ANNUAL REPORT
OF
GLACIER MEASUREMENTS

1950

GLACIER NATIONAL PARK, MONT.

BY

M. E. BEATTY, CHIEF PARK NATURALIST
GLACIER NATIONAL PARK

ARTHUR JOHNSON, DISTRICT ENGINEER
U.S. GEOLOGICAL SURVEY
TACOMA, WASH.

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
AND
GEOLOGICAL SURVEY

ANNUAL REPORT OF GLACIER MEASUREMENTS FOR 1950
GLACIER NATIONAL PARK, MONTANA

General

This year's field work and report was accomplished through the combined efforts of a number of government agencies and private organizations who contributed time, personnel, and funds to carry out the project. The whole-hearted cooperation of those individuals participating or contributing to the project is deeply appreciated. Also, the fact that so many different agencies of the federal government have worked on a single project in perfect harmony is a tribute to good government.

Government and private organizations participating directly or indirectly in this year's study of park glaciers include the United States Geological Survey offices in Helena, Montana and Tacoma, Washington; the United States Forest Service Northern Region office in Missoula, Montana; the United States Weather Bureau in Helena, Billings, and Missoula, Montana; the American Geographical Society of New York; the American Geophysical Society of New York; the American Geophysical Union through its sub-committee on glaciers of the American Rocky Mountains; the Glacier Natural History Association; and the National Park Service in Glacier National Park.

Field Work - Meteorological & Hydrological

The first field trip of the year was made on July 20 to service the High Altitude Precipitation Gage near the Grinnell Glacier. Snow drifts along the trail necessitated back packing all supplies, tools and equipment up the trail. Members of the party included Messrs. Dightman and Irgen, U. S. Weather Bureau, Helena, Montana; Mr. C. S. Heidel, U.S. G.S., Helena, Montana; and Park Naturalists Beatty and Robinson. Measurements were made both by dip stick and volume weight to ascertain the amount of winter precipitation and the gage was recharged with calcium chloride and water, with a coating of oil, for the ensuing year. Total precipitation recorded by the gage for the period from September 7, 1949 to July 20, 1950 was 125.1 inches. Precipitation records at park headquarters for the same period totaled 28.6 inches.

Mr. Heidel, with his assistants, made periodic readings throughout the summer and fall of the flow record gage installed by the U.S. Geological Survey at the outlet of Grinnell Lake. The statistics thus obtained will be correlated with the precipitation records to determine relationships wherever possible.

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Field Work - Aerial Photography & Mapping

As a result of a $400 grant from the American Geographical Society of New York and a $500 donation from the Glacier Natural History Association, supplemented by naturalist funds for glacier measuring, it was possible to initiate a program of aerial photography and mapping of park glaciers. Arrangements were made with the U.S. Forest Service in Missoula to use their equipment and personnel to carry on the project.

Due to the heavy snow year the aerial flight to photograph park glaciers was delayed as long as possible in the hope that the glacier surfaces would be free of snow. Special forecasts on flight conditions and weather along the Continental Divide were obtained daily during the latter part of August from the U.S. Weather Bureau stations at Billings and Missoula. The day selected for the flight, September 1, proved perfect for flying and photography, although it proved a poor year for photographing the park glaciers due to the excessive amount of the previous winter's snow still remaining on the ground in shaded areas and on the surface of the glaciers.

The plane was a two motor AT-11 belonging to the Johnson Flying Service of Missoula, under contract to the U.S. Forest Service. The Forest Service aerial photographer took 103 vertical pictures of approximately 30 park glaciers. A list of the glaciers photographed, together with the best stereoscopic pairs and individual prints, is appended to this report. All pictures are of top quality and relatively free from shadows, due to a slight overcast of light cirrus clouds at 20,000 ft. The flight was made at 16,000 ft. with Park Naturalist Beatty as navigator. Total flying time from Missoula for the plane was four hours, half of which was spent over the park.

Prints of the aerial photographs were rushed through for use in establishing base lines and ground controls prior to fall storms. Before making the aerial flight large limed circles were placed around certain stations on already established base lines by naturalist personnel and these were readily identified in the aerial pictures.

Field work was started on September 12 at Grinnell Glacier and completed on September 23 following visits to both Sperry and Jackson Glaciers. Participating in the field work were Arthur Johnson and Jesse Colbert, U.S.G.S., Tacoma, Washington, Donald Sawhill, U.S.F.S., Missoula, Park Naturalists Beatty and Robinson, plus other park personnel on a part-time basis.

Mr. Sawhill, assisted by one member of the party, established ground controls for each of the three glaciers mentioned above for use in making aerial maps while Mr. Johnson, assisted by other members of the party, made plane table maps of the ice front and profiles across the glaciers. Photographs of the glaciers and details of the work were taken by Mr. Beatty and Jim Davis in both black and white and color.

Due to the large size of the party and the extra food and equipment, a pack train of eleven animals was required during most of the trip. The party camped out at the end of the horse trail to Sperry Glacier and also at Gunsight Lake. Fortunately, the weather held good during the entire time, otherwise camping would have been rather rugged. Expenses of the entire project ran much higher than anticipated so only Jackson Glacier was mapped in entirety by aerial methods. It is hoped that either Sperry or Grinnell can be mapped next year and other glaciers photographed. Under this method, complete mapping of each glacier during a three year interval is possible, and field work can be cut to a minimum. Now that ground controls have been established for all three glaciers, the cost of the aerial mapping program will be considerably reduced for future years. A summary of expenditures for glacier research during the 1950 year is appended to this report.

Weather.

Snowfall during the past winter, 1949-1950, totaled 198.3 inches at West Glacier (Park Headquarters), elevation 3154 ft. The previous year's snowfall of 166.6 inches was the heaviest in twenty years and now this record is again broken by the current figure which is 71% above normal. As a result of five successive years of above normal snowfall, a definite lessening in the rate of frontal recession is now becoming apparent. Similarly, volume loss is considerably less based on a study of profiles for Grinnell and Sperry. Sperry showed practically no change in surface elevation between the 1949 and 1950 measurements.

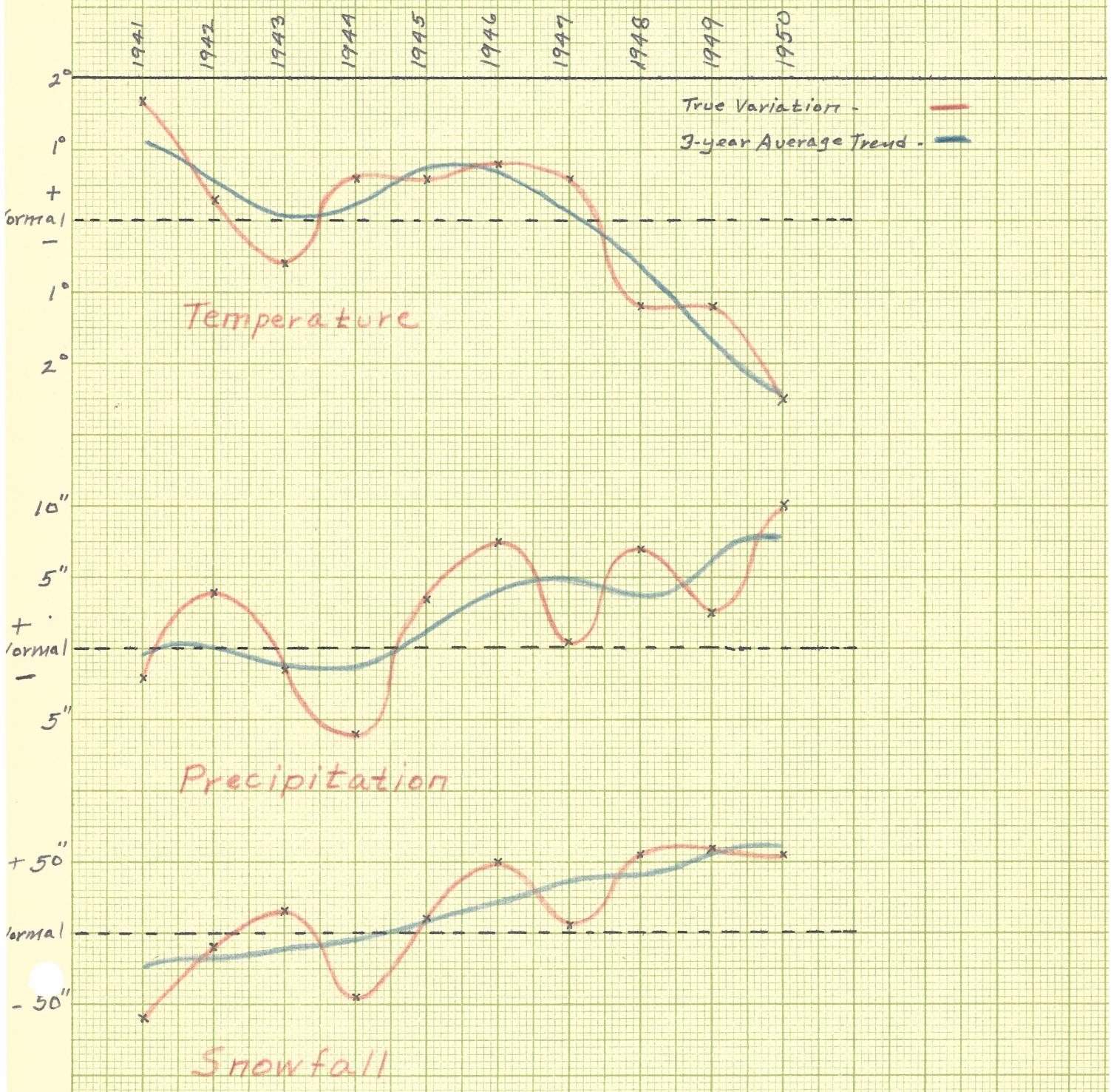
Past attempts to correlate weather records at park headquarters with recession rates of the glaciers have been unsuccessful. This year we have tried a new approach to the problem by including records from Babb, elevation 4461 feet, on the east side of the park and Summit, elevation 5213 feet, on the Continental Divide adjacent to the southern boundary of the park. By plotting departure from normal for temperature, precipitation, and snowfall of these three stations for the past ten years, a fairly representative picture of weather averages for the park results. This average is shown on the attached chart (Chart A) together with a trend line determined by taking running three year averages of the true variation.

Below normal temperatures since 1947 combined with above normal precipitation and snowfall since 1945, as portrayed graphically in the chart, seems to explain the reason for the abrupt change in the rate of recession of the ice fronts. Average yearly recession of the Grinnell Glacier front from 1937 to 1945 was 33.8 feet as compared to 14.9 feet for the period from 1945 through 1950.

The trend line further indicates that below normal temperatures and above normal precipitation and snowfall will continue for several more years before a return to normal, in which case our major glaciers may show both increase in volume and frontal advance. Certainly there is definite indication of a major cyclic change starting in 1945.

-Variations from Normal-

Average of 3 Stations – West Glacier, Summit, & Babb, Montana



WEATHER STATISTICS
GLACIER NATIONAL PARK
West Glacier (Park Hdqts) Station
(Elev. 3154 ft.)

Year	Mean Annual Temperature (degrees)	Calendar Year Precipitation (inches)	Cal. Year Snowfall (inches)	Fiscal Year Snowfall (inches)	Years Included
1931	43.0	22.72	75.7	----	(1930-31)
1932	41.2	34.33	148.4	----	(1931-32)
1933	42.5	36.97	157.4	173.0	(1932-33)
1934	45.6	22.71	82.8	94.6	(1933-34)
1935	40.9	17.43	108.5	117.4	(1934-35)
1936	41.7	23.04	147.2	146.1	(1935-36)
1937	40.7	27.97	137.2	144.8	(1936-37)
1938	42.9	26.48	104.2	67.2	(1937-38)
1939	44.0	22.13	79.9	136.6	(1938-39)
1940	44.8	27.25	90.9	56.1	(1939-40)
1941	44.4	22.22	65.0	85.8	(1940-41)
1942	42.8	27.44	104.7	53.0	(1941-42)
1943	41.26	21.84	95.7	152.4	(1942-43)
1944	43.13	18.59	57.5	46.2	(1943-44)
1945	43.07	30.28	98.7	68.7	(1944-45)
1946	42.55	37.19	149.4	137.1	(1945-46)
1947	42.96	31.58	119.8	143.5	(1946-47)
1948	40.9	31.07	175.2	139.2	(1947-48)
1949	40.4	26.65	162.1	166.6	(1948-49)
1950	40.1	33.84	174.6	198.3	(1949-50)
1951					(1940-51)
1952					(1951-52)
1953					(1952-53)
1954					(1953-54)
1955					(1954-55)
(1945 NORMALS)	42.3	25.72	112.0 (approx.)		
20 Yr. AVERAGE (1931-50)	42.44	27.09	116.8		
5 Yr. AVERAGE (1946-50)	41.4	32.07	156.2	156.9	
Departure from Normal (1946-50)	- 0.9	+ 6.35	+ 44.2	+ 44.9	

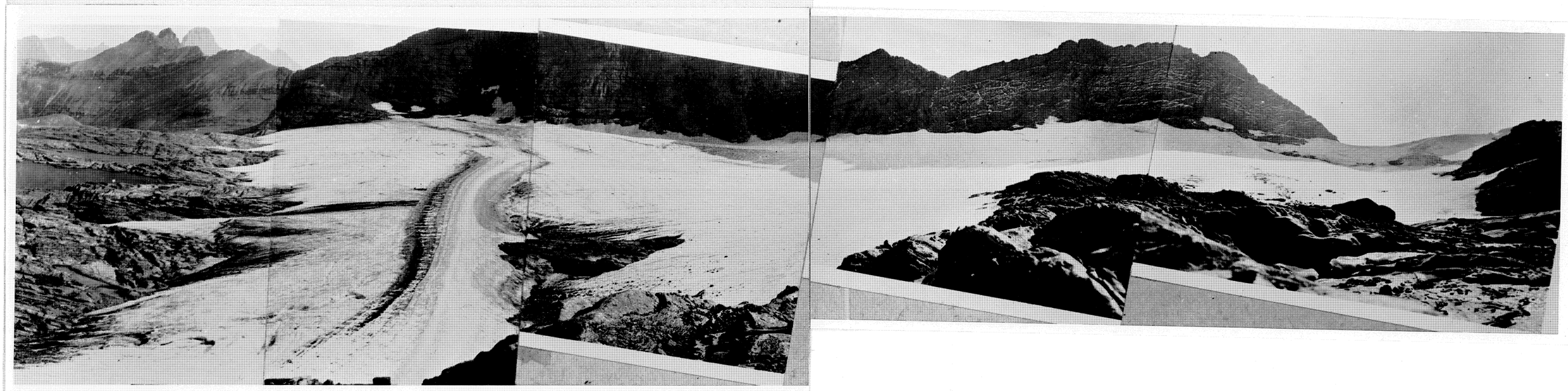


Photo # 1 SPERRY GLACIER Beatty photos

Panoramic view of the glacier and ice front taken September 19 from photo point established in 1945. (See photo #2, 1945, 1946, and 1948; photo #3, 1947; and photo #1, 1949 reports for comparisons).

