

1954 GLACIER MEASUREMENT REPORT

ROCKY MOUNTAIN NATIONAL PARK
Estes Park, Colorado

By

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and
Edwin C. Alberts, Park Naturalist
Rocky Mountain National Park

December 1, 1954



UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

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Introduction

Surveys of Tyndall and Andrews Glaciers were initiated in 1932, and these surveys have been made annually since that time, excluding the years of 1936 and 1943. Five small glaciers are included within the boundaries of Rocky Mountain National Park, but three of these glaciers - Rowe, Sprague, and Taylor - are rather inaccessible and not well adapted to the present methods of measurement. In addition, the relative locations of Tyndall and Andrews Glaciers make it feasible to include both glaciers in a one day trip, and they represent the extremes in exposure, topographic position, and degree of slope of the five glaciers. That is, Tyndall Glacier is one of the glaciers which is reposing on a slope with an extreme angle that protects it from sun and wind. On the other hand, Andrews Glacier is situated on a slope of low angle, relative to the other glaciers in the park, and this low angle slope gives maximum exposure to sun and wind.

The 1954 glacier measurement trip was made on August 30, 1954, by four members of the naturalist staff, one member of the ranger staff and thirty-five park visitors. The measurement party was under the direction of Seasonal Park Naturalist J. Herbert Heger, assisted by Ranger-Naturalist Frank R. Beck and Ranger T.F. Hornbein. The party left Bear Lake at 6:30 A.M. and ascended Tyndall Gorge to the base of Tyndall Glacier, where the first measurements were made. The visitor group, conducted by Ranger-Naturalists Albert Razum and Joan Seear, left Bear Lake at 7:30 A.M. and followed the customary route up the Flattop Mountain trail to the head of Tyndall Gorge, where they joined the measurement party.

The weather on August 30, 1954, was fair and calm until about 11:00 A.M. Throughout the rest of the day the skies were alternately cloudy and clear. However, unusually warm weather persisted and no strong winds were noted.

Methods of Measurement

Since the advent of annual glacier surveys in 1932, the only data that have been obtained are measurements concerning the actual fluctuations of the glaciers' assumed termini. With this end in view, the first survey party devised a simple system of measurements from fixed stations to the nearest ice which lends itself to rapid checking. However, this simple system is very inaccurate and it is useful only in qualitative observations. The present system consists of two types of qualitative measurements:

1. Photographs of the changes in configuration of the glaciers' termini and changes in areal extent of the glaciers.
2. Linear measurements from previously established stations to the nearest exposures of presumed glacial ice at the glaciers' termini, which are arbitrarily designated as the "snouts" of the glaciers. These measurements are of little value because:
 - A) of the arbitrary designation of the "snout"
 - B) the supposedly "fixed" stations are located on morainal blocks which are subject to displacement.
 - C) the linear measurements are along the ground slope and at an oblique angle to the line of retreat or advance of the glaciers' termini.

A study of the figures in tables II and III will show that the only conclusion which can be drawn from the present data is that the glaciers seem to be retreating slowly, although there have been occasional minor advances during years of unusually heavy snowfall.

These figures are extremely erratic because determination of the true "snouts" of the glaciers, particularly of Tyndall Glacier, is almost impossible.

In recent years the scientific observation of the advance or retreat of glaciers has become an increasingly important supplement to direct meteorological observations of climatic variations. The author suggests that the following methods of measurement would be desirable in future glacier surveys:

1. Photographs of the areal extent of the glaciers. Continuance of this type of observation will be valuable in determining to what extent exposure to sun and wind, topographic position, shape, etc., have on the configuration of the glaciers.
2. Establishment of a line of stakes across the center of the glaciers by standard triangulation methods to determine the rate of flow of the glaciers. A row of six metal stakes was placed across the face of Tyndall Glacier in 1953, but apparently melted out of the ice by the summer of 1954. It is probable that the metal stakes conducted too much heat from the sun, and future stakes should be at least six feet long or constructed from high grade hard wood with pointed metal tips.
3. Stadia measurements of the termini of the glaciers by means of a plane table and alidade. Measurements by this method will accurately establish the presumed termini, permit accurate mapping of the termini, provide quantitative data regarding gain or loss in volume, and more detailed data regarding advance or retreat of the termini. As a rough estimate, adequate stadia measurements would require a minimum of three men - one instrument man and two rod men - and for at least two days for each glacier.
4. If funds were available, thermal bore holes should be drilled to bedrock beneath the glaciers in order to determine the total volume of the glaciers and configuration of the floor of the glaciers. Although this type of data is of scientific importance, it would not be absolutely necessary for the small glaciers that are extant in the Park. The cost estimate would be about

\$1,000 or more, and require the services of at least one technician. It might be more feasible to determine depth of the ice and configuration of the cirque by means of seismic equipment.

