

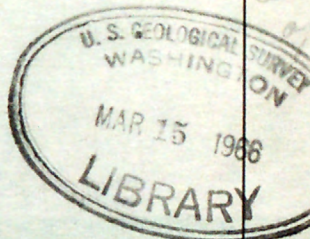
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U. S. GEOLOGICAL SURVEY
AND
U. S. NATIONAL PARK SERVICE
GLACIER OBSERVATIONS
GLACIER NATIONAL PARK, MONTANA
1963



by
Arthur Johnson

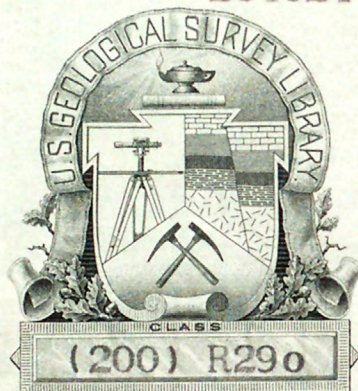
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JUN 28 1967

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1963 PROGRESS REPORT
GLACIER OBSERVATIONS
GLACIER NATIONAL PARK, MONTANA
INTRODUCTION

This report records the results obtained during the 1963 season in the continuing program of observations on the Grinnell and Sperry Glaciers in Glacier National Park, Montana. This is carried on cooperatively by the Geological Survey, the National Park Service, and the Weather Bureau. It includes the determination of annual changes in the surface elevation of the glaciers by the measurement of profiles; changes during the summer months by the establishment of and observations at ablation stakes; mapping the glacier termini in selected years to record advance or recession; determination of annual movement by the location of marked rocks; the operation of two storage-precipitation gages in the immediate vicinity of the Grinnell Glacier to record annual precipitation; the operation of two gaging stations, one just below the Grinnell Glacier during the summer months and one just below the outlet of Grinnell Lake on a year-round basis; the temperature data near the Grinnell Glacier and temperature and precipitation data at the Sperry Chalet near the Sperry Glacier during the summer months.

Temperature data for the months of July, August, and September at West Glacier, Sperry Chalet, and Grinnell Glacier for the years 1960-1963 are shown in table 1 along with mean values at West Glacier based on the 30-year record 1931-1960. Assuming that conditions at

West Glacier are indicative for this section of the State it is seen that the mean temperature for July was 2.3° below the 30-year average, while the August and September values were 1.2° and 3.7° above the 30-year average. Temperature conditions in September were particularly noteworthy. Dightman reported that

Dightman, R. A.,

Climatological Data, Montana

September 1963, Volume 66, No. 9,

"At several long-record points (Helena, Kalispell, Glasgow, Great Falls, Billings, among others), this September ranked very close to the warmest on record. For example, since 1880 (84 years), it has averaged warmer only twice at Helena, and similar warmth covered most of the State. Many maximums observed on the 30th (see daily temperature tables) were the highest observed so late in the season for periods of record varying up to 84 years (89° at Helena, 85° at Missoula, 90° at Billings, etc.). During the last week daily maximums averaged nearly 20° above normal over most of the area."

No snowfall was recorded at any observation station in Montana during September. In connection with the measurement at ablation stakes it was observed that Grinnell Glacier was still completely exposed on October 15 and that Sperry Glacier had only a few patches of fresh snow on October 18.

Table 1 - Temperature and precipitation data,
July, August, and September, 1960, 1961, 1962, and 1963