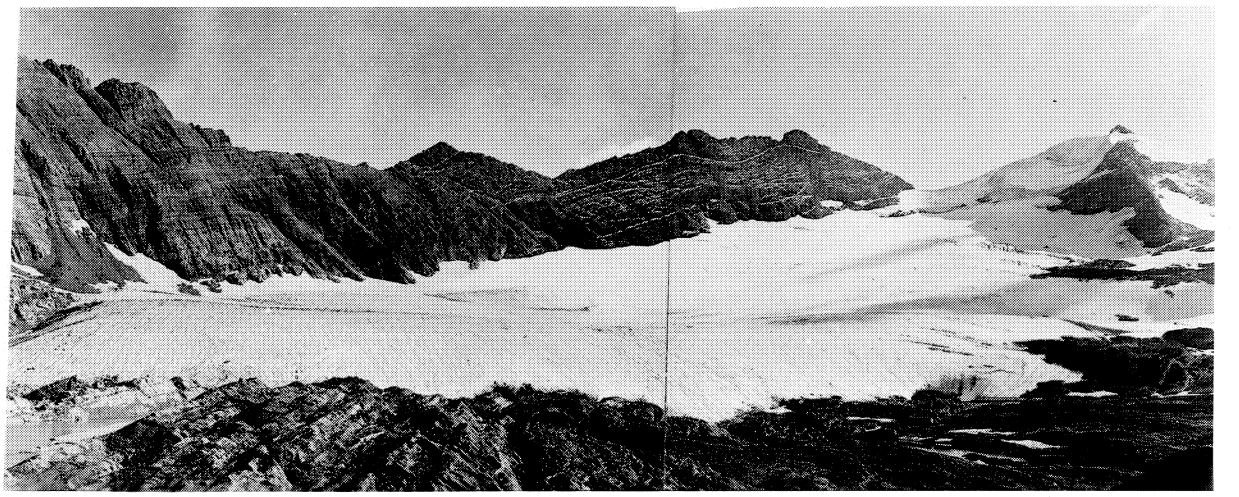


Photo #2 SPERRY GLACIER Beatty photos

Panoramic view of glacier from point on moraine northwest from ice front. Distance to front is approximately $\frac{1}{4}$ mile. Comparison with photo #2, 1949 report shows little change in the year.

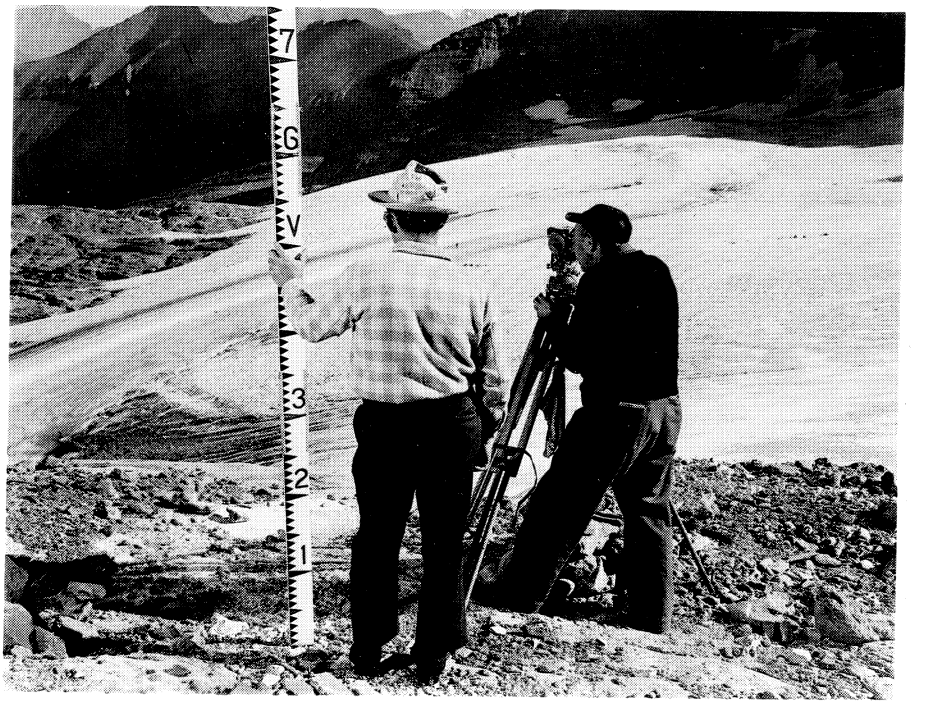


Photo #3 SPERRY GLACIER Davis photo

Establishing control points for aerial photos and map. Don Sawhill, U. S. Forest Service at theodolite and Jesse Colbert, U. S. Geological Survey, with rod.

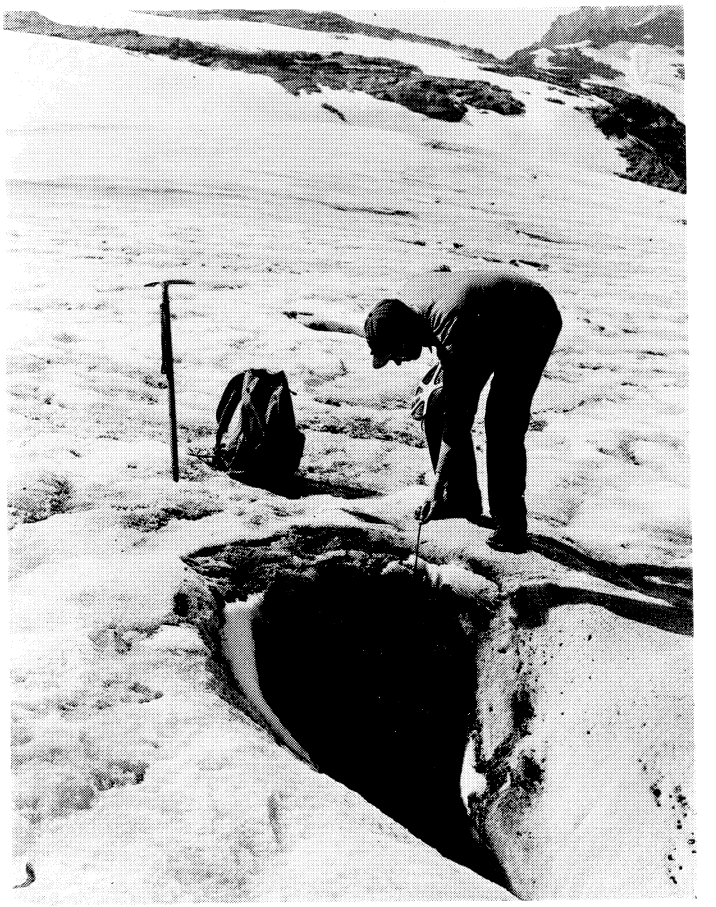


Photo #4 SPERRY GLACIER Davis photo

Chief Park Naturalist Beatty using a weighted steel tape to determine the depth of a moulin. Depths of several similar moulins in vicinity varied between 35 and 40 feet.

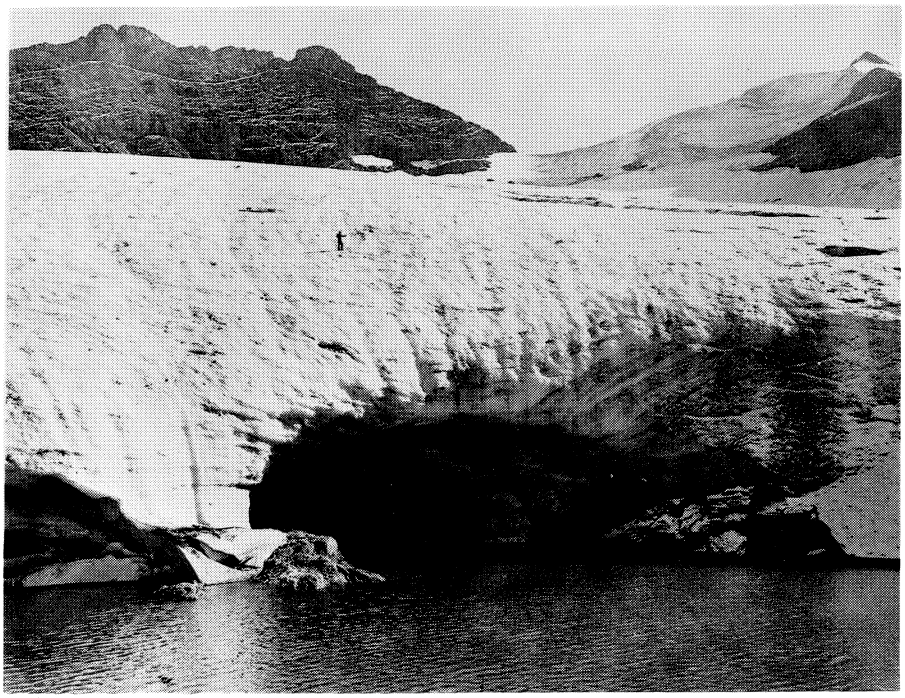


Photo #5 SPERRY GLACIER Davis photo

Ice cave at front of glacier between stations B & C. Park Naturalist Robinson enroute to give a rod shot on the front to right of cave.

Photo #6 SPERRY GLACIER Davis photo

Evening campfire at camp site near hitchrack at end of Sperry horse trail. Left to right: Mrs. Beatty, Ed Beatty, Jesse Colbert, Art Johnson, Don Robinson, Don Sawhill - Jim Davis (with back to camera).

SPERRY GLACIER

The terminus was mapped in 1950, the cross profile and longitudinal profile first measured in 1949 were remeasured and the position of 7 rocks on the glacier surface first located in 1949 were relocated and their movement determined. A short longitudinal profile near left edge which was first measured in 1947 was remeasured.

The position of the 1950 terminus, along with the positions for 1938, 1945, 1947 and 1949 is shown on Figure 1. The change since 1949 varied considerably, in one place somewhat over 100 feet whereas in other places it was essentially the same as, or slightly in advance of, the 1949 position. In some places there was some residual snow, making the position of the actual ice front somewhat uncertain. Continuing the method used in the 1949 report, a comparison was made for certain sections of the front as well as the entire front to show the recession since some previous year. The tabulation from the 1949 report with data added for 1950 follows.

Recession of Terminus

Period	2,000 foot section of front a/ Recession for period	Annual rate	2,640 foot section of front b/ Recession for period	Annual rate	3,400 foot section of front c/ Recession for period	Annual rate
1938-1945	358	51.1	351	50.1	-	-
1945-1947	79	39.5	81	40.5	-	-
1947-1948	35	35.0	34	34.0	-	-
1948-1949	43	43.0	-	-	-	-
1949-1950	25	25.0				
1938-1948	472	47.2	466	46.6	446	44.6
1948-1950			62	31.0	67	33.5
1938-1949	515	46.8	-	-	-	-

a/ Between B and E
b/ Between A and E
c/ From about 300 feet southwest of A to about 200 feet northeast of G

The 1950 cross profile measurements showed practically no change in the surface elevation of the glacier since 1949. The longitudinal profile near center of glacier showed a small change in certain sections since 1949. The short, longitudinal profile through Point A near left edge of glacier showed an interesting change since it was first measured in 1947. The ridge and valley have moved upstream about 75 feet along with a lowering of about 15 feet of the ice surface. On Figure 2 is shown the cross profile and longitudinal profile near center of glacier for 1950 and also the longitudinal profile through Point A for 1947 and 1950. The approximate surface profile in 1938, based on the map by J. L. Dyson, has been indicated in all three instances. As mentioned in the 1949 report, the 1938 profiles should not be taken too literally as it has not been possible to obtain an exact correlation between the 1938 map and subsequent work. The mean elevations for sections of the cross profile as well as the entire cross profile was computed and a similar procedure followed for the longitudinal profile near center of glacier. The results of these computations are shown in the following tabulation.