Tyndall Glacier

The weather was unusually warm when the measurement party reached the snout of Tyndall Glacier, and copious flows of water issued from the snout of the glacier. It was quite evident that there had been a definite loss in ice volume since 1953. Two of the nunataks (see plate I) that were quite prominent in 1953 are no longer surrounded by glacial ice; therefore, they cannot be classed as nunataks this year. Little or no contemporary snow was noted on Tyndall Glacier, and, in the author's opinion, more glacial ice is exposed in 1954 than at any time since the advent of the glacier surveys.

The usual problem of determining the true snout of the glacier was encountered by the 1954 measurement party. However, it was definitely established that glacial ice does extend under the morainal debris at Tyndall Glacier although the actual distance that the ice extends under the debris is indeterminable. Solid glacial ice was observed in about four areas beyond the exposed snout where overlying outwash material had been swept away by the surface melt water from the glacier. The slope distance from station X to the nearest ice was 66'6". A recession of 6'6" since 1953, measured at an oblique angle to the line of recession. The slope distance from station X' to the snout was 96'6". A recession of 6'6" since 1953, also measured at an oblique angle to the line of recession. The amount of rock debris covering the snout is considerably greater in 1954 than it was in 1953 (see plates 5 and 6). Most of this debris is evidently old material, not from rock falls within the last year, because the surfaces of the debris are rather highly weathered. The author believes that this material has been covered by contemporary snow in past years. At the farthest extent of the snout, where the ice was exposed, the ice was three feet thick and contained boulders up to one foot in diameter.

One of the most interesting features that was observed in 1954 was a large ice cave at the southeastern edge of the glacier (see plate 7). This ice cave was approximately 200 feet long, 6-10 feet high, and 30 ft. deep (see plate 8). Boulders up to three feet in diameter were exposed in the roof of the cave. Blue ice and a "marble" effect were observed in some portions of the cave roof. The individual layers of the "marble" effect averaged about six inches in

thickness. At the back of the cave the roof sloped off abruptly to a height of one foot above the cave floor, and then extended for an unknown distance back under the glacial ice.

The bergschrund area at the head of Tyndall Glacier was better exposed than in 1953 (see plates 1 and 9). Hornbein examined the bergschrund, and he estimated it to be 175 yards long, a maximum of 50-60 feet wide, and a maximum of 50-60 feet deep.

In 1953 Mr. Hornbein set a row of six metal stakes across Tyndall Glacier, which were to be used, in 1954 and subsequent years, to give a clue to the rate of movement of Tyndall Glacier. However, a thorough examination of the glacier in 1954 by Mr. Hornbein failed to disclose any of these metal stakes. Therefore, it was not possible to make any measurements regarding the rate of movement of Tyndall Glacier.

Tyndall Glacier is located on an extremely steep slope, and the upper surface of the ice has a maximum slope of 65° gradually diminishing to a slope of 20° at the snout.

Andrews Glacier

The weather had become cloudy, but remained unseasonably warm, when the measurement party arrived at the snout of Andrews Glacier. Large quantities of water were issuing from the snout of the glacier, and there was little or no contemporary snow on the surface of the glacier. In contrast to the surface slope of Tyndall Glacier, the surface slope of Andrews Glacier is a maximum 25° at the lower end, and a minimum of 15° at the upper end of the glacier.

For the first time, to the author's knowledge, the snout of Andrews Glacier was above the level of the lake, therefore, the maximum extent of the glacial snout was easily determined (see plate 12). The slope distance from station X''' to the snout of the glacier was 92'6", an apparent recession of 46'6" since 1953 (see table III). However, this particular measurement is made in a line nearly perpendicular to the line of retreat of the glacier and since in previous years the snout of the glacier has extended into the lake, the snout was designated as the farthest extent of ice above the level of the lake. The slope distance from station X' to the snout of the glacier was 160'0". This is an apparent advance of seven feet since 1953. However, this is only an approximation because the farthest extent of the snout was at less of an oblique angle from station X' than it was in 1953 (see plate 10).