		West Glacier				Sperry Chalet				Grinnell Glacier			
	Mean a/	1960	1961	1962	1963	1960	1961	1962	1963	1960	1961	1962	1963
Temperature °F													
Mean:													
July	64.0	66.1	64.8	61.3	61.7	62.7	58.0	52.9	53.5	—	—	—	56.1
August	62.0	57.9	66.4	60.6	63.2	50.7	61.9	51.0	56.6	51.1	61.7	54.5	57.5
September	53.3	52.9	47.5	52.2	57.0								
Maximum:													
July	—	93	89	88	90	84	75	74	76	—	—	—	79
August	—	87	96	91	90	76	90	82	81	81	89	84	82
September	—	80	76	79	89								
Mean Maximum:													
July	80.6	84.4	81.1	77.4	77.5	73.0	67.8	61.2	62.0	—	—	—	66.4
August	78.5	70.2	84.6	75.5	79.3	57.6	71.8	58.9	66.5	59.3	73.6	63.5	68.4
September	67.2	67.8	59.7	67.7	72.3								
Minimum:													
July	—	40	35	33	39	39	37	32	35	—	—	—	37
August	—	34	39	37	37	30	36	31	36	31	33	35	38
September	—	26	20	27	32								
Mean Minimum:													
July	47.3	47.8	48.5	45.2	45.9	52.3	48.2	44.5	44.9	—	—	—	45.5
August	45.5	45.5	48.1	45.7	47.1	43.7	51.9	43.1	46.7	42.8	49.8	45.2	—
September	39.4	38.0	35.3	36.7	42.7								
Precipitation, inches:													
July	1.27	0.00	2.20	0.58	1.70	0.15	3.27	0.76	2.30	—	—	—	—
August	1.33	2.75	0.76	1.03	0.79	3.82	3.30	2.41	1.60	—	—	—	—
September	1.89	0.59	3.33	1.65	1.80								

a/ From 30-year record, 1931-1960.

GRINNELL GLACIER

General

The first field work of the season was started on July 8. At that time there was still so much snow left in a small drainage course crossing the horse trail about $3/4$ mile from its end that saddle and pack horses could not be taken across it. This same situation was encountered on July 14, 1962. It was therefore necessary to back-pack the equipment from this point to the end of the horse trail and, as usual, from there to the glacier. With the exception of a small area near ablation stake no. 4 (see figure 2) the entire glacier was still covered with snow from the previous winter. Considerable difficulty was experienced in boring holes for the ablation stakes due to the snow cover. Only two stakes were placed and operations discontinued until July 26.

Surface Changes

Profiles

The three profiles, located as shown on figure 2, which have been measured in previous years were remeasured. The profiles for 1957, 1962, and 1963 are shown graphically on figure 1. The mean elevations for subdivisions of these profiles are shown in tables 2, 3, and 4 for all years in which measurements were made. In comparing values in these tables the difference in dates of measurement must be considered. Reference to these tables show that the glacier surface at time of measurement in 1963 was appreciably lower than during any previous measurement. This is consistent with the above-normal temperatures observed during August and September.

As shown in figure 1 the configuration of the profiles remain much the same from year to year. There is one exception in the case of profile no. 3 for 1962. The irregularity in the area about 250 feet from the edge of the glacier was caused by a scree-covered area, which, due to the insulating effect of the scree cover, was somewhat higher than the surrounding ice area moving across the profile alignment. In 1962 the high part of this scree-covered area was almost directly on the profile alignment but due to the movement of the glacier the effect was only slightly noticeable in 1963.

Table 2. - Profile No. 1, Grinnell Glacier, Montana

Mean elevations, feet

Date	Distance from reference point, feet			
	100-500	500-1000	1000-1500	1500-2000
Sept. 14, 1950	6463.5	6510.3	---	---
Aug. 22, 1952	6463.6	6510.0	6529.5	---
Sept. 4, 1953	6460.2	6505.5	6523.6	---
Sept. 27, 1954	6461.1	6505.8	---	---
Sept. 8, 1955	6462.0	6505.1	6523.9	---
Aug. 30, 1956	6462.6	6504.4	6522.9	6515.4
Aug. 13, 1957	6461.6	6504.0	6522.0	6513.6
Sept. 10, 1957	6458.1	6500.7	6518.3	6508.3
Aug. 12, 1958	6454.8	6497.0	6513.2	6503.2
Sept. 14, 1958	6449.2	6491.1	6507.8	6497.6
Aug. 14, 1959	6454.9	6496.3	6514.4	6501.9
Sept. 12, 1959	6452.2	6495.7	6512.2	6500.3
Sept. 2, 1960	6453.0	6495.9	6511.1	6502.3
Sept. 19, 1961	6447.0	6489.2	---	---
Sept. 1, 1962	6446.6	6488.4	6505.0	6496.1
Sept. 12, 1963	6440.6	6484.2	6499.9	6492.4