CROSS PROFILE
Mean elevations for sections as indicated

Date	Sta. 100-1100	Sta. 1100-2100	Sta. 2100-3100	Sta. 100-3100
Aug. 30, 1949	7598.9	7535.1	7593.6	7575.9
	-1.0	-0.6	+0.7	-0.4
Sept.19, 1950	7597.9	7534.5	7594.3	7575.5

LONGITUDINAL PROFILE
Mean elevation for sections as indicated

	Upstream from Cross Profile		Downstream from Cross Profile			
Date	Sta. 0-500	Sta. 500-800	Sta. 0-500	Sta. 500-1000	Sta. 1000-1500	Sta. 1500-1800
Aug. 30,1949	7569.9	-	7492.4	7449.2	-	-
	+0.8		-1.2	-1.6		
Sept.19,1950	7570.7	7663.0	7491.2	7447.6	7398.2	7320.0

As noted from the foregoing table, the differences between 1949 and 1950 are too small to show graphically.

The observed data for the various profiles is shown at the end of this section.

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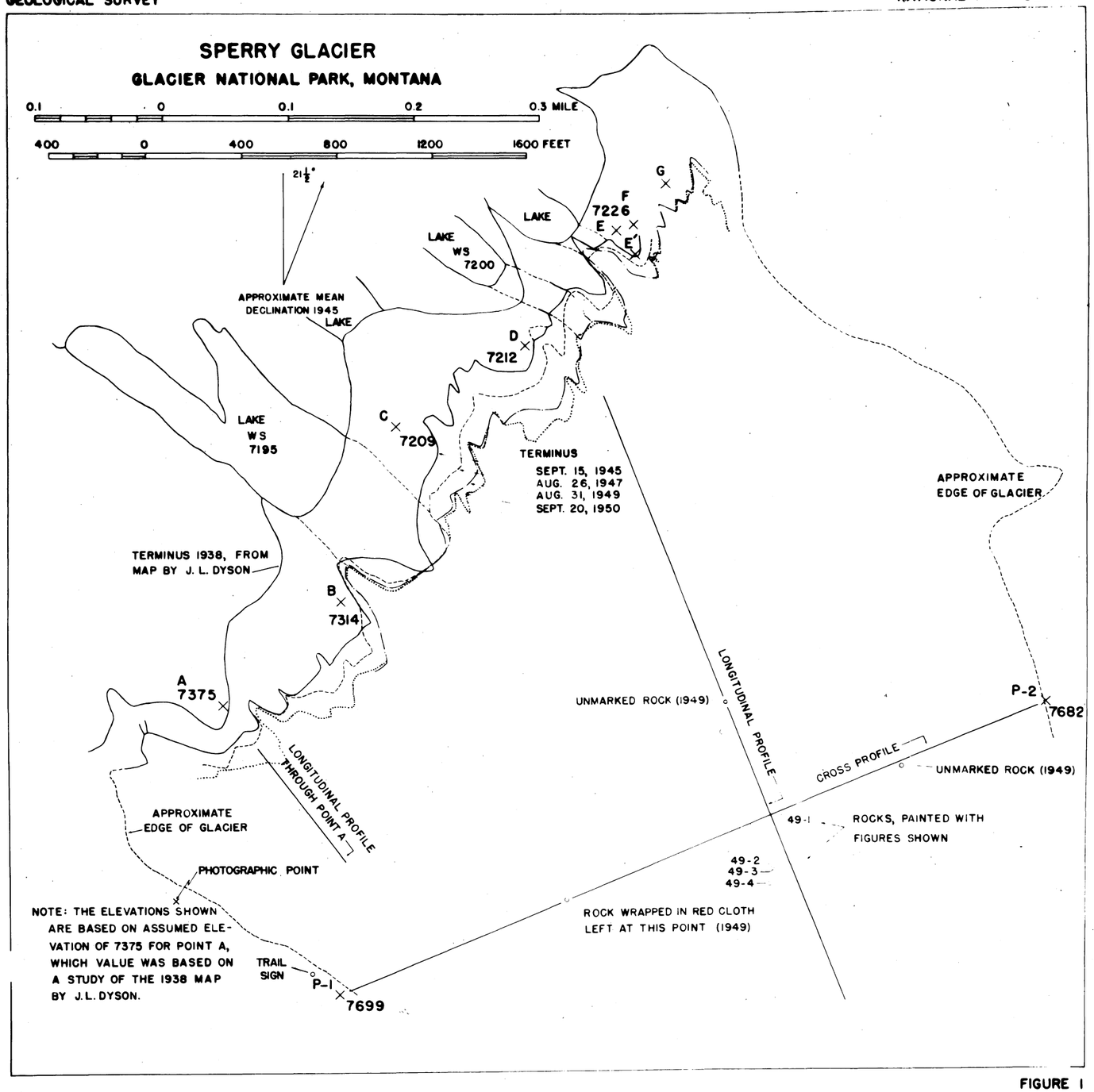
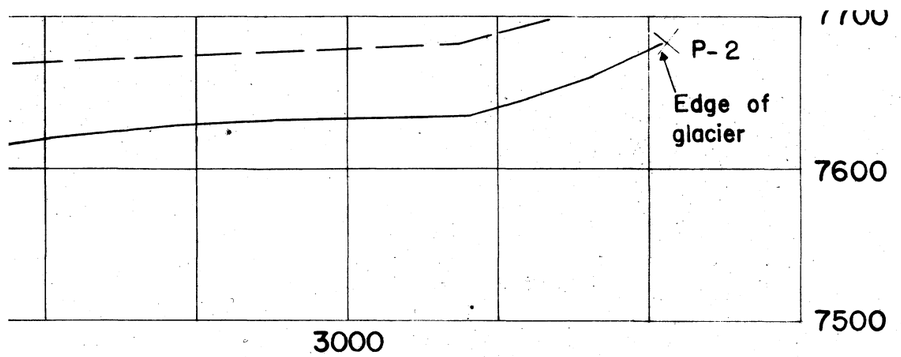
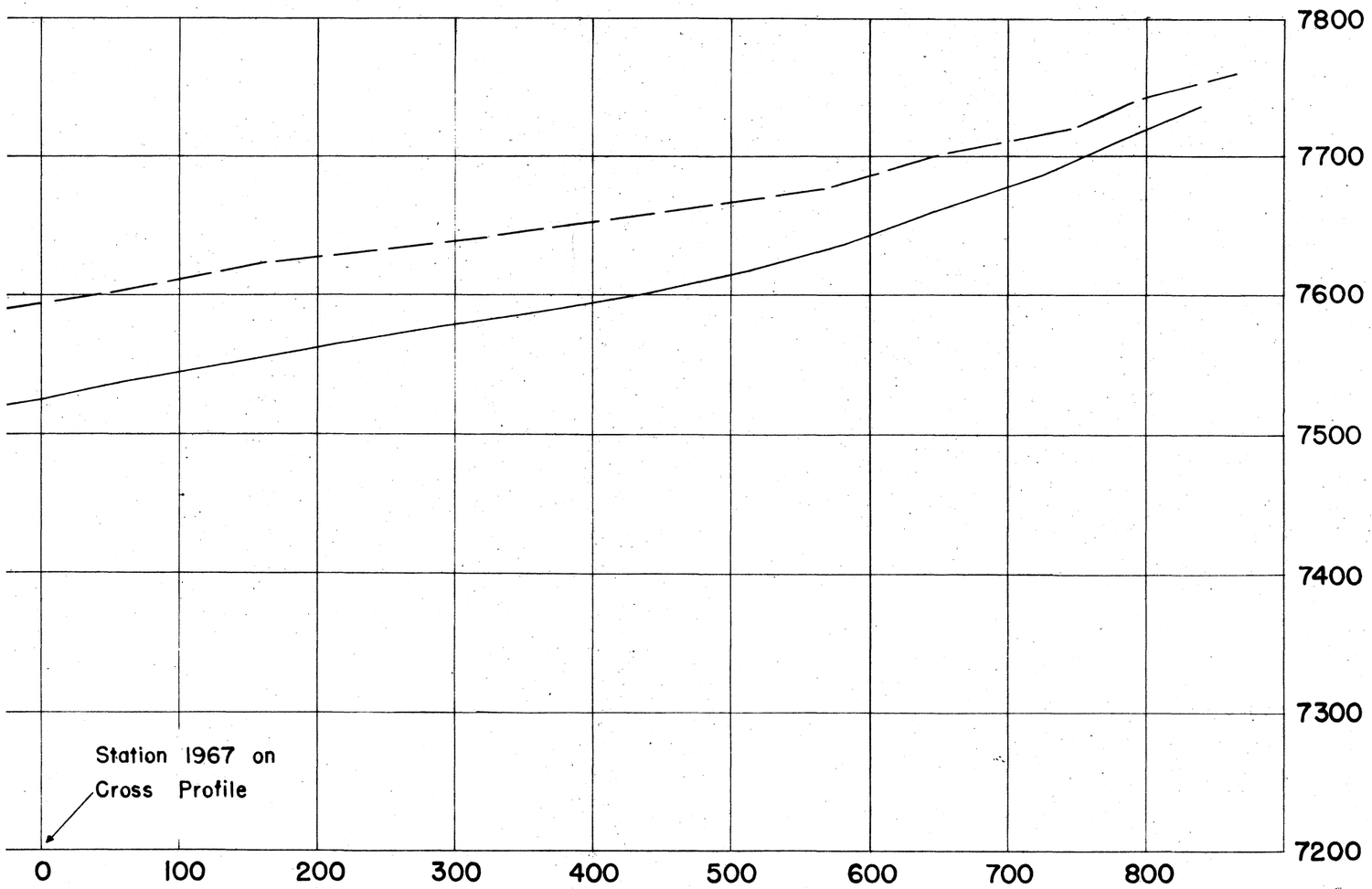


FIGURE 1

FIGURE 2





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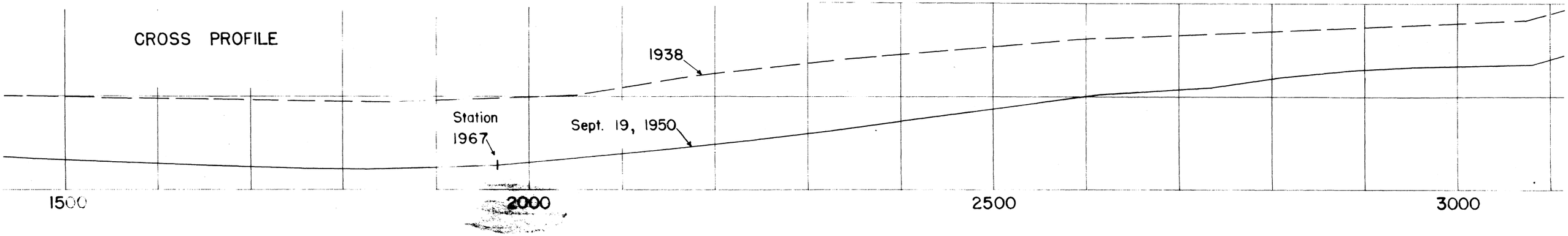
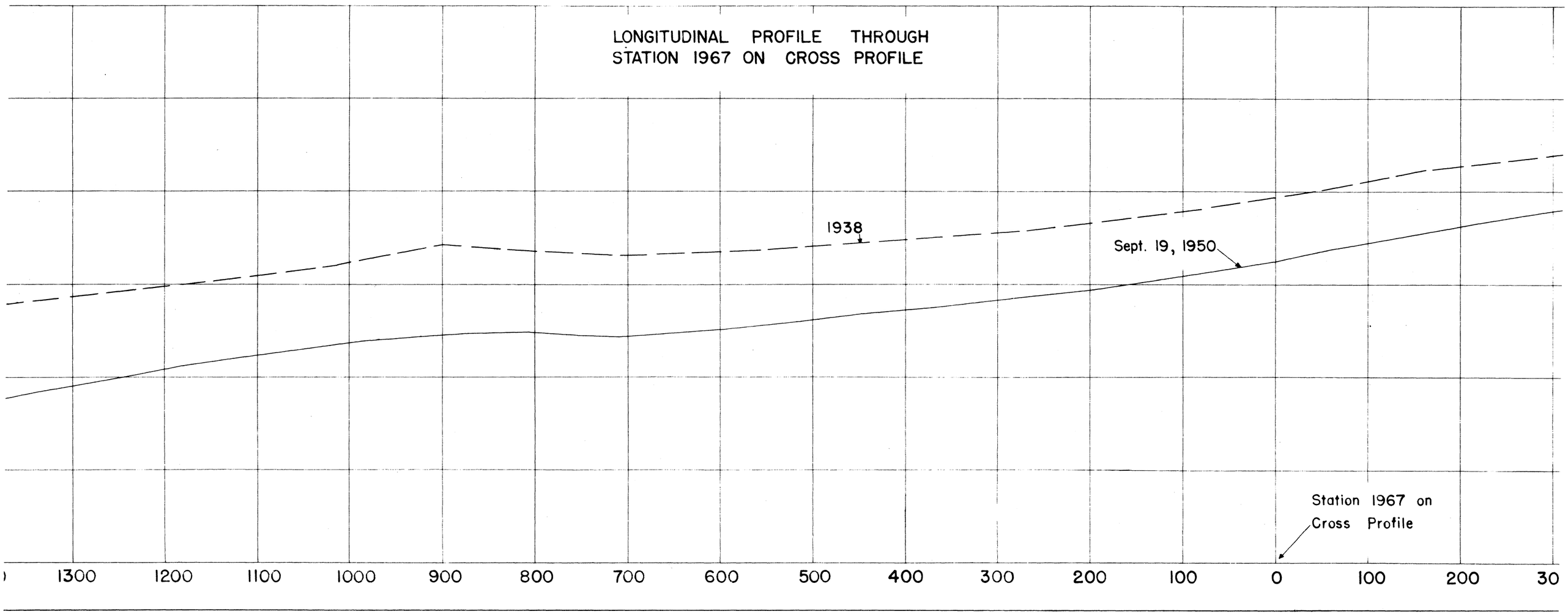
SPERRY GLACIER
GLACIER NATIONAL PARK, MONTANA
PROFILES