The delta at the snout of Andrews Glacier was more fully exposed in 1954 than in 1953 (see plate 13), partly because of the recession of the snout and partly because the level of the lake had dropped approximately twelve inches (station X' was exposed above the water, see plate 15). The water issuing from the snout of the glacier was carrying a heavy burden of glacial flour and silt, and the lake into which the water emptied was quite milky in color.

The most interesting feature that was observed on Andrews Glacier was the rather marked shrinkage along the lateral edges of the glacier, particularly the southern margin (see plate 10), and the resultant exposure of about twelve crevasses on the southern margin of the glacier (see plate 15). The crevasses were first observed in 1953, but at that time they were rather small. Most of the crevasses in 1954 were confined to the trough along the southern margin of the glacier (see plate 15). These smaller crevasses are approximately 50 feet long, a maximum of 6 feet wide, and a maximum of 25 feet deep. However, near the upper end of the glacier there are two extremely large crevasses (see plates 10 and 15). The higher of these two crevasses extends clear across the surface of the glacier, but it is a maximum of only three feet wide and thirty feet deep (see plate 15). The other large crevasse (see plate 15) extends about half way across the glacier, and it is a maximum of 6' wide and 150 ft. deep (see plates 15 and 16).

Although the true snout of Andrews Glacier is more easily determined than that of Tyndall Glacier, the linear measurements are just as erratic and inaccurate because of the extreme angles between the lines of measurement and the line of retreat of the glacial ice. However, the photographs definitely indicate a decrease in size and volume of both Tyndall and Andrews Glaciers since the 1953 survey.

TABLE I
WEATHER STATISTICS

<u>MONTH</u>	<u>TEMPERATURES</u>				<u>PRECIPITATION</u>	
	<u>Mean</u> <u>Max.</u>	<u>Mean</u> <u>Min.</u>	<u>Days 90°</u> <u>or over</u>	<u>Days 32°</u> <u>or lower</u>	<u>Total</u>	<u>Max. Snow</u> <u>on ground</u>
<u>Estes Park</u>						
July 1953	78.8	45.0	0	0	3.09	0
August 1953	75.2	43.1	0	0	2.08	0
September 1953	73.5	36.3	0	11	0.58	0
1954 "Season"						
October 1953	62.0	25.8	0	26	0.36	0
November 1953	49.3	24.2	0	25	0.65	0
December 1953	37.9	15.2	0	30	0.29	T
January 1954	44.0	21.5	0	28	0.16	3"
February 1954	50.6	25.2	0	21	0.06	T
March 1954	41.7	15.2	0	29	0.82	T
April 1954	61.8	31.2	0	19	0.34	T
May 1954	63.1	34.7	0	11	0.85	0
June 1954	75.9	40.8	2	4	0.46	0
July 1954	81.5	49.5	0	0	2.33	0
August 1954	77.4	44.4	0	0	1.22	0
September 1954	72.0	40.0	0	4	2.31	0
1954 "Season"						
Means & Totals	59.8	30.6	2	197	9.85"	-
<u>Grand Lake</u>						
July 1953	74.8	36.7	0	9	4.20	0
August 1953	71.0	35.3	0	13	3.93	0
September 1953	71.1	25.8	0	27	0.24	0
1954 "Season"						
October 1953	59.4	20.4	0	30	0.46	2"
November 1953	45.4	14.0	0	30	1.62	9"
December 1953	28.9	0.6	0	31	1.02	15"
January 1954	36.4	6.3	0	31	0.66	20"
February 1954	41.3	8.2	0	28	0.45	17"
March 1954	38.0	8.7	0	31	2.38	24"
April 1954	54.7	21.0	0	30	0.70	1"
May 1954	61.8	26.3	0	29	1.03	0
June 1954	71.3	30.3	0	20	1.16	0
July 1954	77.5	39.4	1	0	2.82	0
August 1954	74.5	34.2	0	14	2.80	0
September 1954	69.6	31.1	0	16	2.49	0
1954 "Season"						
Means & Totals	54.9	20.0	1	290	17.59	-

TABLE I-A

The 1954 "Glacier Season" was universally considered unusually dry, and it was expected that the glaciers would have a minimum of contemporary snow cover. That it was unusually dry is borne out by the following data:

<u>Year</u>	<u>Estes Park</u>	<u>Grand Lake</u>
1954 (Oct. 1953 - Sept. 1954, inc.)	9.85"	17.59"
1953 (July 1952 - Sept. 1953, inc.)	15.38"	26.43"
1952 (July 1951 - June 1952, inc.)	17.41"	27.63"
1951 (Aug. 1950 - June 1951, inc.)	12.00"	16.01"
1950 (Aug. 1949 - July 1950, inc.)	10.15"	15.27"
1949 (Aug. 1948 - July 1949, inc.)	20.04"	19.16"
1948 (Sept. 1947 - July 1948, inc.)	15.1"	21.1"

Table II

Tyndall Glacier

<u>Year</u>	<u>Station X to "Ice"</u>	<u>Station X' to "Ice"</u>
1932	-	30'8"
1933	-	63'4"
1934	-	72'5"
1935	-	38'6"
1936	-	No measurements
1937	-	196'9"
1938	-	62'4"
1939	-	105'4"
1940	-	56'0"
1941	-	No measurements
1942	-	0'0"
1943	-	No measurements
1944	-	56'3"
1945	-	54'4"
1946	-	112'11"
1947	-	5'0" (estimated)
1948	-	260'0"
1949	-	106'0"
1950	94'	110'0"
1951	3'	10'0"
1952	54'	50'0"
1953	60'	90'0"
1954	66'6"	96'6"

Table III

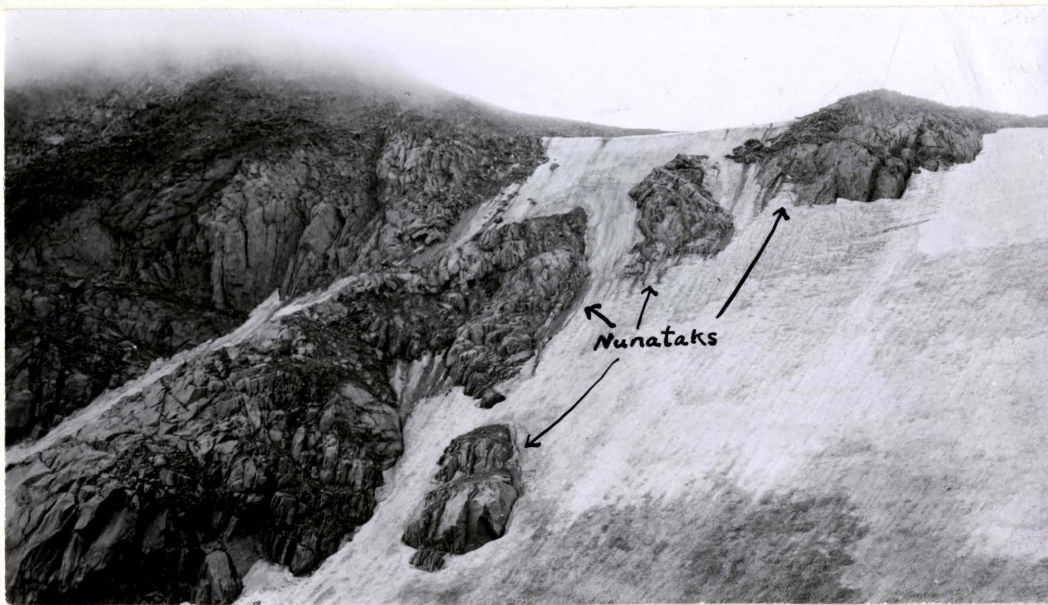
Andrews Glacier

<u>Year</u>	<u>Station X' to "Ice"</u>	<u>Station X''' to "Ice"</u>
1932	48'7"	-
1933	58'10"	-
1934	139'0"	-
1935	66'0"	-
1936	No measurements	-
1937	96'10"	-
1938	32'3"	48'11"
1939	92'0"	23'0"
1940	170'0" (estimated)	16'9"
1941	212'5"	54'3"
1942	155'8"	49'1"
1943	No measurements	No measurements
1944	253'0"	79'2"
1945	210'6"	65'7"
1946	224'9"	60'8"
1947	201'9"	66'0"
1948	210'0"	56'0"
1949	164'0"	64'0"
1950	194'0"	68'0"
1951	165'0"	63'0"
1952	142'0"	81'0"
1953	167'0"	46'0"
1954	160'0"	92'6"

