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UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

----- NATIONAL PARK

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1940

GLACIER SURVEY

ROCKY MOUNTAIN NATIONAL PARK

by -----

H. R. Gregg
Park Naturalist

F. E. MATTHES COLLECTION

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ARNO B. CAMMERER,
Director.

MAT-1940-2

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
ROCKY MOUNTAIN NATIONAL PARK
ESTES PARK, COLO.

November 29, 1940

Dr. Francois E. Matthes,
U.S. Geological Survey,
Washington, D. C.

Dear Dr. Matthes:

Enclosed is the 1940 report on glaciers in Rocky Mountain National Park.

This year, due to an injury, I found it impossible to make the measurement trip, sending one of the ranger-naturalists on our staff in my place. As a result, he made some of the measurements on the basis of our discussions and review of the previous reports and photographs, and failed to take exactly the same comparative data that I would have obtained had I made the survey personally. As a result, the complete accuracy of the data is questionable, but the general trends indicated by the data, except for suggested advance of Tyndall Glacier, are substantial. The photographs probably make up in completeness for the inaccuracy of the detailed data.

Thanks again for the copy of the 1939 Committee report, received a short time ago.

Yours very truly,

David H. Canfield
Superintendent

By: *Raymond Gregg*
Park Naturalist

1940 GLACIER STUDIES
ROCKY MOUNTAIN NATIONAL PARK

As in previous years since 1932, with the exception of 1936, when personnel was not available for the purpose, studies of the frontal position and other changes in the Tyndall and Andrews glaciers were made at the close of the 1940 season, as discussed below.

Method of Measurement

Measurements are made from fixed stations well in front of the ice terminus, as it has existed since the initiation of studies. These stations are marked by white "X" marks on firmly fixed rocks. In each case, to check stability of the station from which measurement is made, reference stations at measured distances are established in triangles, and each year, the distance on the legs of these triangles is measured. When it is determined that no change has occurred in the position of the station for measurement, taping measure on ground slope is made from the station to the nearest front of the ice. If the measuring station appears after checking to have shifted, the shift is calculated, and the measurement increased or decreased to allow for this shift.

1940 Glacier Survey Party

Park Service personnel of the survey party consisted of Park Ranger Harold M. Ratcliff and Ranger-Naturalist Paul W. Nesbit. This report is submitted almost verbatim from the notes prepared by Mr. Nesbit, who substituted for the writer, who was restrained by an injury from making the trip. The trip was opened to park visitors capable of the strenuous effort required, and the following persons accompanied the leaders; Temporary ranger Bloomquist, Mr. and Mrs. George White, Mr. and Mrs. Fossett, and Miss Jeannette Heffron, of Chicago, Illinois; Mrs. O. A. Shepherd, of Kansas City, Kansas; Misses Mildred Holmes and Mary Lou Michener, of Wichita, Kansas; George Webb, of Little River, Florida; Harris Waterman, of Peoria, Ill. Measurements were made by Rangers Ratcliff and Bloomquist; photographs by Mr. Nesbit.

Log: (Sept. 13, 1940)

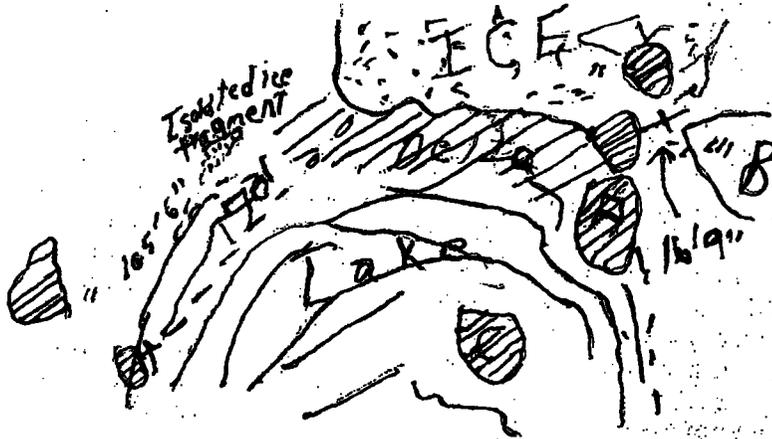
- 8:10 a.m. Start from Glacier Gorge Jet.
- 10:30 a.m. Arrived at lake below Andrews Glacier
- 12:30 p.m. Arrived at top of Andrews Glacier
- to (party of various ability,
- 1:30 p.m. reflected in elapsed time)
- 2:30 p.m. Arrived at top of Tyndall Glacier
- 3:15 p.m. Reached foot of Tyndall Glacier
- 5:45 p.m. Reached Bear Lake via Tyndall Gorge

Weather

Cloudy and threatening at start of trip. Although the clouds had been over Andrews and Tyndall glaciers, they lifted enough to allow photographs to be made, with some sun at Andrews. When the party reached the crest of Tyndall glacier it started to sprinkle, and continued to do so until the measuring party was below the Pool of Jade. The rainfall was heaviest at the time measurements were made at the foot of Tyndall, making exposure of the best quality of pictures almost impossible. Passably good pictures were obtained in spite of the light being so poor.