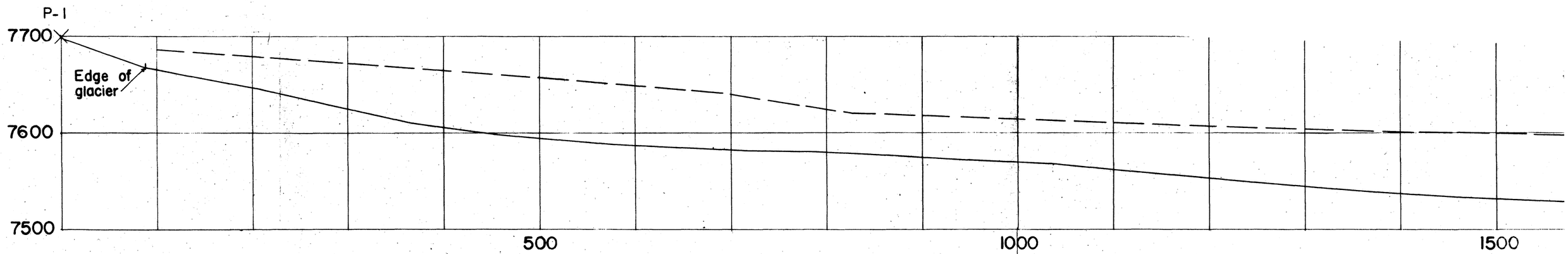
For location of profiles see Fig. 1

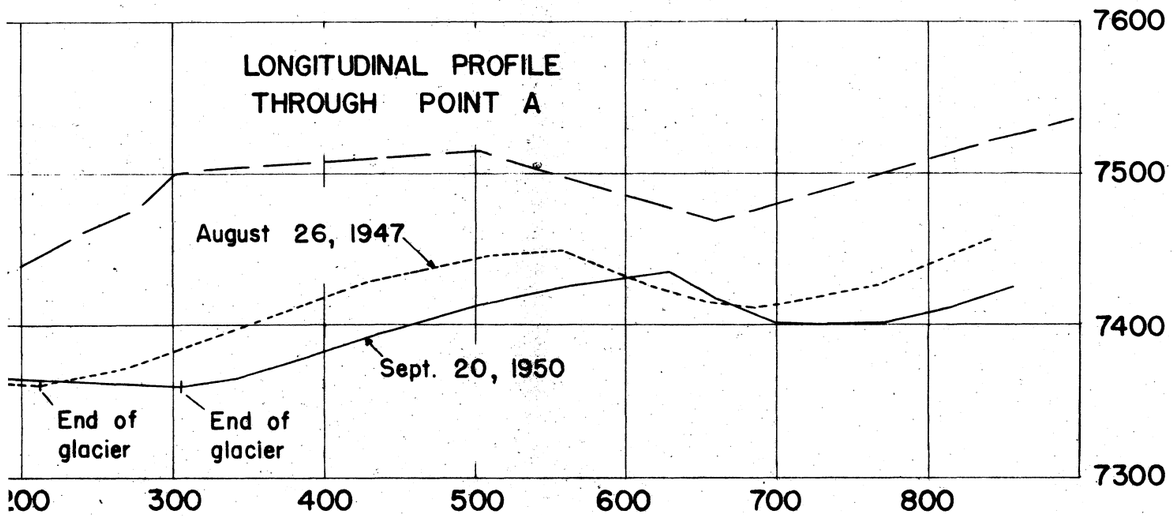
Elevations based on an assumed value of 7375 for Point A

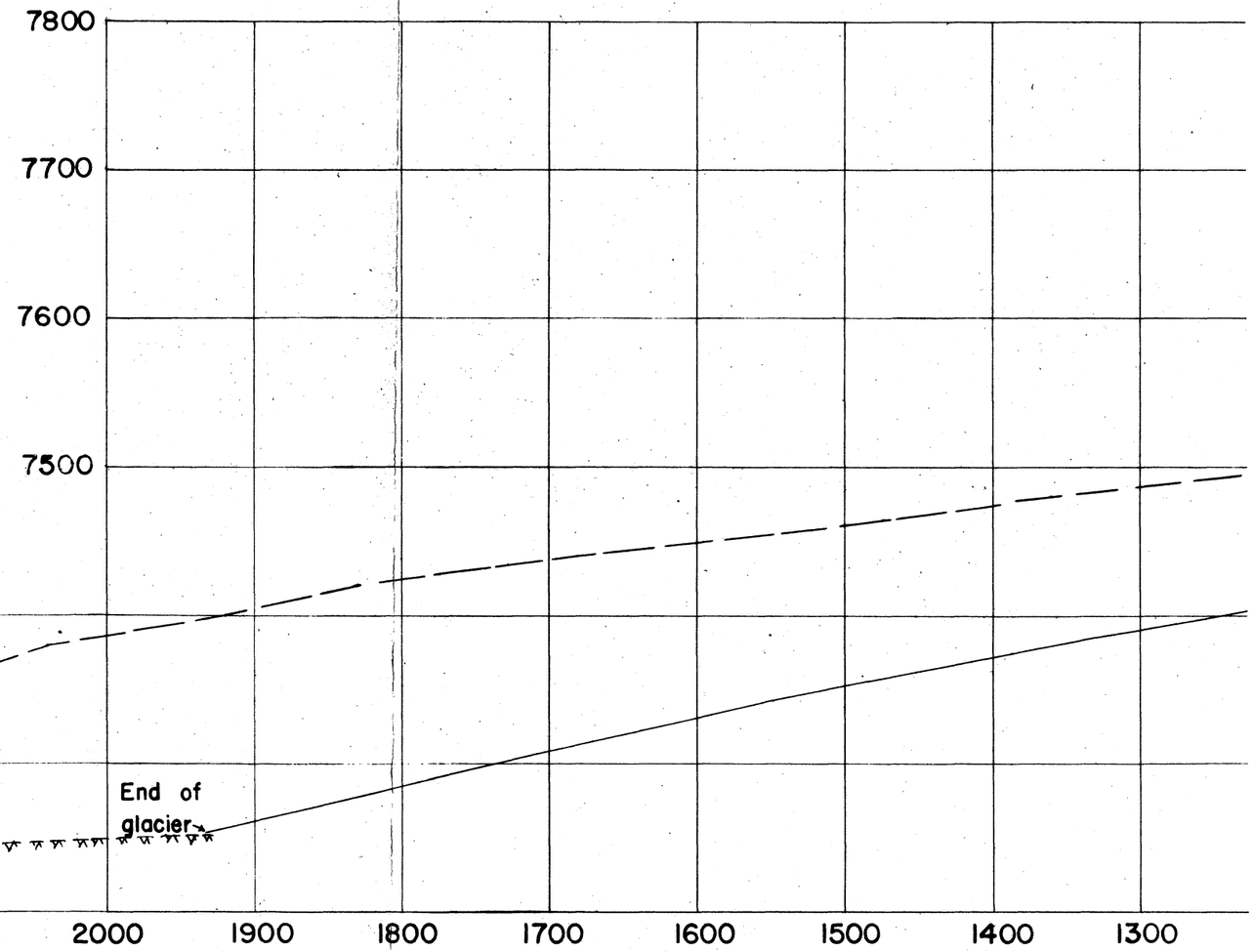
1938 profiles determined from map by J.L.Dyson and are only approximate

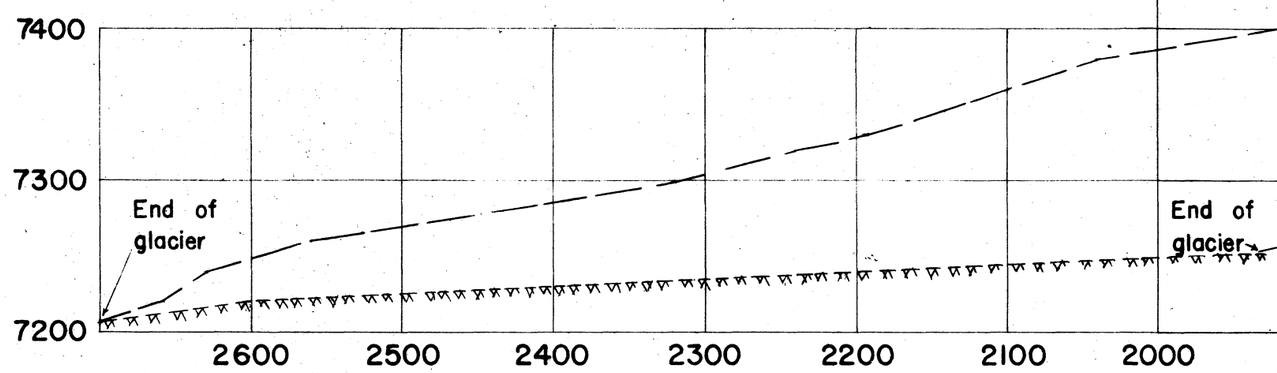

CROSS PROFILE
1938
Station
1967
Sept. 19, 1950
1500
2000
2500
3000

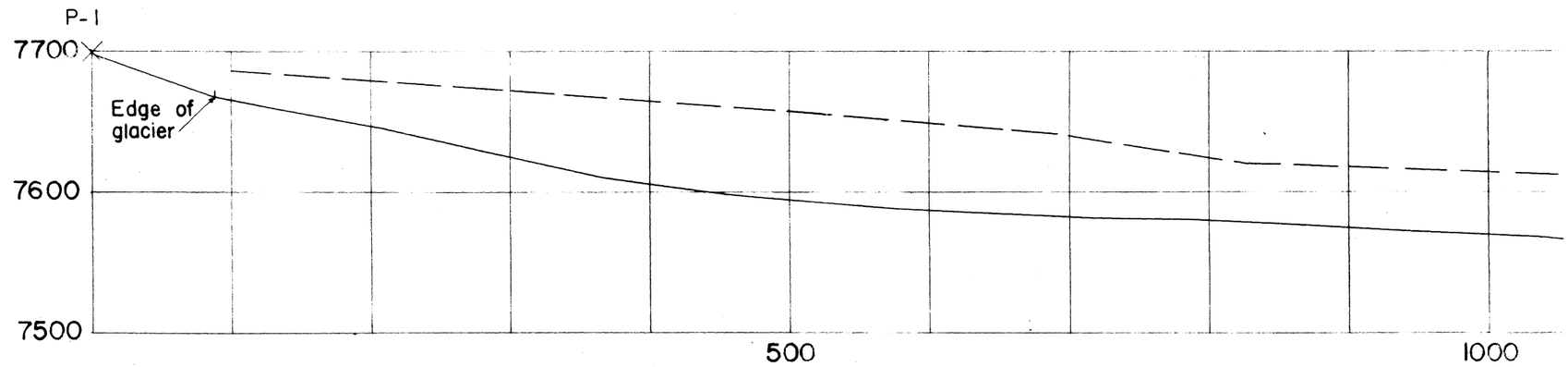

LONGITUDINAL PROFILE THROUGH
STATION 1967 ON CROSS PROFILE
1938
Sept. 19, 1950
Station 1967 on
Cross Profile
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
100
200

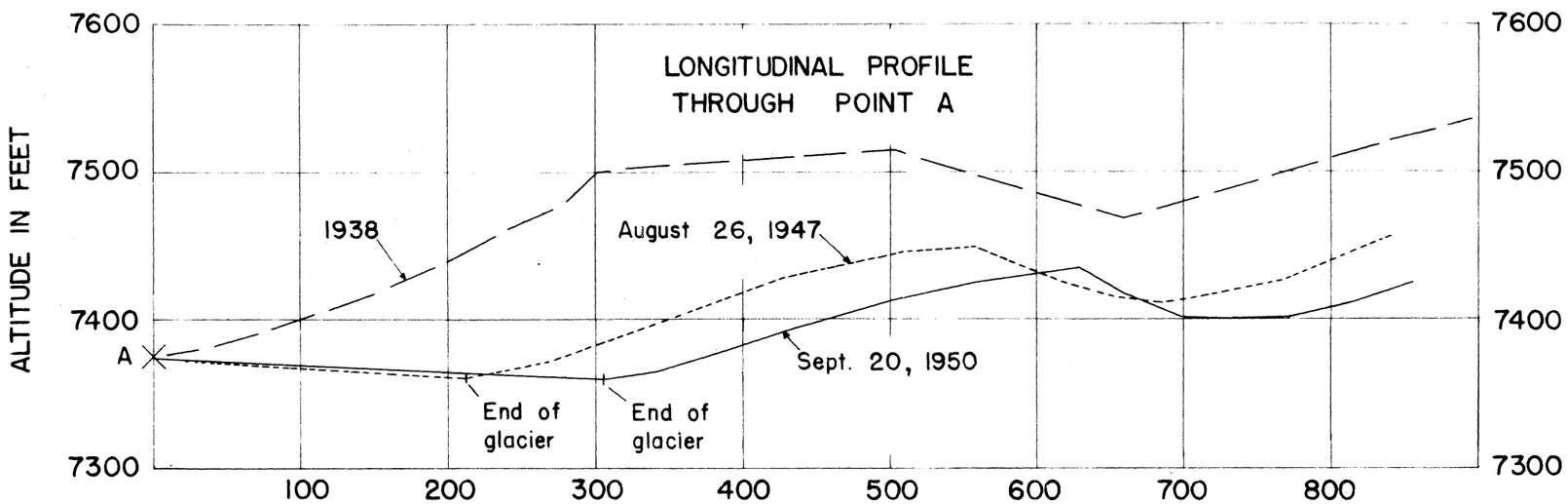

P-1
7700
7600
7500
Edge of glacier
500
1000
1500

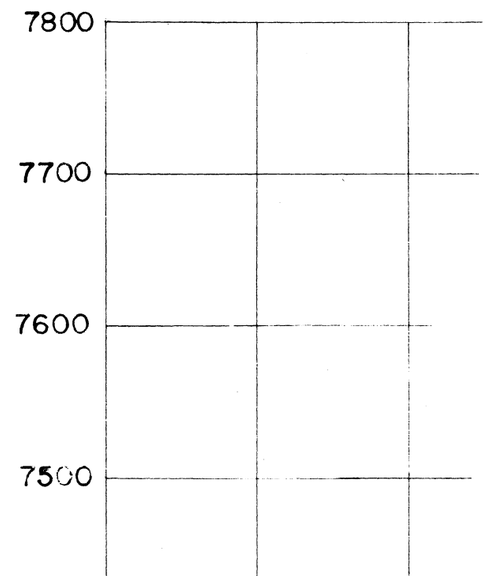

LONGITUDINAL PROFILE
THROUGH POINT A
7600
7500
7400
7300
August 26, 1947
Sept. 20, 1950
End of glacier
End of glacier
300
400
500
600
700
800