Table 3. - Profile No. 2, Grinnell Glacier, Montana

Mean elevations, feet

Date	Distance from reference point, feet				
	100-500	500-1000	1000-1500	1500-2000	2000-2500
Sept. 11, 1950	6460.1	6523.3	6564.8	---	---
Aug. 22, 1952	6460.3	6522.6	6563.8	6604.8	---
Sept. 4, 1953	6458.4	6519.5	---	---	---
Sept. 27, 1954	6459.5	6522.0	6564.4	---	---
Sept. 6, 1955	6460.6	6521.8	6563.9	---	---
Aug. 30, 1956	6461.7	6521.6	6563.8	6604.6	6659.9
Aug. 13, 1957	6460.2	6521.3	6563.2	6602.9	6657.2
Sept. 10, 1957	6456.6	6517.9	6560.6	6600.9	6654.9
Aug. 12, 1958	6452.5	6515.2	6557.1	6596.4	6649.6
Sept. 15, 1958	6446.4	6509.8	6551.6	6591.2	6642.7
Aug. 11, 1959	6453.0	6516.2	6553.6	6593.4	6651.6
Sept. 12, 1959	6449.9	6513.6	6555.7	6597.1	6649.5
Sept. 3, 4, 6, 1960	6449.9	6514.1	6555.5	6594.7	6646.7
Sept. 1, 2, 1962	6442.8	6506.4	6547.4	6586.9	6640.7
Sept. 12, 1963	6437.5	6499.2	6541.8	6582.4	6634.4

Table 4. -- Profile No. 3, Grinnell Glacier, Montana

Mean elevations, feet

Date	Distance from reference point, feet	
	300-1000	1000-1700
Sept. 11, 1957	6577.9	6681.4
Aug. 13, 1958	6575.0	6677.5
Aug. 15, 1959	6575.7	6679.3
Sept. 12, 1959	6573.9	6677.9
Sept. 6, 1960	6574.1	6676.7
Sept. 3, 1962	6573.4	6673.2
Sept. 13, 1963	6769.1	6667.3

Ablation

Two ablation stakes were placed on July 9 and eight during the period July 26-28. The results of observations on September 12, September 26, and October 15 are shown in table 5. As indicated in the table, stake no. 4 had completely melted out by September 12, resulting in an ablation of over 13 feet since placed on July 9. As the snow depth was less than one foot at the time the stake was placed an ablation or loss of over 12 feet of ice occurred during a 65-day period. On September 26 all the stakes at no. 5 were lying on the glacier surface. These must have either been removed from the hole by a combination of floating and wind action or else by some passing tourist. A literal interpretation would indicate an ablation of almost 6 feet since the observation on September 12, a figure entirely inconsistent with all other observed data. Considering the 7 stakes with the 79-81 day record the average ablation for the period was 12.1 feet.

This is the fourth season that ablation stakes have been placed. The results observed in 1960, 1961, and 1962 were summarized in the 1962 progress report.

Table 5. Ablation, Grinnell Glacier, Montana

(1963 season)

Stake No.	Date placed	Depth of hole (feet)	Depth of snow (feet)	September 12, 13 ^{a/}		September 26		October 15		Season	
				No. of days b/	Ablation (feet)	No. of days b/	Ablation (feet)	No. of days b/	Ablation (feet)	No. of days c/	Ablation (feet)
1	July 26	16.4	2.0	48	10.3	14	1.7	19	1.0	81	13.0
2	July 27	19.7	4.0	47	10.4	14	0.9	19	1.5	80	12.8
3	July 27	14.4	10.0	47	10.3	14	0.6	19	1.0	80	11.9
4	July 9	13.1	0.7	65	13.1 d/	—	—	—	—	65	13.1
5	July 9	17.0	5.0	65	11.2	—	—	—	—	65	11.2
6	July 27	16.4	4.0	47	9.3	14	1.4	19	1.2	80	11.9
7	July 28	16.4	0.0	47	9.7	13	1.3	19	1.3	79	11.2.3
8	July 28	16.4	2.5	47	9.6	13	0.5	19	1.8	79	11.9
8A	July 28	19.7	All	47	10.1	13	0.4	—	—	60	10.5
9	July 28	16.4	2.5	47	10.8	13	0.5	19	0.9	79	12.2

a/ Stakes 1-6 measured on September 12.

Stakes 7-9 measured on September 13.

b/ Since previous observation.

c/ Since stake was placed.

d/ Stake completely melted out. Ablation somewhat more than 13.1 feet.