The following accounts of the measurements and findings at the two glaciers studied are quoted from Mr. Nesbit's field notes.

ANDREWS GLACIER



Lettered yocks correspond to Plate I

The small isolated block of 1939 (Along the south edge of the lakelet in front of the glacier) had disappeared entirely, and now a small isolated block was found further back than the ice front of 1939 by 13½ feet. The nearest attached ice was 179 feet (from Station X', the point for measurement), which is farther back from this point than any previous measurement has shown it to be. In fact, it is so far and at such an angle from Station X', that the measurement ceases to measure vertical retreat. Since the line of measurement was the cord length along the shore rather than out across the water, it would seem that 170' would be a better air-line distance.

The measurement from Station X'' (which was established in 1938, and used as a partial check in 1939) should give a better figure for the actual vertical retreat of the ice. Since the ice was 23 feet in front of this point in 1939, and 16 feet, 9 inches back of it this year, it would follow that the ice front has receded 39 feet 9 inches, or approximately 40 feet, to a point farther back than had previously been measured.

The point X''' was painted on the rock with paint. However, the exact point taken in 1939 could not be determined, and an error of up to 5 feet may be introduced. Point X''' is determined by sighting over the point of the neighboring rock from Station X'. It was painted as high as could be reached from a smaller rock, but is likely to be snow-covered in a year of heavy snow, even throughout September, (in which case, measurement from Station X' will have to be used for comparison).

Interesting features of Andrews Glacier in 1940 include the growing delta reaching out into the lakelet; the greater amount of mud and rocks on the snout; and a narrow, but long crevasse opening near the top of the glacier.

"Suggest that next year an offset measurement be made from Point X' straight west to a point even with the snout of the glacier. A compass would be helpful in getting an accurate measurement or another station might be marked to determine the line of measurement." (Nesbit)

Measurements and comparison with previous measurements are as follows:

Station X' to Ice			Station X''' to Ice Front		
1940	170'	(Appr.)	1940	minus 16'	9"
1939	92'		1939	23'	
1938	32'	5"	1938	48'	11"
1937	96'	10"			
1935	66'				
1934	139'				
1933	58'	10"			
1932	48'	7"			

Apparent recession, 1939-1940, on North front: 39' 9"

Apparent recession, 1939-40, on south front: 78'

CUMULATIVE RECESSSION SINCE 1932: 121' 5"

As has been suggested, measurements on the line from Station X' to "nearest ice" has two defects: (1) the "nearest ice" often is an ice-compacted apron of accumulation along the edge and in front of the true snout of the moving glacial ice; (2) the angle northward of a due west line from Station X' to the true front when shrinkage reaches the level attained in 1940 is such as to make a noticeable deviation from accuracy. Discounting possible inaccuracy in determining Station X''', (which we believe Mr. Nesbit overestimates, since he had marked photographs on the spot for reference in locating it, and our study of his photograph of the point marked leads us to believe it is almost exactly at the point used by the writer in 1939), it is our belief that the true fluctuating vertical measurement is reflected in the measurement from Station X''', and so long as it is possible to use this figure, it is recommended that it be followed. Therefore, we consider that in the year 1939-40 Andrew Glacier receded 39' 9".

This represents a cumulative recession since 1932, when Station X''' was established, of 65' 8". There is no reason to believe that this glacier ever was at a point behind that of 1940, at least since records have been kept.

TYNDALL GLACIER

(At Tyndall Glacier, the party did not use the same determination of ice front as was employed in 1939, so that figures for this glacier mean less than the photographs do. Mr. Nesbit's figures reflect a gain in proximity of ice front to Station X', the measuring point, but photographs make it evident that recession continued from the recessive point indicated in the 1939 measurements.)



"Tyndall Glacier appeared to be reduced in size since the previous year, but ice was actually closer to the measurement point this year. This may be due to slipping downward of the whole mass of ice, but there seems to be no greater bergschrund at the top to indicate any great slip. A difference between the X points on the reference triangle behind X' is evidence of some movement. Melting of ice at the glacier's foot, underneath the rocks may have caused the nearby station to slip downward some, but only 5 feet at the most, and not enough to account for the difference of 52 feet in the longer measurement, and of 49' 4" in the shorter measurement. At least, these figures do not disagree greatly, and it might be assumed that the ice front has advanced an average of 50' 8".

"A study of photos shows that new rocks have rolled down from the glacier. In fact, rocks rolled about every five minutes while the observations were being made. The photos also show more complete melting away of the previous winters' (or winter's) snow. Also melting back along the north side, and south extension, are shown in the photos."

Following these conclusions, it must be shown numerically that there was an annual recession of "plus" 50' 8", an advance. This would make a cumulative recession figure since 1932 of 24 feet.