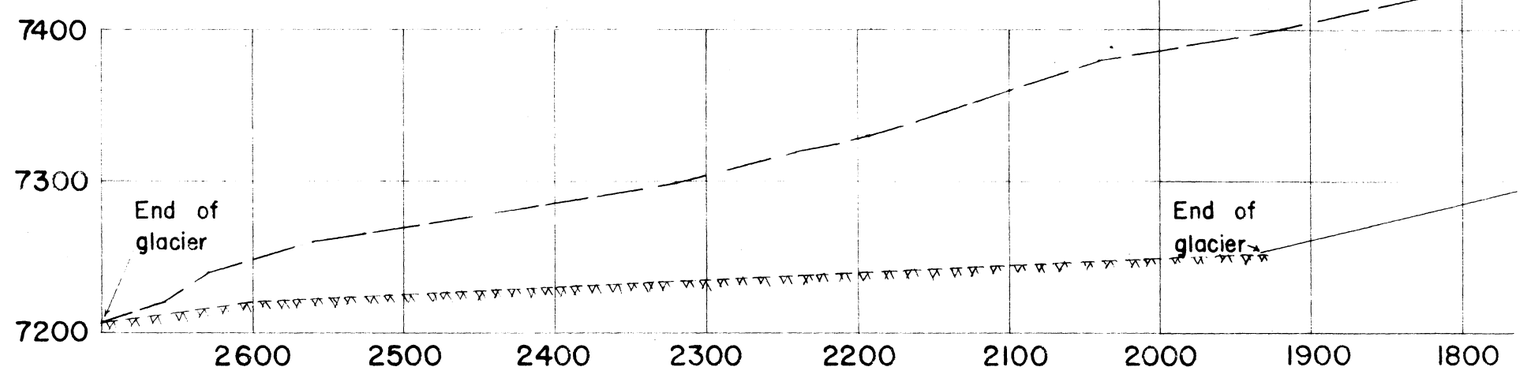

7800
7700
7600
7500
End of glacier
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300


7400
7300
7200
End of glacier


P-1
7700
7600
7500
Edge of glacier
500
1000


LONGITUDINAL PROFILE
THROUGH POINT A
ALTITUDE IN FEET
7600
7500
7400
7300
A
1938
August 26, 1947
Sept. 20, 1950
End of glacier
End of glacier
100
200
300
400
500
600
700
800


7800
7700
7600
7500


7400
7300
7200
End of glacier
End of glacier
2600
2500
2400
2300
2200
2100
2000
1900
1800

On Figure 1 is shown the position of 7 rocks which were first located in 1949. These were all relocated in 1950. Movement varied from 10 to 25 feet. In one case, rock 49-1, there was no apparent forward movement but a lateral movement of 8' was indicated. This may be due to some inconsistency in the field observations. It is of interest to note that all the rocks were readily found.

SPERRY GLACIER

Longitudinal Profile through Point A

August 26, 1947		September 20, 1950	
Dist. from initial point (feet)	Elevation (feet)	Dist. from initial point (feet)	Elevation (feet)
0 a/	7375	0 a/	7375
210 b/	7362	305 b/	7360
270	7373	345	7367
353	7403	385	7378
427	7429	435	7394
437	7432	502	7413
509	7447	560	7426
554	7451	629	7435
620	7425	661	7417
659	7416	696	7404
689	7413	732	7400
767	7429	769	7402
839	7458	813	7412
		854	7427

a/ Point A. Elevation assumed from study of 1938 map by J. L. Dyson

b/ End of glacier

SPERRY GLACIER

Cross Profile

August 30, 1949		September 19, 1950	
Dist. from initial point (feet)	Altitude (feet)	Dist. from initial point (feet)	Altitude (feet)
0 a/	7699	0 a/	7699
93 b/	7665	87 b/	Edge 7668
170	7652	147	7657
288	7623	204	7646
435	7601	276	7630
550	7590	367	7610
707	7586	455	7598
885	7580	577	7588
1034	7570	717	7582
1138	7560	788	7580
1238	7552	869	7577
1342	7543	949	7573
1437	7536	1034	7568
1532	7531	1123	7560
1637	7527	1217	7552
1732	7524	1297	7545
1857	7522	1376	7539
1967 c/	7527	1466	7533
2052	7533	1571	7529
2136	7540	1661	7526
2235	7552	1756	7523
2332	7563	1826	7522
2422	7575	1893	7524
2501	7586	1967 a/	7527
2594	7597	2051	7534
2683	7607	2151	7543
2767	7616	2244	7553
2861	7625	2328	7563
2956	7632	2402	7573
3106	7625	2480	7584
3192 d/	7665	2549	7593
3219 e/	7682	2618	7602
		2737	7610
		2801	7620
		2885	7628
		2952	7632
		3015	7633
		3082	7635
		3119	7646
		3162	7660
		3219 d/ e/	7683

a/ Initial point on left bank. Altitude based on assumed value of 7375 for Point A, a painted mark on rock ridge below front of glacier near left edge. For location see Figure 1.
b/ Left edge of glacier.
c/ Intersection with longitudinal profile.
d/ Right edge of glacier.
e/ Marked point on right bank.

SPERRY GLACIER

Longitudinal Profile through
Station 1967 on Cross Profile

August 30, 1949		September 19, 1950			
Dist. from initial point (feet)	Alt. (ft)	Dist. from initial point (feet)	Alt. (ft)	Dist. from initial point (feet)	Alt. (ft)
Upstream from Cross Profile		Upstream from Cross Profile			
557	7628	838	7735	1550	7343
491	7611	777	7710	1622	7327
		724	7687	1712	7306
398	7594			1788	7288
306	7579	647	7661	1873	7268
209	7564	583	7638		
108	7546	514	7618	1934	7253
0 a/	7527	432	7601		
Downstream from Cross Profile		364	7589		
99	7510	292	7578		
202	7496	218	7566		
305	7483	136	7552		
415	7474	59	7538		
519	7466	0 a/	7527		
		Downstream from Cross Profile			
741	7440	94	7510		
843	7447	192	7496		
939	7446	286	7485		
1033	7438	365	7477		
1111	7427	449	7469		
		518	7460		
		597	7452		
		711	7443		
		757	7445		
		808	7448		
		873	7447		
		923	7444		
		988	7438		
		1051	7430		
		1116	7422		
		1180	7412		
		1253	7399		
		1331	7385		
		1408	7371		
		1483	7357		

a/ Station 1967 on cross profile.

Photo #7 JACKSON GLACIER Beatty photos

Panoramic view of old ice front which shows apparent advance for the year (see Figure 4 this report). Note development of new front in upper right center.

Photo #8 JACKSON GLACIER Beatty photos

View along newly developed ice front in line with control point J-3 (see photo #9 this report). Note exposed bedrock and tendency of isolated ice blocks to move down dip slope faster than main ice mass . This accounts for irregularity of movement along old front as shown in Figure 4.

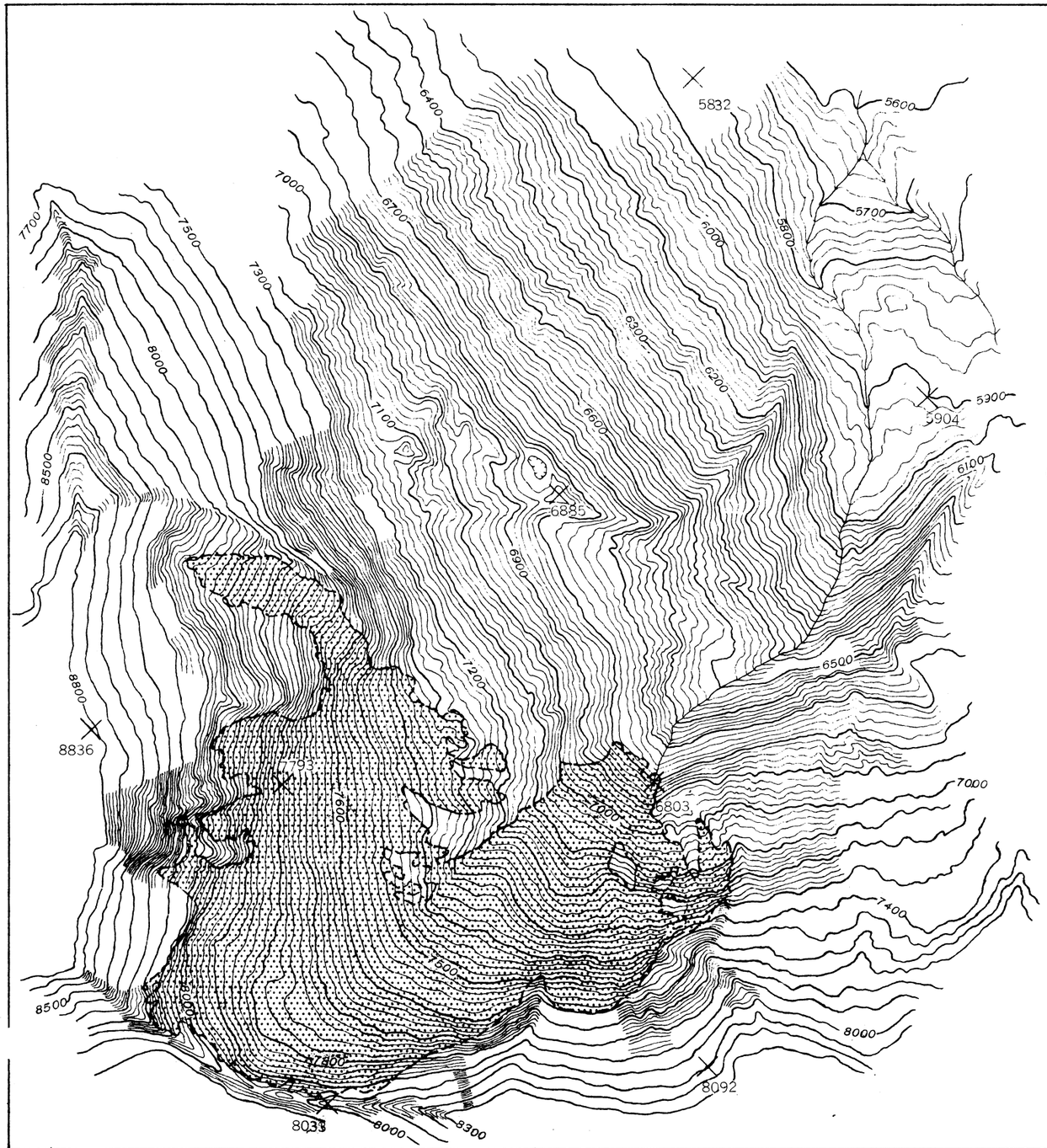
JACKSON GLACIER

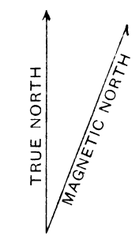
A map of the Jackson Glacier was compiled by photogrammetric methods by the Forest Service in Missoula. A print of this map is included as Figure 3 in this report. An aerial photo of Jackson Glacier (photo #9) follows Figure 3.

The terminus was again outlined and is shown on Figure 4 along with positions in 1947 and 1949. The edges of the glacier for a short distance up from the main terminus was shown. Four large, prominent rocks were located which it is believed can be relocated in future years to show movement.

The termini shown for the three years do not indicate any definite trend during the period unless it be that a more or less state of equilibrium has been reached. The variations shown are probably due mainly to irregularities in the front caused by large blocks of ice breaking away from the main body and sliding down the steep dip slope. Transverse crevasses a short distance above the glacier suggest the above thought. (See photo #8).

Fig 3





UNITED STATES
GEOLOGICAL SURVEY

UNITED STATES
NATIONAL PARK SERVICE

JACKSON GLACIER

GLACIER NATIONAL PARK, MONTANA

Scale 1:12000 or 1 inch = 1000 feet

0.1 0 0.5 1 Mile

1000 0 1000 2000 3000 4000 5000 Feet

Contour interval 20 feet
Datum is approximate mean sea level

Topography compiled from aerial photographs by U.S. Forest Service, Missoula, Montana, using KEK plotter. Aerial photographs, scale about 1:14,000 taken September 1, 1950.