Movement

The results of the observations on movement since 1947 are shown graphically on figure 2-A. In 1963, eight previously marked rocks were relocated to determine movement during the year. In general, the 1963 observations were consistent with those of previous years. The observations to date indicate an average annual movement of from 35 to 50 feet per year, the greater rate being in the southern portion of the glacier.

Rock 50-1 showed a movement of 50 feet which is somewhat greater than in previous years. This is considered due to the fact that this rock is now on a steeper portion of the glacier and some sliding may have occurred. The usefulness of this rock as an indicator of movement is nearing an end. Consequently another rock, shown as 63-1 in figure 2-A, was located as a replacement.

Rock 58-1 is a flat slab roughly 4 feet square and about 1 foot thick. When first located this rock spanned a crevasse about 2 feet wide. In 1963 this crevasse was less than a foot in width.

Three additional rocks, designated as 63-2, 63-3, and 63-4, on figure 2-A were located for future observations. These should be useful indicators for the next 40 to 50 years.

It would be desirable during the 1964 season to select and locate one or two rocks near the original position of rock 50-2 but somewhat closer to the headwall for future observations. Also select and locate two or three suitable rocks about midway between 59-5 and the headwall.

Recession

The front or edge of the glacier bordering the lake showed a marked recession since 1962 as shown on figure 2-A. A projection or "nose" along the ice front that was very prominent in 1962 was barely noticeable in 1963. The 1963 shore line was 200 feet back from the point of the 1962 "nose". There was a definite recession of the ice front from the lake to about BM 6425, beyond which the 1963 front was much the same as in 1962.

Precipitation and Runoff

The two storage precipitation gages, established and maintained by the Weather Bureau and the National Park Service, one in 1949 and one in 1955, were continued in operation. The gaging station at the outlet of Grinnell Lake, established in 1949, and the one just below the glacier established in 1959, were also continued in operation. The results of the observations at the two precipitation gages, along with the runoff at the outlet of Grinnell Lake for corresponding periods are shown in table 6. The time of observations at the precipitation gages varies from year to year so the observed results are not strictly comparable on an annual basis. However, summer precipitation is usually rather low so the difference between the observed values and the values if observed on the same date each year would not be an appreciable percentage of the total. The amounts listed are therefore close to true annual values. Considering the 13-year period, July 21, 1950 to July 18, 1963, the average at gage no. 1 was 104.2 inches. The average annual runoff at the gaging station below Grinnell Lake

for the same period was 96.1 inches, or only 8 inches less than the observed precipitation at gage no. 1. This difference is probably low and as the runoff figures are more definite than the precipitation figures it would indicate that the catch at gage no. 1 is somewhat less than the average for the entire basin above the gaging station.

The relation between runoff at the gaging station below Grinnell Lake and the measured precipitation at the two gages varies appreciably from year to year. This relationship is strongly influenced by summer temperatures. High summer temperature following a winter of low snowfall could result in a high runoff value. Conversely a summer of low temperatures could result in a low value of runoff even though the snowfall for the preceding winter had been high.

The measured precipitation at gage no. 2, as in previous years, was much greater than at gage no. 1. For the 8 years of record available at these two gages the observed values for no. 2 average 50 percent greater than at no. 1. Year-to-year comparisons have varied from a minimum of 34 percent to a maximum of 65 percent. As stated in previous reports the differences in wind patterns, which in turn are influenced by the rugged mountain terrain are, no doubt, primarily responsible for the pronounced difference in catch at the two gages.

The gaging station immediately below the glacier (see figure 2) was placed in operation for the season on July 1. The recorder had continued in operation until January 8, following the last inspection on October 3, 1962. The stage discharge relation during portions of this period was affected by ice.

The results obtained thus far at this station are shown in table 7 and compared with the record for the corresponding months at the gaging station below the outlet of Grinnell Lake. The comparisons for the months of August and September are the most significant. The records for July, except for 1960 and 1963 are partly estimated as the station was not placed in operation until after July 1. Records for October and subsequent months are affected by ice and based to some extent on estimations. For the five seasons of record the runoff at the station below the glacier for August and September averaged 85 and 75 percent respectively of the corresponding values at the station below the outlet of Grinnell Lake. The August ratios varied from 75 to 96 percent and the September ratios from 54 to 88 percent. The area of the gaging station below the glacier is 32 percent of that at the gaging station below the outlet of Grinnell Lake.