TABLE IV

SNOW DEPTHS AND WATER CONTENT FOR PARK

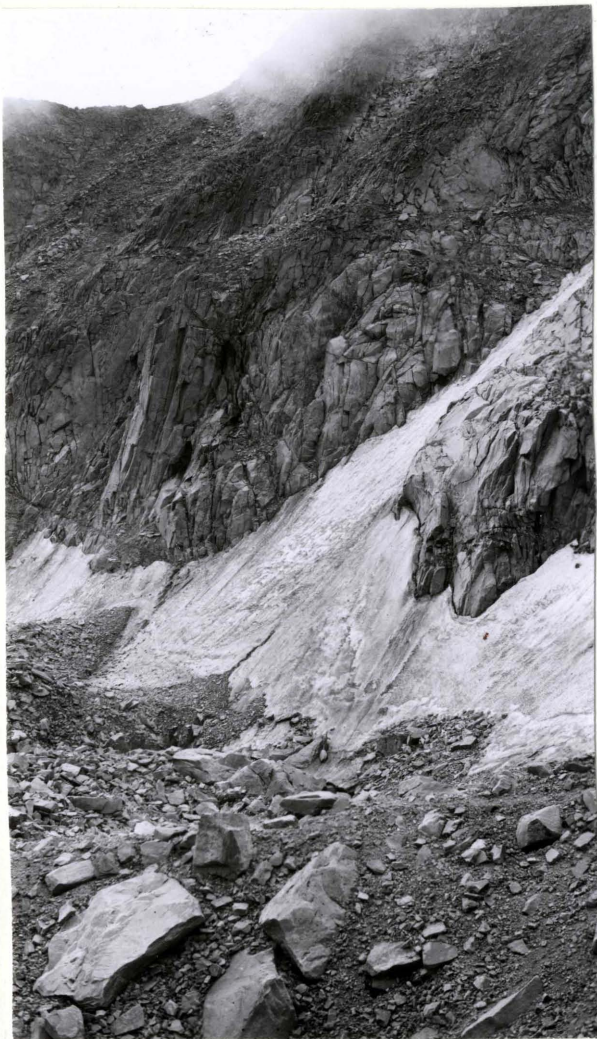
Dates	1954		1953		Means		No. Yrs.
	Snow D.	H ₂ O	Snow D.	H ₂ O	Snow D.	H ₂ O	
#116 - Copeland Lake (Alt. 8,600')							
Jan. 31	"Not enough snow"		11.40"	2.60"	22.24"	5.22"	5
Feb. 28	"Not enough snow"		18.30"	4.80"	20.27"	5.89"	5
Mar. 31	14.36"	4.27"	13.45"	3.27"	19.38"	5.94"	6
Apr. 30	"Not enough snow"		5.54"	2.27"	5.47"	2.24"	6
#41 - Wild Basin (Alt. 10,000')							
Jan. 31	25.50"	5.50"	28.10"	6.30"	32.52"	8.22"	16
Feb. 28	31.51"	7.80"	40.50"	10.75"	40.12"	10.84"	16
Mar. 31	45.24"	11.49"	45.08"	13.13"	46.76"	14.28"	16
Apr. 30	23.55"	7.38"	39.88"	15.04"	39.80"	14.41"	16
#115 - Deer Ridge (Alt. 9,050')							
Jan. 31	"Not enough snow"		13.50"	2.50"	20.90"	4.70"	5
Feb. 28	"Not enough snow"		17.50"	4.20"	22.16"	6.00"	5
Mar. 31	14.40"	4.00"	11.14"	3.36"	22.25"	6.28"	6
Apr. 30	"Not enough snow"		10.57"	3.78"	12.37"	3.86"	5
#95 - Hidden Valley (Alt. 9,550')							
Jan. 31	26.40"	5.70"	27.50"	5.30"	30.78"	6.92"	14
Feb. 28	26.50"	6.20"	32.00"	8.00"	36.90"	9.05"	14
Mar. 31	45.70"	10.78"	31.93"	9.36"	43.42"	12.19"	14
Apr. 30	26.92"	7.07"	41.28"	13.64"	43.74"	13.30"	14
#127 - Grand Lake (Alt. 8,600')							
Jan. 31	20.58"	3.50"	30.00"	4.92"	31.79"	6.46"	6
Feb. 28	20.12"	3.54"	27.90"	6.33"	32.17"	7.80"	6
Mar. 31	29.87"	6.00"	27.58"	5.92"	36.05"	9.32"	6
Apr. 30	"Not enough snow"		12.30"	3.80"	17.10"	5.80"	5
#64 - North Inlet (Alt. 9,000')							
Jan. 31	--	--	30.08"	6.18"	24.89"	5.82"	15
Feb. 28	21.38"	4.33"	--	--	30.27"	7.41"	16
Mar. 31	32.50"	6.70"	28.00"	8.45"	33.44"	9.62"	16
Apr. 30	"Not enough snow"		22.75"	7.60"	23.35"	7.66"	16
#12 - Phantom Valley (Alt. 9,038')							
Jan. 31	21.28"	4.28"	30.06"	6.65"	26.22"	5.97"	18
Feb. 28	20.09"	4.34"	32.75"	9.25"	32.81"	8.44"	18
Mar. 31	36.56"	9.12"	29.03"	8.18"	34.98"	10.19"	18
Apr. 30	"Not enough snow"		19.50"	7.31"	19.49"	7.02"	18
#65 - Lake Irene (Alt. 10,600')							
Jan. 31	42.07"	11.53"	--	--	48.65"	13.24"	15
Feb. 28	50.68"	13.32"	56.35"	18.42"	59.05"	17.89"	17
Mar. 31	69.50"	17.14"	53.75"	20.43"	66.17"	21.85"	16
Apr. 30	48.20"	16.85"	59.89"	23.07"	63.64"	24.04"	16