Altitude of initial point, highest point on west moraine, assumed as 6,885 by reference to survey made by J.L. Dyson in 1939. Altitudes of other points indicated determined by triangulation.

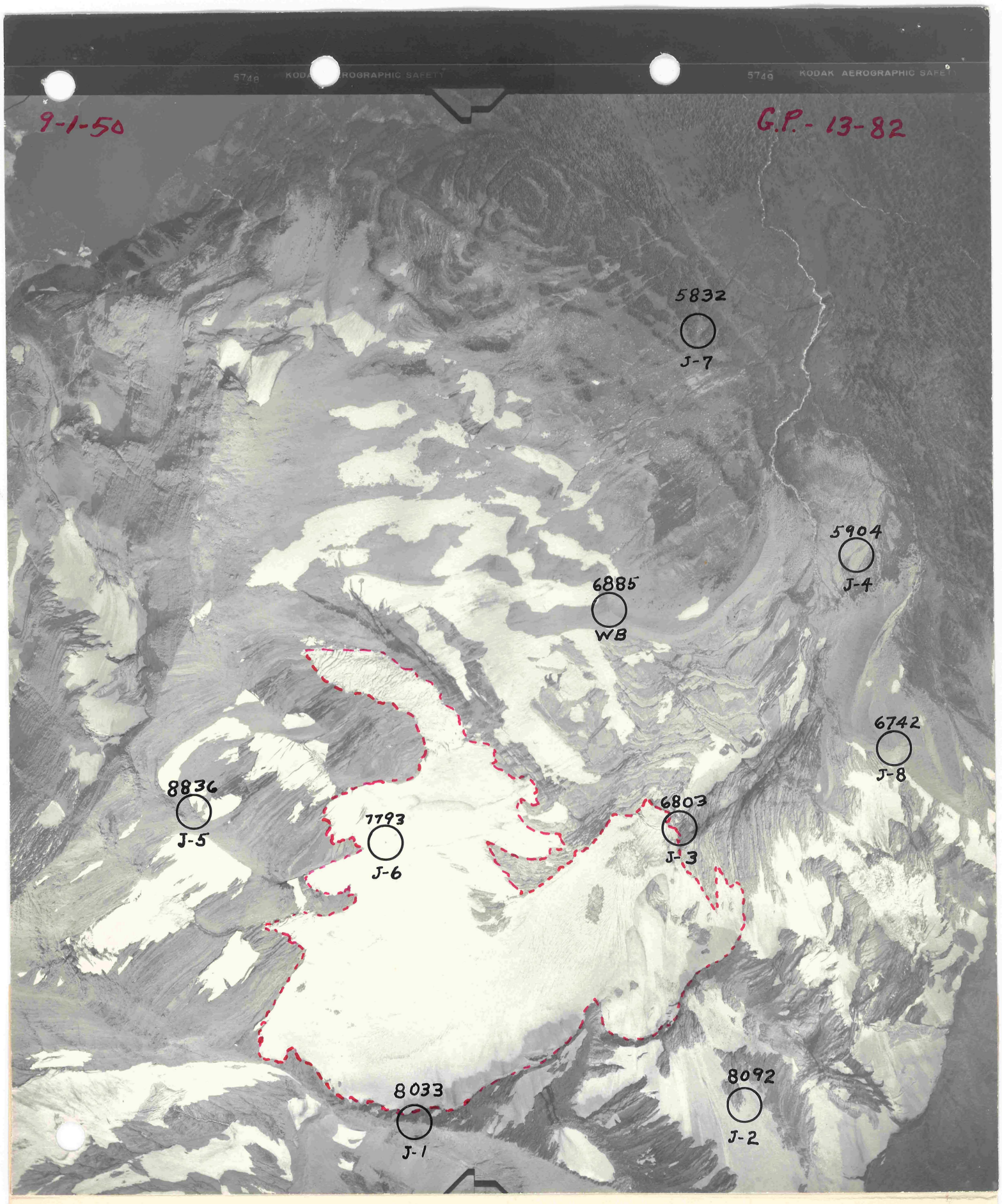


Photo #9 JACKSON GLACIER U.S.F.S. photo

Aerial photo of Jackson Glacier basin showing glacier outline and control points in color. This was one of the photos used in making the topographic map of the glacier which accompanies this report.

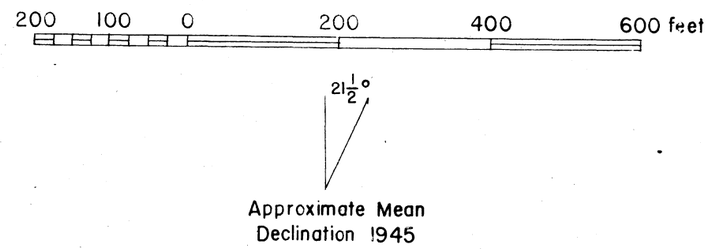
FIGURE 4

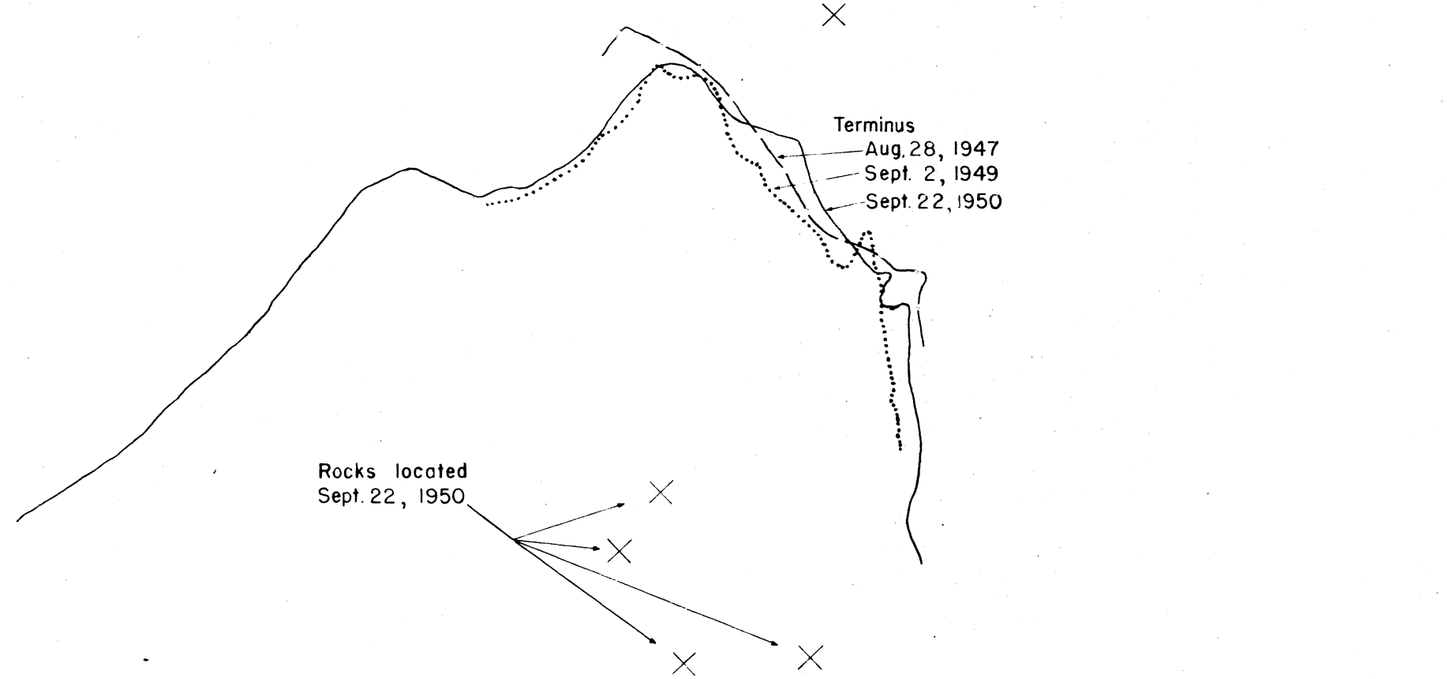
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY NATIONAL PARK SERVICE

JACKSON GLACIER

GLACIER NATIONAL PARK, MONTANA

Scale 1:2400 (1 inch = 200 feet)





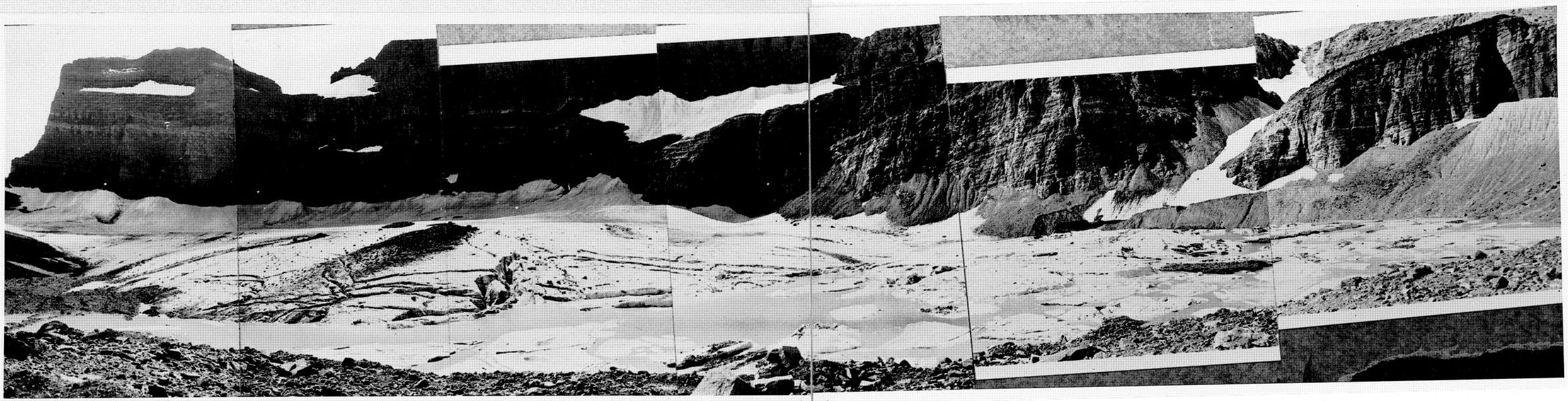


Photo #10 GRINNELL GLACIER Beatty photos

Panoramic view of glacier taken from Station D - photo point established in 1944. (See photo #9, 1944; photos #1, 1945, 1946, 1947; and photo #7, 1949 reports for comparison).

GRINNELL GLACIER

The terminus was mapped in 1950 and is shown on Figure 5 along with the terminal positions in 1937, 1945 and 1947. The 1937 position was taken from the survey by J. L. Dyson. The 1950 terminus had receded as much as 100 feet in places from the 1947 position. For about a 500 foot section near the central portion of the front, the 1950 position was essentially the same as it was both in 1945 and 1947. Taking a half mile section of the front, as indicated on Figure 5, the average recession since 1937 was measured for 1945, 1947 and 1950. These values are as shown below.

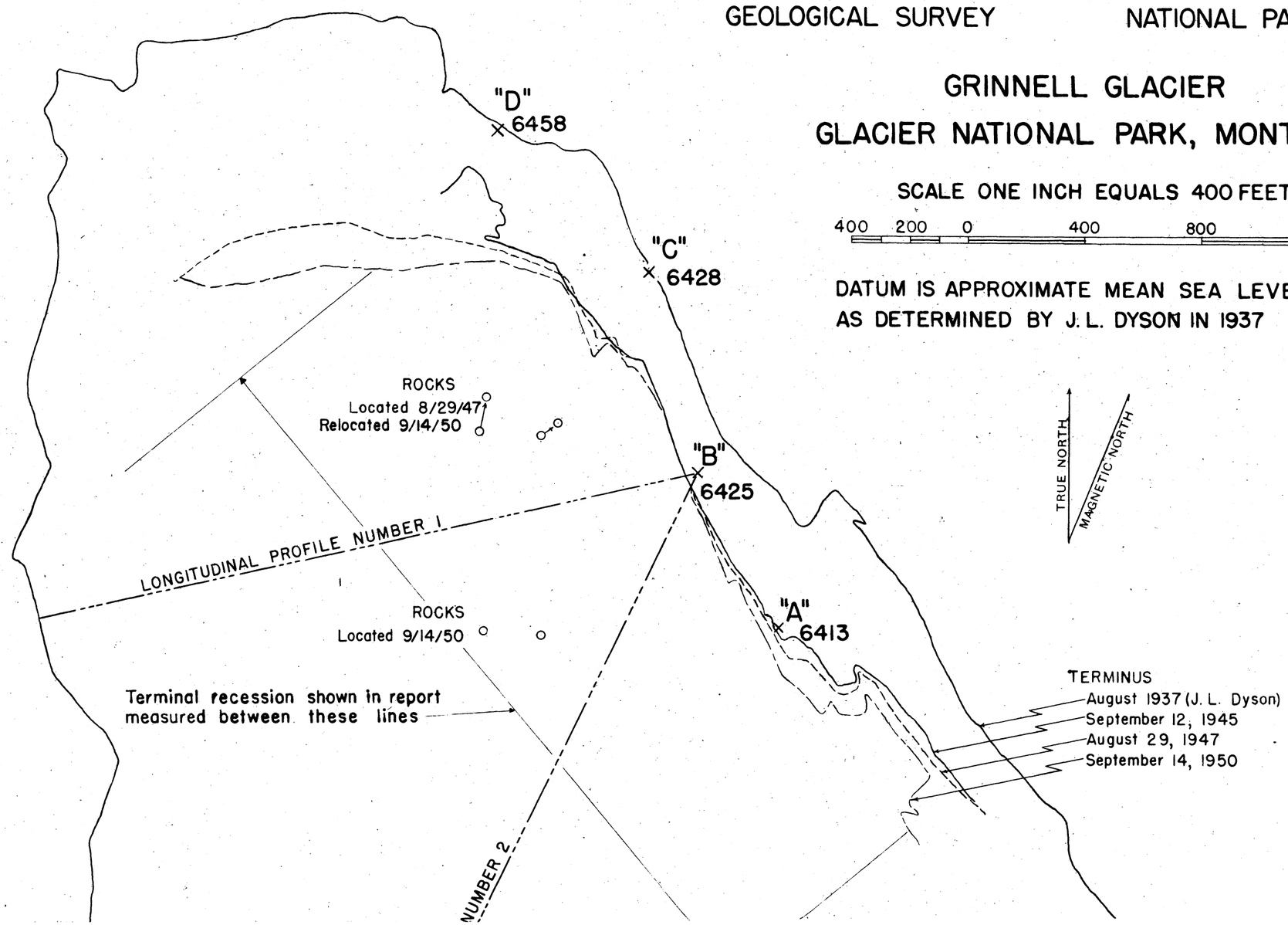
Period	Recession (feet)	Average annual Recession (feet)	Total recession since 1937 (feet)
1937-1945	270	33.8	270
1945-1947	29	14.5	299
1947-1950	46	15.3	344

From the above data it appears that there has been a marked decrease in the rate of terminal recession starting about 1945.