Table 6. - Precipitation and runoff data in vicinity of Grinnell Glacier

Period	Number of days	Precipitation (inches) : A Gage No. 1 a/	B Gage No. 2 b/	Percent : B/A	Runoff (inches) : c/
Aug. 27, 1949-July 20, 1950	327	125.1	-		87.0
July 21, 1950-July 24, 1951	369	117.5	-		109.8
July 25, 1951-July 15, 1952	357	108.3	-		90.4
July 16, 1952-July 31, 1953	381	106.9	-		101.9
Aug. 1, 1953-Aug. 5, 1954	370	138.2	-		107.3
Aug. 6, 1954-Aug. 10, 1955	370	109.2	-		105.2
Aug. 11, 1955-Aug. 7, 1956	363	100.7	152.8 d/	152	98.5
Aug. 8, 1956-July 16, 1957	342	88.7	137.2	155	81.4
Aug. 17, 1957-July 17, 1958	365	78.9	115.8	147	84.0
July 18, 1958-Aug. 4, 1959	383	111.6	184.6	165	108.8
Aug. 5, 1959-July 21, 1960	352	107.7	166.6	155	91.6
July 22, 1960-Aug. 8, 1961	383	98.3	131.8	134	106.1
Aug. 9, 1961-July 26, 1962	352	87.1	121.4	139	73.3
July 27, 1962-July 18, 1963	356	101.1	157.6	157	90.7

a/ Measured at storage precipitation gage near end of horse trail 0.4 mile from glacier.

b/ Measured at storage precipitation gage about $\frac{1}{2}$ mile southeast of gage described in footnote a/.

c/ Measured at gaging station at outlet of Grinnell Lake.

d/ August 15, 1955 to August 7, 1956.

Table 7 . - Runoff Comparisons, Grinnell Creek
at Grinnell Glacier and Grinnell Creek
near Many Glacier (just below outlet
of Grinnell Lake)

	Grinnell Creek at Grinnell Glacier		Grinnell Creek near Many Glacier		Percent A/B
Month	Runoff		Runoff		
	Acre-feet A	Inches	Acre-feet B	Inches	
July 1959	2460	41.93	4310	23.27	57
August	1700	28.98	2260	12.21	75
September	1230	20.97	2280	12.29	54
October 1959	662	11.29	1500	8.09	44
July 1960	2770	47.30	4180	22.57	66
August	1700	28.98	2080	11.23	82
September	975	16.62	1190	6.44	82
October	351	5.98	599	3.24	59
November 1960	115	1.96	336	1.81	34
July 1961	2570	43.88	3500	18.90	73
August	2260	38.51	2360	12.75	96
September	666	11.35	944	5.10	71
October	1190	20.20	2530	13.65	47
November 1961	51	0.87	403	2.18	13
July 1962	2090	35.57	2820	15.25	74
August	1840	31.37	2170	11.74	85
September	729	12.42	935	5.05	78
October	529	9.01	1050	5.65	50
November	329	5.60	664	3.59	50
December 1962	113	1.93	403	2.18	28
July 1963	2310	39.39	3650	19.72	68
August	1860	31.78	2170	11.71	86
September 1963	1350	23.09	1530	8.25	88

Drainage Areas

Square miles	Acres	Square miles	Acres
1.10	704	3.47	2221

SPERRY GLACIER

Surface Changes

Profiles

Cross Profile

As indicated in table 8 there was no significant difference between 1963 and 1962 for this profile. The 1963 measurement was 9 days later than in 1962. If measured on comparable dates the 1963 profile would probably have been slightly above that for 1962. From station 300 to 1200 (distance in feet from reference point) the 1963 surface was slightly above that for 1962, the maximum difference being about 4 feet. From station 1200 to 3000 the 1963 surface was coincident with or slightly below the 1962 surface. Beyond 3000 the 1963 surface was slightly above that for 1962. The lowest part of the profile, as in previous years, was between station 1750 and 1850. It was lower by one or two feet than in 1962, but not quite as low as in 1961.

