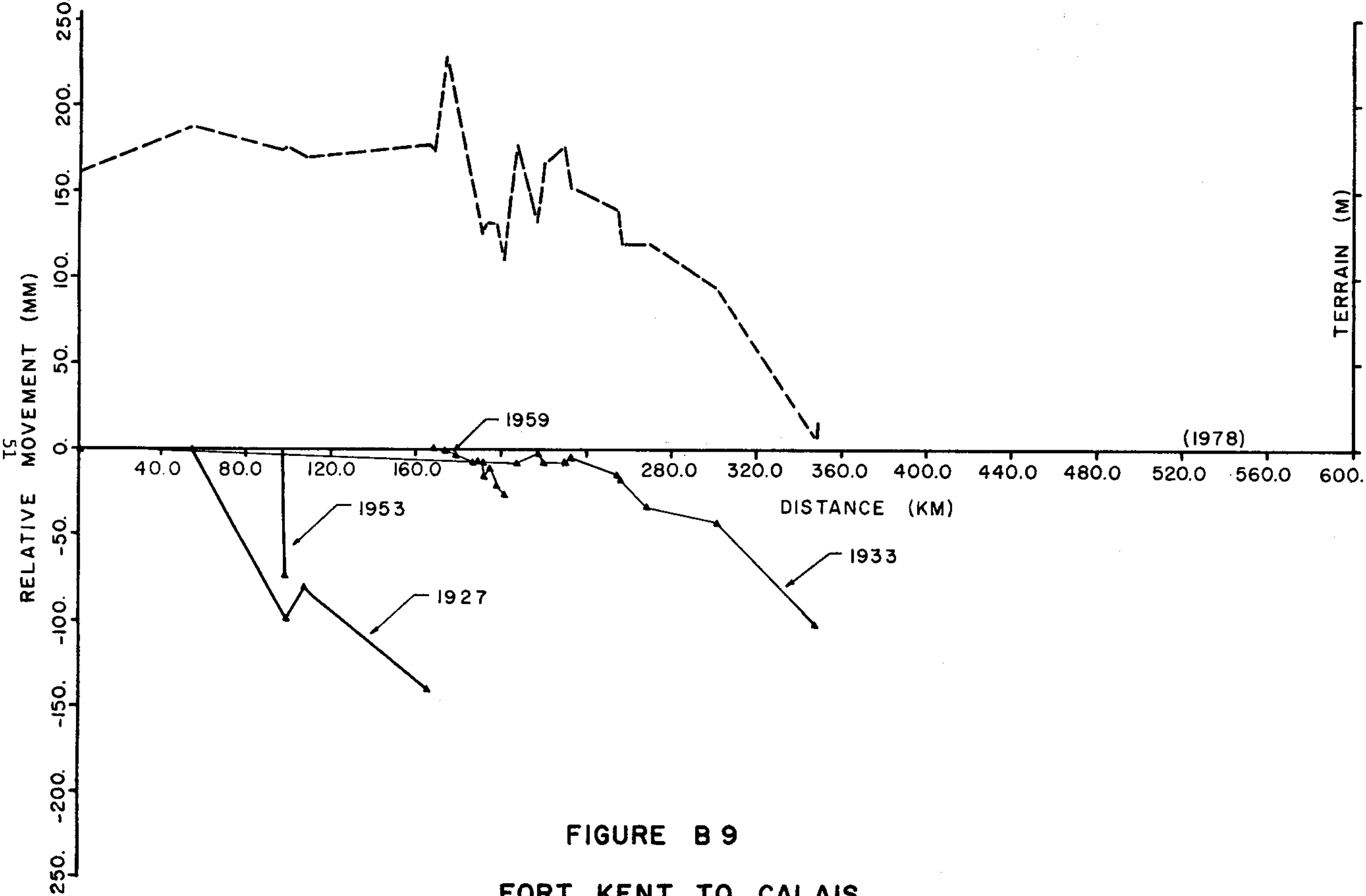

FIGURE B 9

FORT KENT TO CALAIS

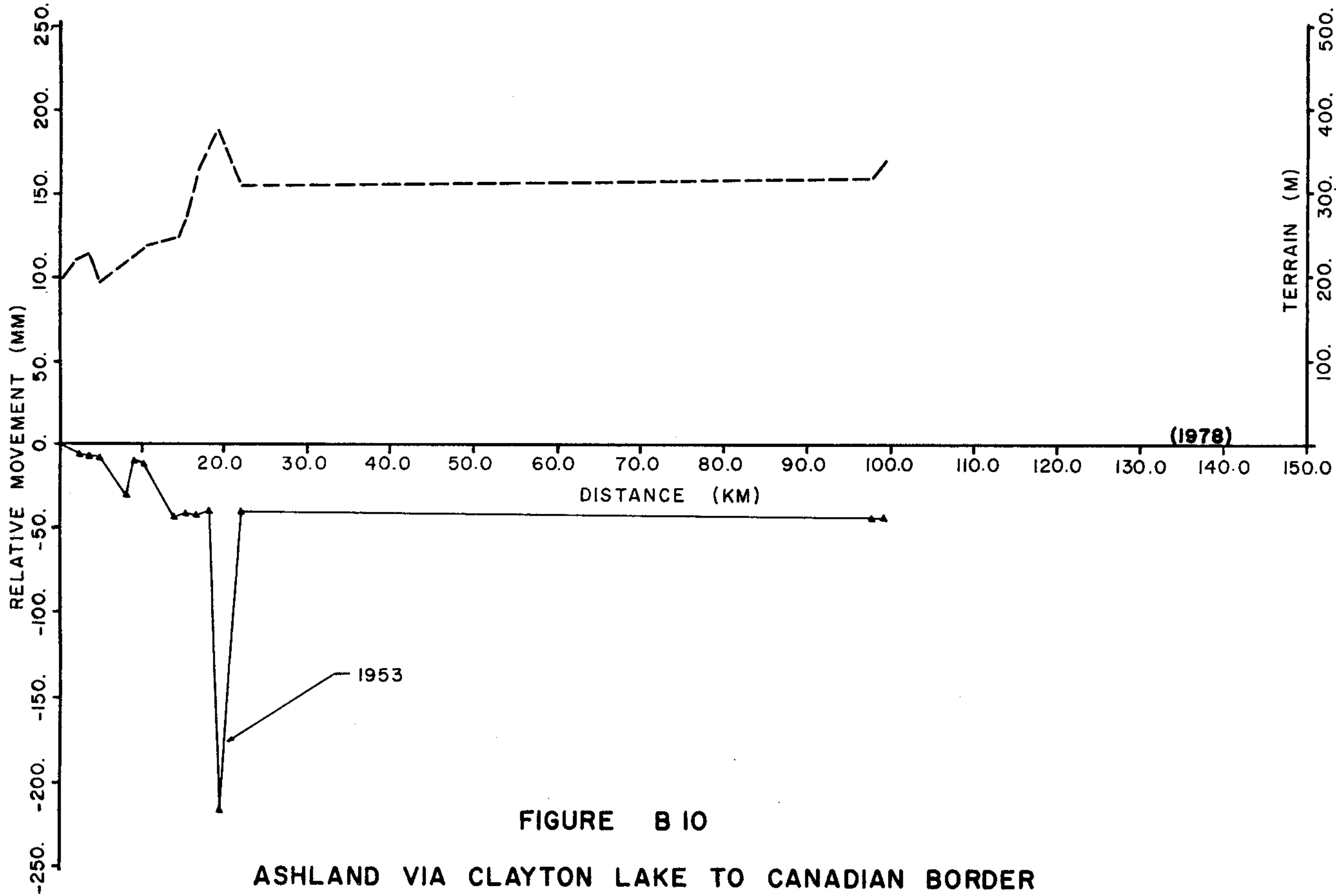

FIGURE B 10

ASHLAND VIA CLAYTON LAKE TO CANADIAN BORDER

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