Two longitudinal profiles, both originating at Point B, were measured in 1950 and are shown on Figure 6. Using the 1937 and 1946 maps by J. L. Dyson profiles along the same alignments were determined which are also shown on Figure 6. A study of these profiles indicates that the decrease in surface elevation between 1946 and 1950 was at a somewhat lesser rate than during the period 1937-1946. This coincides with a decrease in the rate of terminal recession apparent during the same period. The observed data for the two profiles measured in 1950 is shown at the end of this section.

Two rocks which were located in 1947 were relocated in 1950. The positions in both years are shown on Figure 5. One of them moved 120 feet or at a rate of 40 feet per year, whereas the second one only moved 70 feet or 18 feet per year. The movement in each case was normal to the front of the glacier. The rocks were only 250 feet apart so the marked variation in the rate of movement is somewhat surprising. Additional rocks were located in 1950 for determining movement in future years.

FIGURE 5



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY NATIONAL PARK SERVICE

GRINNELL GLACIER
GLACIER NATIONAL PARK, MONTANA

SCALE ONE INCH EQUALS 400 FEET

400 200 0 400 800 1200 Feet

DATUM IS APPROXIMATE MEAN SEA LEVEL
AS DETERMINED BY J. L. DYSON IN 1937

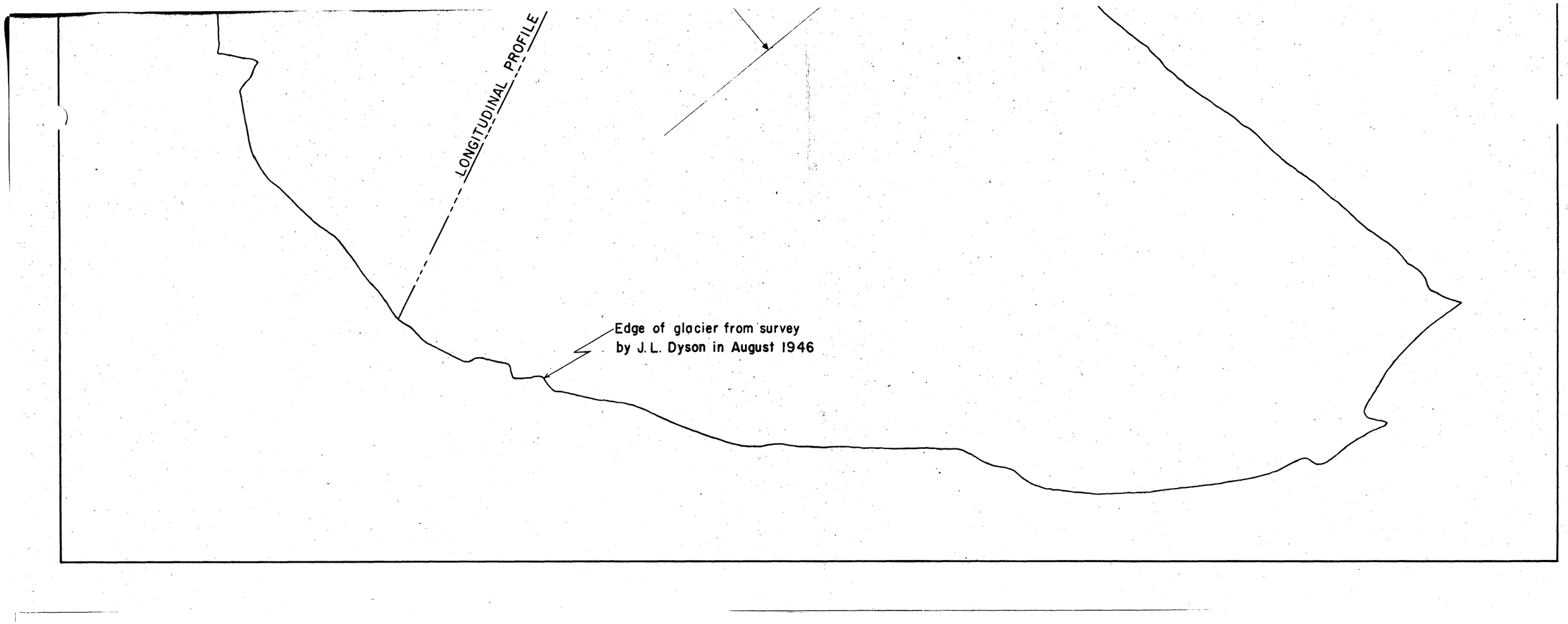

LONGITUDINAL PROFILE
Edge of glacier from survey
by J. L. Dyson in August 1946

FIGURE 6

UNITED STATES
GEOLOGICAL SURVEY

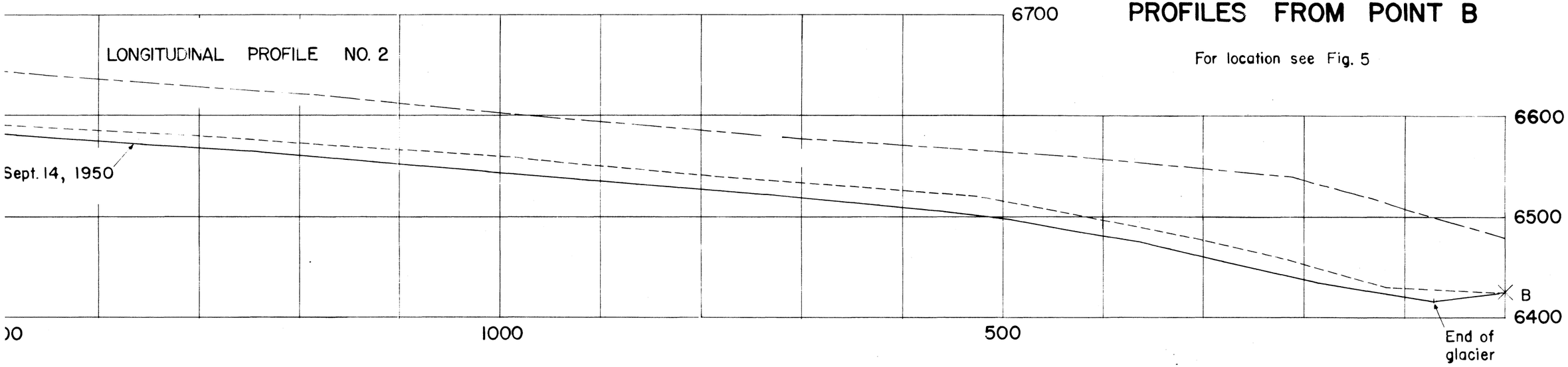
UNITED STATES
NATIONAL PARK SERVICE

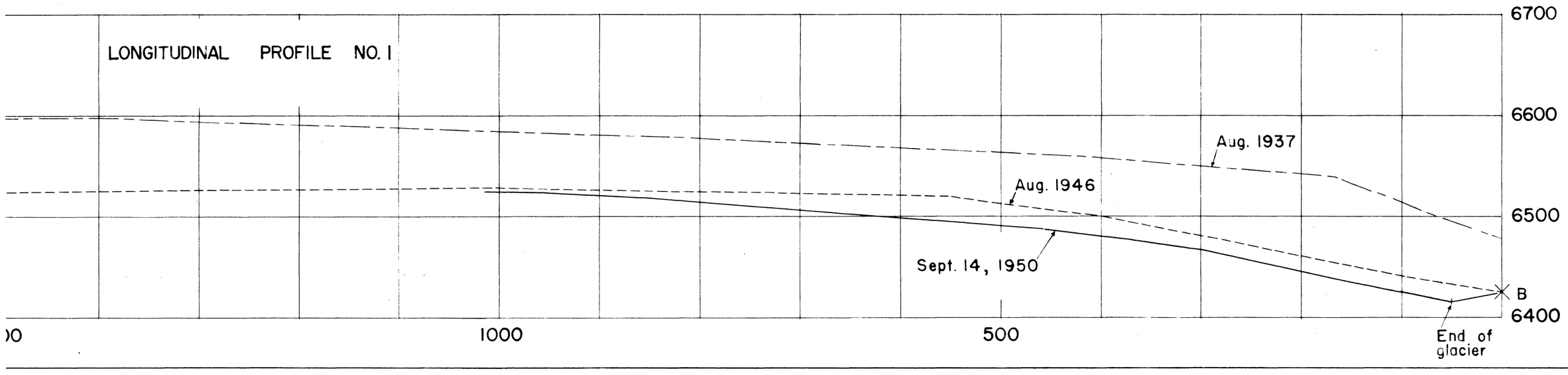
GRINNELL GLACIER

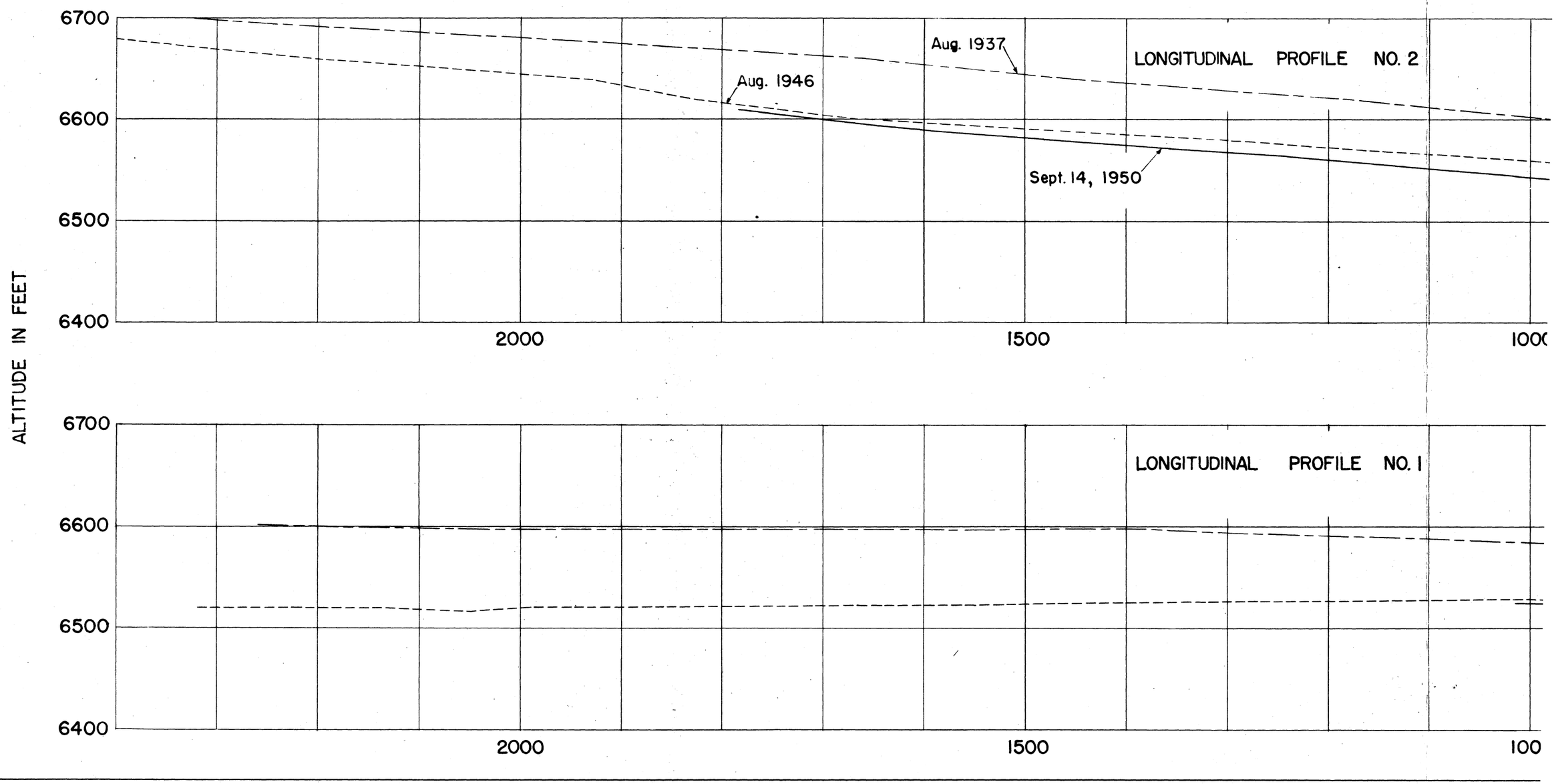
GLACIER NATIONAL PARK, MONTANA

PROFILES FROM POINT B

For location see Fig. 5






ALTITUDE IN FEET
6700
6600
6500
6400
2000
1500
1000
Aug. 1937
Aug. 1946
Sept. 14, 1950
LONGITUDINAL PROFILE NO. 2
6700
6600
6500
6400
2000
1500
100
LONGITUDINAL PROFILE NO. 1

GRINNELL GLACIER

Longitudinal Profiles from Point B

September 14, 1950

Profile No. 1		Profile No. 2	
Distance from Point B (feet)	Elevation (feet)	Distance from Point B (feet)	Elevation (feet)
0 a/	6425	0 a/	6425
47	6417	70	6417
122	6429	185	6435
194	6444	277	6456
251	6458	359	6474
295	6467	422	6485
368	6478	490	6497
456	6488	558	6506
551	6495	622	6512
616	6501	727	6522
685	6506	811	6529
740	6510	920	6538
848	6519	1014	6546
958	6524	1133	6556
1013	6526	1242	6565
		1357	6573
		1481	6582
		1644	6595
		1783	6611

a/ Point B. Elevation of this point from J. L. Dyson's 1946 map.