Tyndall Glacier from P-3. Bergschrund and nunataks at head of Glacier.
August 28, 1953



Tyndall Glacier from near P-3 showing bergschrund and nunataks at head of glacier. August 30, 1954



General view of the southeastern
end of Tyndall Glacier from P-1.
August 28, 1953.



General view of the southeastern
end of Tyndall Glacier.
August 30, 1954.





Recessional moraine at the base of Tyndall Glacier, showing stations X and X'. August 28, 1953.



Recessional moraine at the base of Tyndall Glacier, showing stations X and X' and the snout of the glacier. August 30, 1954.



Recessional moraine at base of Tyndall Glacier, taken from snout of glacier, showing stations X and X'. August 28, 1953.



Recessional moraine at base of Tyndall Glacier, taken from snout of glacier, showing stations X and X'. August 30, 1954.

Same view did not turn out in 1953.



General view of snout of Tyndall Glacier from P-2 looking north, showing stations X and X'. August 30, 1954.

Same view did not turn out in 1953.



General view of snout of Tyndall Glacier from station X, showing farthest extent of exposed ice. August 30, 1954.



View from P-1 looking south, showing ice snout, stations X and X', and entrance to small ice cave. August 28, 1953.



View from P-1 looking south, showing ice snout, stations X and X', and entrance to large ice cave. August 30, 1954.



General views inside large ice cave at southeastern end of Tyndall Glacier. August 30, 1954.



General view, looking south, of the bergschrund at the head of Tyndall Glacier, taken from the head of Tyndall Gorge. August 30, 1954.



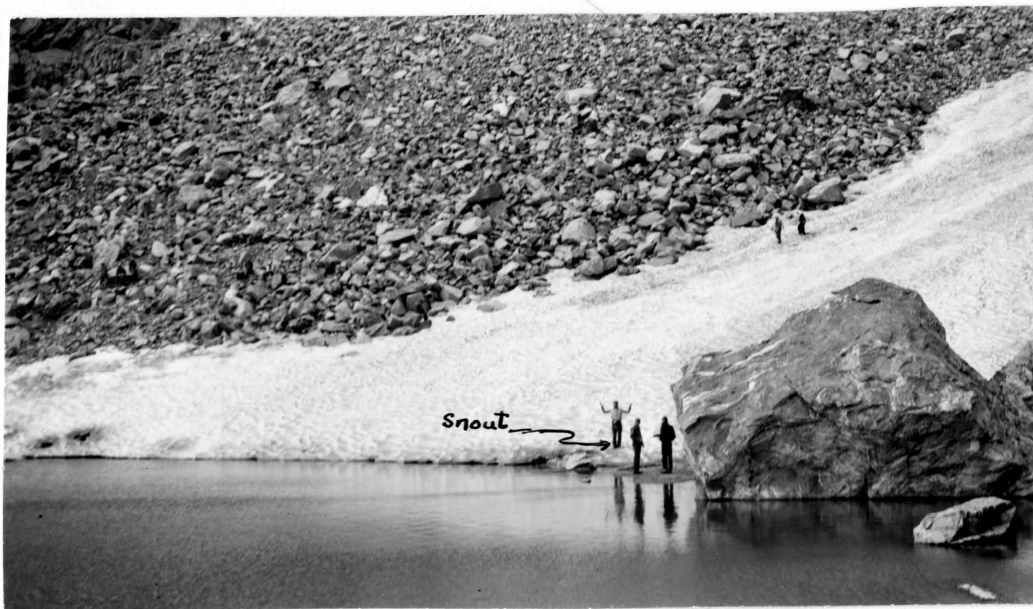
General view of the bergschrund at the head of Tyndall Glacier, taken from the snout of the glacier looking east. August 30, 1954.