An examination of table 8 shows that the 1961 profile was lower than in any other year of observation. The average net decrease for the entire profile since 1949, the first year of measurement, was 6 feet. The difference was most pronounced in the middle portion of the glacier, from station 1100 to 2100, in which the average difference was 10 feet. During the period of record the changes between successive measurements have been both positive and negative with no particular trend indicated. This profile for the years 1950, 1957, and 1961, is shown on figure 3.

Table 8 - Mean elevations, Sperry Glacier,
Cross profile.

Date	Distance from reference point, feet							
	100-1,100		1,100-2,100		2,100-3,100		100-3,100	
	Mean elev. ft.	Change ft.	Mean elev. ft.	Change ft.	Mean elev. ft.	Change ft.	Mean elev. ft.	Change ft.
Aug. 30, 1949	7598.9		7535.1		7593.6		7575.9	
Sept. 19, 1950		- 1.0		- 0.6		+ 0.7		- 0.4
Aug. 19, 1952	7597.9	+ 5.6	7534.5	+ 4.5	7594.3	+ 6.1	7575.5	+ 5.5
Aug. 23, 1956	7603.5	+ 3.5	7539.0	+ 0.9	7600.4	+ 3.1	7581.0	+ 2.4
Sept. 14, 1957	7607.0	- 5.4	7539.9	- 5.7	7603.5	- 8.1	7583.4	- 6.3
Aug. 16, 1958	7601.6	- 4.9	7534.2	- 5.4	7595.4	- 4.8	7577.1	- 5.1
Aug. 18, 1959	7596.7	+ 3.6	7528.8	+ 2.3	7590.6	+ 2.3	7572.0	+ 2.8
Sept. 14, 1961	7600.3	- 4.3	7531.1	- 6.1	7592.9	- 5.1	7574.8	- 5.2
Aug. 30, 1962	7596.0	+ 2.3	7525.0	+ 1.1	7587.8	+ 0.6	7569.6	+ 1.3
Sept. 8, 1963	7598.3	+ 1.2	7526.1	- 0.3	7588.4	- 0.4	7570.9	+ 0.2
	7599.5		7525.8		7588.0		7571.1	

Profile No. 1 (Longitudinal)

The upglacier section of profile no. 1 was essentially the same in 1963 as in 1962. The downglacier section in 1963, except for a short distance, was below 1962 throughout. The crest of the ridge, which roughly parallels the front of the glacier, was two to three feet lower than in 1962, and was 20 to 30 feet upglacier from the 1962 position. The trough was two to three feet lower at the lowest point. In the first 1,000 feet downglacier from the initial point the 1963 surface was three to four feet lower than in 1962 except for the one short distance above mentioned where the 1963 and 1962 surfaces were essentially the same. From station 1000 to the front of the glacier the difference between the 1963 and 1962 surfaces increased, and in the first 100 feet back from the front the difference was as much as 15 or 16 feet. Only the downglacier section of profile 1 for 1963 has been shown on figure 3 for sake of clarity. The front on the profile alignment showed a recession of 40 feet since 1962. There was an ice tongue beyond this point but this appeared to be residual snow rather than part of the main glacier. It is of interest to note the steady and continual lowering of the downglacier section of this profile whereas the upglacier stays much the same, fluctuating within rather narrow limits. This seems to indicate a continuing shrinkage in the lower portion of the glacier that is not evident in the upper portion.

The data for the years of record for this profile are shown in table 9.