AERIAL PHOTOS OF GLACIERS
Glacier National Park, Montana
September 1, 1950

(All Forest Service photos prefixed by G.P. 13)
(Example: G.P. 13-12)

Glaciers photographed	Print Numbers	Approx. Flight Direction
KINTLA - AGASSIZ - BABY	1 to 7	West to East
AGASSIZ - BABY	8 to 10	North to South
RAINBOW	11 to 14	West to East
TWO OCEAN - VULTURE	15 to 19	North to South
DIXON - THUNDERBIRD	20 to 25	East to West
MICHE WABUN - WHITECROW	26 to 30	North to South
SHEPARD-CHANEY-IPASHA-AHERN	31 to 36	N.W. to S.E.
OLD SUN & 3 unnamed	37 to 44	37-39 E to W; 40-44 NE to SW
ICEBERG LAKE	45 to 46	N to S
NORTH SWIFTCURRENT	47 to 48	E to W
GRINNELL-SWIFTCURRENT-GEM	49 to 53	W to E
PIEGAN	54 to 56	N to S
SEXTON	57 to 61	57-58 S to N; 59-61 N to S
SPERRY	62 to 73	62-67 E to W; 68-73 NE to SW
HARRISON	74 to 76	W to E
JACKSON - BLACKFOOT) LOGAN-RED EAGLE-PUMPELLY)	77 to 94	77-84 E to W; 85-91 W to E 92-94 E to W
MT. STIMSON AREA (3 unnamed)	95 to 98	N to S
GRANT - STANTON	99 to 103	SE to NW

REPORT OF STATUS OF GLACIERS
Glacier National Park
1950

Note: Aerial Photos all carry prefix: G.P. 13 (Example: G.P. 13 - 56)

Location: 1st col. - Township North; 2nd col. - Range West;
3rd col. - Section

AERIAL PHOTOGRAPHS

Name	Location	Photo best sterio pair	Best Single	Remarks
Agassiz	37; 20; 26	5 & 6	6	Heavy snow cover; probably inactive.
Ahern	36; 17; 23	35 & 36	36 or 44	Fair size but probably inactive.
Baby	36; 20; 3	None	10	Snow patches only; inactive.
Blackfoot	33; 16; 22-23	88 & 94 78 & 89	88 & 89	Active.
Boulder	37; 19; 20	None	None	Entirely gone.
Carter	36; 19; 16	None	None	Believed active.
Chaney	36; 17; 30	33 & 34	33	Appears active.
Dixon	37; 19; 35-36	21 & 22	22	Active.
Grinnell	35; 17; 25-26-36	50-51-52	51	Active.
Harris	37; 20; 19-20	None	None	No information.
Harrison	33; 17; 25-26-36	74 & 75	75 Also 85	One of our four largest glaciers.
Herbst	37; 19; 10	None	None	No information.
Hudson	37; 19; 15	None	None	No information
Ipasha	36; 17; 29	34 & 35	34	Appears active

AERIAL PHOTOGRAPHS

Name	Location	Photo best sterio pair	Best Single	Remarks
Jackson	33; 16; 21-22	81, 82 & 83	82	Active.
Kintla	37; 20; 27-28 33-34	2, 3, 4	3	Four separate ice bodies, all of which appear active.
Logan	33; 16; 24	77 & 91	77	Appears active
Lupfer	31; 15; 2	None	None	No information but probably gone.
Miche Wabun	37; 17; 20	26 & 27	26	Small and likely inactive
N.Swift-current	35; 17; 15	47 & 48	47	3 small lobes; possibly active.
Old Sun	36; 17; 21	42 & 43	42	Appears thin but still active.
Piegan	34; 16; 15	55 & 56	56	Fairly good size and possibly active.
Pumpelly	33; 16; 25-26	88-89 & 92 & 93	93	Active.
Rainbow	36; 19; 17-18 20	12 & 13	13	Still good size and active.
Red Eagle	33; 15; 19	77 & 91	77	Questionable.
Sexton	34; 16; 13	57 & 58	58	Still fair size and active.
Shepard	36; 18; 24	31 & 32	31	Small and likely inactive.
Siyeh	34; 16; 2	None	None	Entirely gone.
Sperry	33; 17; 10-15	70 & 71	70	Active.
Swiftcurrent	35; 17; 23	49 & 50	49	Small but active.
Thunderbird	37; 19; 26-27	23 & 24	24	Active.
Two Ocean	36; 19; 35	16 & 17	17	Appears active.

AERIAL PHOTOGRAPHS

Name	Location	Photo best sterio pair	Best Single	Remarks
Vulture	36; 19; 35	17 & 18	17	Active.
Weasel Collar	36; 19; 8	None	None	Very active.
Whitecrow	37; 17; 32	29 & 30	29	Small but still active
		UNNAMED GLACIERS (or unofficial)		
Gem	35; 17; 36	51 & 52	51	Wind drift? Completely snow covered.
Stimson	32; 15; 18-19-20 28-29	96, 97, 98	97	4 small ice bodies which appear active.
Thompson	32; 16; 3-4-9-10	None	None	Should photograph.
James	33; 14; 30	None	None	No information.
Split Mt.	33; 15; 22-23	None	None	No information.
Little Chief	33; 15; 5 & 8	None	None	No information.
Twin Lakes	33; 17; 2	None	None	Believed gone.
Gunsight	33; 17; 14-24	69 & 70	69	Several small ice bodies, one of which appears active.
Clements	34; 17; 23	None	None	Gone.
Oberlin	34; 17; 14-15	None	None	Mostly gone.
Iceberg	35; 17; 2	45 & 46	46	Mostly gone.
S. Carter	36; 19; 22	None	None	Should photograph (two).
S. of Gunsight Pass	33; 17; 23-24	83 & 84	84	Possibity of 6 small glaciers.
S. of Mt. Logan	33; 16; 25	90 & 92	90	Questionable.

Total active glaciers, based on aerial photos or other data - - - -	30
Total with doubtful status -	17
Total former glaciers now entirely gone - - - - - - - - - - - - - - -	7
Total former glaciers on which we have no current data - - - - - - -	10
Total number of former glaciers represented -- - - - - - - - - - - - -	64

AERIAL MAPPING PROGRAM

Itemization of Costs - U. S. Forest Service, Missoula - $1,000.00 Limitation

AERIAL PHOTOGRAPHY:

Plane Rental (approx. 4 hrs.)	$237.67	
Plane Rental (handling charge)	14.26	
Camera Rental	15.00	
Lab. costs, 16 hrs. @ $2.41	38.56	
Film used, 3/4 roll	49.37	
Film Developing, 1 roll	8.00	
Set contact prints, 103 @ .45	46.35	
Oxygen, 1 filling	1.00	$410.21

FIELD WORK:

Planning & Supervision - salaries -	No charge	
Planning & Supervision - travel	$ 40.26	
Establishing Controls:		
Salaries - - - - - - - - - - -	231.36	
Travel - - - - - - - - - - - -	58.36	$329.98

OFFICE WORK:

Computing, 40½ hrs @ 2.92	No charge	
38½ hrs @ 2.63	101.26	
Base Layout, 3 hrs @ 2.05	6.15	
Adjust photos to control, 15 hrs @ 2.62	39.30	
Map construction, 43 hrs.@ 2.62	112.66	$259.37
TOTAL PAID U.S.F.S.		$999.56

SOURCE OF FUNDS FOR PAYMENT

American Geographical Society of New York - Donation	$ 400.00
Glacier Natural History Association - Donation	500.00
Glacier National Park - Naturalist funds	100.00
TOTAL	$1,000.00

FUNDS EXPENDED BY GLACIER NATIONAL PARK FOR 1950 GLACIER MEASUREMENT PROGRAM

Direct Expenditures from Naturalist Funds

Horse rental	$ 200.00		
Travel and subsistence	68.15		
Glacier report	50.00		
Paid to U.S.F.S.	100.00	$ 418.15	

Funds donated to Park for Aerial Mapping Program

American Geographic Society of N.Y.	$ 400.00		
Glacier Natural History Association	500.00		
Glacier National Park (included above)	- - -	$ 900.00	
ACTUAL CASH FUNDS EXPENDED			$ 1,318.15

Indirect costs to Glacier National Park appropriation

Salaries:	Chief Park Naturalist Beatty	465,00	
	Park Naturalist Robinson	360.00	
	Stenographer - report	65.00	
	Ranger packer	125.00	
Miscellaneous:	Supplies	20.00	$ 1,035.00
TOTAL COST TO PARK			$ 2,353.15

NOTE: This does not include costs (salaries & expenses) for other government agencies cooperating in the studies.

Summary and Conclusions

It is now evident that five successive heavy snow years, together with four years of slightly below normal temperatures, has resulted in a material lessening of the rate of shrinkage in park glaciers. Should the present trend continue as a major wetter and colder climatic cycle, it is entirely possible that some of our larger glaciers may start to increase in volume and show an advance along their fronts. Indications, based upon a study of old photographs, point to a 55 year period of depletion for park glaciers hence annual studies at this possible low ebb turning point should prove of immense value to present day and future students of glaciology.

The unexpectedly high record of 125.1 inches precipitation at the Grinnell Glacier storage gage, elevation 6238 feet, leads us to believe that a certain portion of the accumulation must have been due to wind-blown snow. The full year precipitation record at Summit, elevation 5213 feet, was 53.3 inches and it is not logical to expect $2\frac{1}{2}$ times that much precipitation at a higher elevation of only 1,000 feet. Records of the flow gage at the outlet of Grinnell Lake are not yet available to cover this period. With the accumulation of several years records from these two stations some method may be devised to correlate the findings with other measurements. In the meantime it would be advisable to attempt to devise an instrument capable of measuring wind-drift in order to provide a more accurate figure for actual precipitation.

Due to the inconsistency of results between linear measurements from fixed points and averaging the recession along the ice fronts by plane table mapping, it has been decided to drop the tabulation of annual and total recession from the report. Should there ever be need to refer to these tabulations, they may be found in all previous years reports.

The aerial mapping program proved much more expensive than anticipated, hence only one map was completed instead of the three contemplated. Much of the cost was for putting in ground controls and making computations. This item of expense will be deleted in future years, also much of the cost of field trips. Our present goal is to make shorter aerial flights concentrating on only a few glaciers each year. An aerial map of but one of the three major glaciers, Grinnell, Sperry and Jackson will be completed yearly which will give us three year intervals for each glacier. Field trips will be made to but the one glacier being mapped and more time can thus be devoted to work on profiles, rate of movement and other studies. Photographs can be made of the other glaciers by ranger naturalists or other personnel to provide a continuous photographic record each year.

In order to carry out this annual program of glacier measuring, more funds will be required. A request has been made for $1,000.00 for glacier measurements in the 1953 appropriation for Glacier National Park which may or may not be granted. We still lack the necessary funds to carry on the work in the 1952 budget which becomes available next July 1. The Glacier Natural History Association is not sufficiently strong financially to continue a $500 annual donation and it is too much to expect outside organizations, such as the American Geographical Society to continue yearly donations. If the program is worth doing, it should be financed with government funds. It is hoped that arrangements for the U. S. Geological Survey to undertake a more active research program on park glaciers can be completed along the lines proposed by Mr. Beatty with Dr. Bauer and officials of the Survey in Washington, D.C. last January.

Minimum costs of the 1951 program of glacier measuring, other than salaries, are estimated as follows:

Aerial photography	$ 350.00	(plane rental, camera,film,prints)
Aerial map one glacier	150.00	(layout and map construction)
Field trip one glacier	150.00	(horse rental, food, per diem)
Reports	100.00	(photos,charts,graphs,printing)
Travel expense	50.00	(photographing other glaciers, service precipitation gage, car expense)
TOTAL CASH OUTLAY	$ 800.00	
Available naturalist funds	200.00	
CASH NEEDED	$ 600.00	

This represents the bare minimum needed to carry on the program using aerial methods and costs may run even higher should the plane have to make several trips to find the right atmospheric conditions for photography at 16,000 feet elevation. The Glacier Natural History Association can be relied upon to meet such unexpected extra costs but not in addition to a regular donation. It is vital that we have additional financial support in order to carry on glacier studies for the coming season.

M. E. BEATTY

ARTHUR JOHNSON