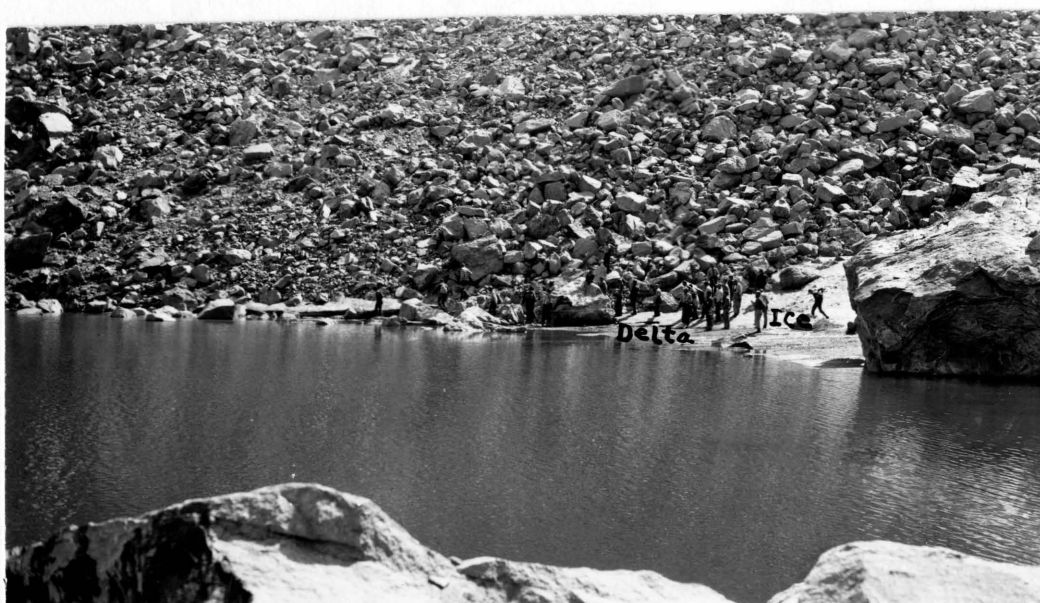
General view, looking west across the lake, showing stations X' and X'''. August 28, 1953.