Table 9. - Mean elevations, Sperry Glacier, Montana

Longitudinal profile No. 1

Date	Distance from reference point, feet						
	Downglacier				Upglacier		
	1500-1700	1000-1500	500-1000	0-500	0-500	500-800	500-1000
	Mean elev. & change ft.	Mean elev. & change ft.	Mean elev. & change ft.	Mean elev. & change ft.	Mean elev. & change ft.	Mean elev. & change ft.	Mean elev. & change ft.
Aug. 30, 1949	---	---	7449.2 - 1.6	7492.4 - 1.2	7569.9 + 0.8	---	---
Sept. 19, 1950	7331.6 - 7.3	7398.2 - 1.2	7447.6 + 5.0	7491.2 + 2.3	7570.7 + 5.3	7663.0 + 8.8	---
Aug. 19, 1952	7324.3 -34.1	7397.0 -19.4	7452.6 + 1.2	7493.5 - 5.3	7576.0 + 1.0	7671.8 + 4.9	---
Aug. 23,24, 1956	7290.2 -10.8	7377.6 - 9.0	7453.8 - 8.0	7488.2 - 7.2	7577.0 - 4.7	7676.7 - 2.9	7716.1 - 2.1
Sept. 14, 1957	7279.4	7368.6 - 9.6	7445.8 - 5.0	7481.0 - 6.6	7572.3 - 5.0	7673.8 - 4.9	7714.0 - 4.5
Aug. 17, 1958	---	7359.0	7440.8	7474.4 - 0.1	7567.3 + 2.9	7668.9 + 4.0	7709.5 + 3.7
Aug. 18, 1959	---	---	---	7474.3 - 9.7	7570.2 - 5.5	7672.9 - 4.9	7713.2 - 6.3
Sept. 14,15, 1961	---	---	7434.8 + 1.0	7464.6 + 1.3	7564.7 + 3.3	7668.0 + 4.9	7706.9 + 6.2
Aug. 30, 1962	---	---	7435.8 - 3.2	7465.9 - 3.2	7568.0 - 0.6	7672.9 + 0.4	7713.1 - 1.0
Sept. 8, 1963	---	---	7432.6	7462.7	7567.4	7673.3	7712.1

Ablation

Eight ablation stakes were placed during the period July 31 - August 4, located as shown in figure 4. The results of measurements on September 8 (or 9) and on October 18 are shown in table 10. From the time the stakes were placed until the observations on September 8 or 9, (35 to 39 days) the ablation varied from 6.5 feet to 8.4 feet, or an average of 7.5 feet (reading at stake 3 was inconsistent on September 8). Five stakes were observed on October 18. The ablation for the season (75-78 days) varied from 8.4 to 11.7 feet, averaging 10.1 feet. The observations at stakes 5 and 6, on September 9, were of particular interest as the stakes set in 1961 were found. The net change at stake 5 was 2.6 feet and at stake 6 it was 2.1 feet. This would indicate that in this area of the glacier each winter's snowfall lasts through most of the following summer protecting the "old ice" of the glacier.

Movement

Two previously marked rocks near the center of the glacier, 49-2 and 49-4 (see fig. 4) were located. Each showed a movement of slightly less than 15 feet since 1962. These two rocks have moved about 190 feet in the 14-year period since first located in 1949, averaging just under 14 feet per year. The "unmarked rock" showed a slightly greater movement than in previous years and this is more likely due to sliding rather than an increase in rate of movement. As above noted, stakes 5 and 6, which were placed in 1961, were located. Stake 6 showed a

movement of 15 to 20 feet. This movement was roughly parallel to the axis of the ridge rather than normal to the front of the glacier. Stake 5-1961 was only approximately located and indicated a movement of approximately 30 feet, in essentially the same direction as noted for stake 6. The amount and direction of movement in this section of the glacier is somewhat surprising as moving down the slope toward the front there are a number of crevasses.

Recession

The right half of the front of this glacier was mapped. The change since 1961 was irregular, but the general trend was toward recession. The left half of the front was not mapped but appeared much the same as in 1961.

Table 10. Ablation, Sperry Glacier, Montana
(1963 season)

Stake No.	Date placed	Depth of hole (feet)	Depth of snow (feet)	September 8		October 18		Season	
				No. of days <u>a/</u>	Ablation (feet)	No. of days <u>a/</u>	Ablation (feet)	No. of days <u>b/</u>	Ablation (feet)
1	July 31	16.4	2.5	39	7.5	—	—	39	7.5
2	July 31	16.4	2.5	39	6.8	—	—	39	6.8
3	Aug. 1	16.4	10.0 <u>c/</u>	—	—	78	9.8	78	9.8
3 A	Aug. 2	19.7	<u>d/</u>	37	6.5	—	—	37	6.5
3 B	Aug. 2	19.7	13.0 <u>c/</u>	37	6.9	40	1.5	77	8.4
4	Aug. 2	13.1	1.0	37	8.1	40	2.1	77	10.2
5	Aug. 4	19.7	13.0 <u>c/</u>	35	8.4	40	3.3	75	11.7
6	Aug. 4	16.4	<u>d/</u>	35	8.0	40	2.4	75	10.4

a/ Since previous observation.

b/ Since stake was placed.

c/ Approximate.

d/ Entire depth of hole.



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