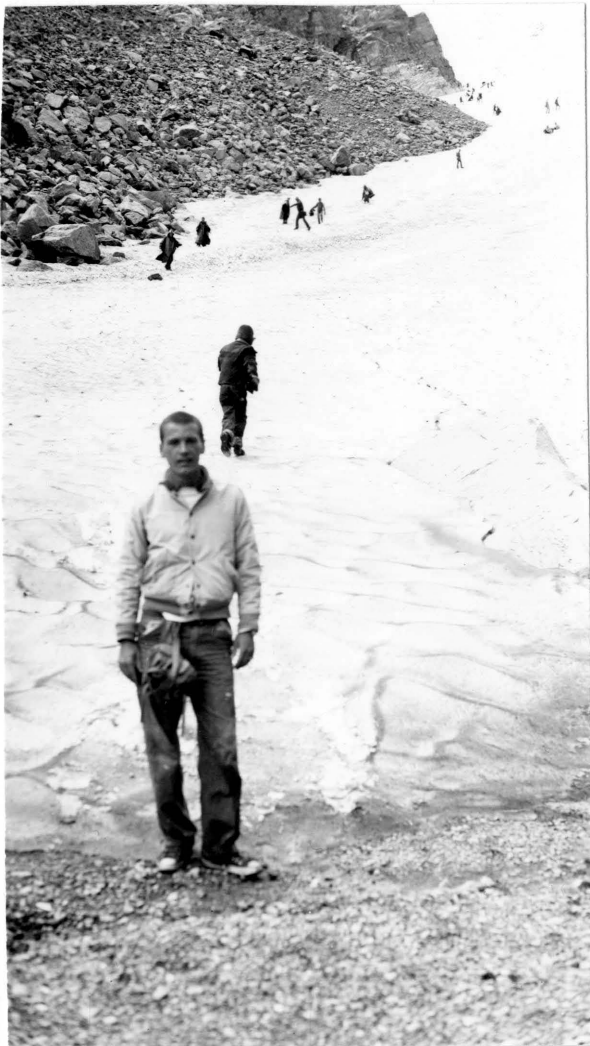
General view, looking west across the lake, showing stations X' and X''', the snout of the glacier and the two largest crevasses. August 30, 1954.



General view, looking southwest from near the position of the snout underwater to the point of measurement. August 28, 1953.



General view from near the same point as above showing the contact between the exposed delta and the glacial ice. August 30, 1954.



General view looking up glacial
snout from delta. August 28, 1953.



General view looking up glacial snout
from delta. August 30, 1954.



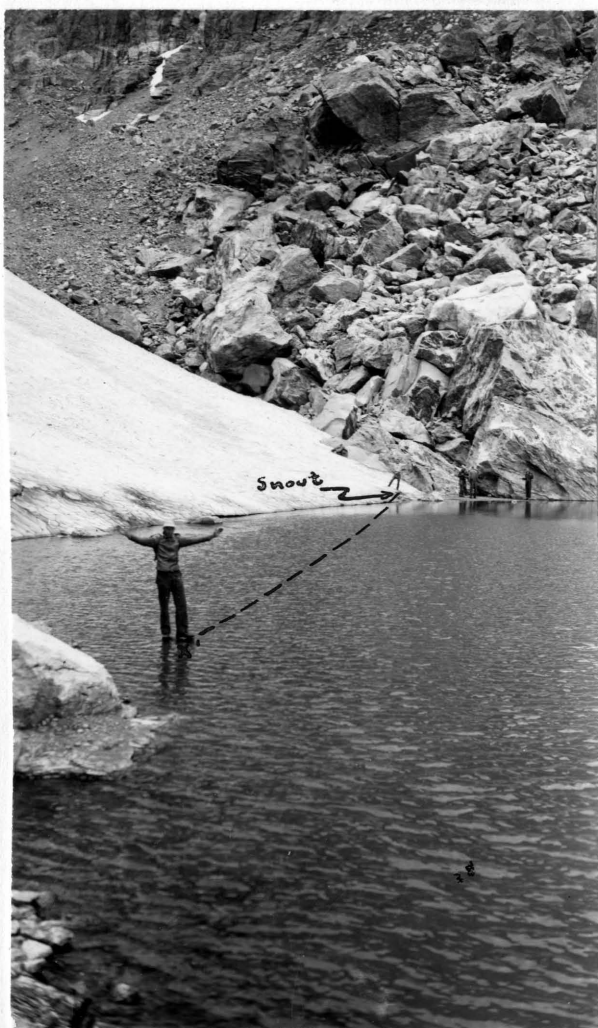


View south, showing position of snout and station X'. Taken from near station X'''. August 28, 1953.



View south from near station X''', showing position of station X' and the contact of glacial ice with the delta. August 30, 1954.





View along line of measurement
from station X'. August 28,
1953.



View along line of measurement from
station X', showing contact of glacial
snout and delta. August 30, 1954.





View down glacier to lake. August 28, 1953



View down glacier, showing contact between glacial ice and delta.
August 30, 1954



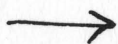
General view west along the southern margin of the glacier showing the crevasses. August 30, 1954.

Detailed view of the deepest crevasse looking north from bedrock. August 30, 1954.





Detailed view from top of deepest
crevasse looking down to bedrock.
Compare with photograph on plate 16.
August 30, 1954.



Detailed view from under the
deepest crevasse looking up.
August 30, 1954.