Measurements and comparisons with previous figures for Tyndall Glacier are as follows:

<u>Station X' to nearest ice</u>			<u>Station X' west to ice</u>		
1940	56'		1940	100'	
1939	105'	4"	1939	152'	
1938	62'	4"	1938	185'	
1937	201'	11"	1937	201'	11"
1935	38'	6"			
1934	72'	5"			
1933	63'	4"			
1932	30'	3"			

Apparent advance on line to west from Station X', 1939 to 1940: 52'

Apparent advance on line from station X' to nearest ice, 1939 to 1940: 49' 4"

Cumulative recession on this line, 1937-1940: 101' 11"

Cumulative recession on this line, 1932-1940: 25' 9"

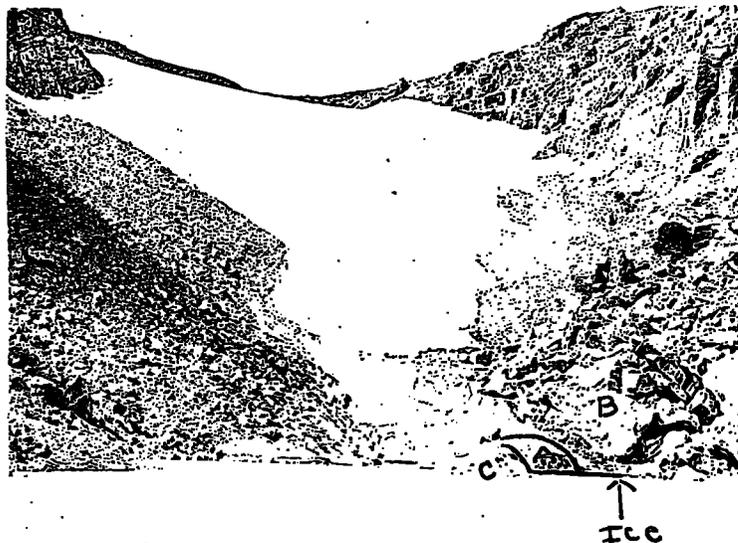
Temperature and Precipitation

On the following page a tabulated summary of meteorological conditions during the 1939-40 glacier year is presented. During the period since 1936, precipitation and temperature data have been so prepared in connection with the glacier study reports. During this period, there has never been so little precipitation. In 1937, the writer made the measurements, and in the case of Andrews Glacier, where changes are more evident to the eye, the light precipitation of 6.65 inches did not produce the amount of shrinkage noted in 1940 when precipitation was only 6.33 inches. Another factor is that the 1937 figure is for Estes Park station only, whereas that for 1940 is an average of Grand Lake and Estes Park stations, the former always showing much more snowfall.

TEMPERATURE AND PRECIPITATION

MONTH	STATION OR AVERAGE	MEAN		SNOW	TOTAL PRECIPIT.
		TEMPERATURE	DEPTH	IN. PRECIP.	
October, 1939	G.L.	37.7	4"	.69	.60
	E.P.	41.8	3 3/4"	.43	.51
	Av.	41.2	3 3/8"	.56	.55
November, 1939	G.L.	28.1	2"	.31	.86
	E.P.	36.7	7"	.03	.04
	Av.	32.4	1"	.17	.45
December, 1939	G.L.	25.0	11"	.77	.77
	E.P.	33.3	3 1/2"	.20	.20
	Av.	28.1	7"	.48	.48
January, 1940	G.L.	15.4	27 1/2"	1.90	1.90
	E.P.	21.4	14 1/2"	.89	.89
	Av.	18.6	20 7/8"	1.39	1.39
February, 1940	G.L.	21.1	11"	1.15	1.15
	E.P.	27.7	10"	.75	.75
	Av.	24.4	10 1/2"	.95	.95
March, 1940	G.L.	27.0	17 1/2"	2.40	2.40
	E.P.	30.1	29 1/2"	1.99	1.99
	Av.	25.5	23 3/8"	2.19	2.19
April, 1940	G.L.	35.4	10"	.95	3.10
	E.P.	39.8	3 1/2"	.20	1.05
	Av.	37.6	6 3/4"	.57	1.67
May, 1940	G.L.	44.5			1.45
	E.P.	49.3			2.20
	Av.	45.4			1.82
June, 1940	G.L.	52.1			1.08
	E.P.	58.6			1.54
	Av.	55.3			1.30
July, 1940	G.L.	57.3			3.22
	E.P.	64.0			3.04
	Av.	60.6			3.13
August, 1940	G.L.	54.8			1.87
	E.P.	60.6			1.91
	Av.	57.7			1.89
September, 1940	G.L.	49.6			1.83
	E.P.	54.3			2.16
	Av.	52.0			1.99
For Glacier Year 1939-40	G.L.	37.2	83"	8.17	19.21
	E.P.	43.3	85 1/2"	4.49	16.48
	Av.	40.2	73 1/8"	6.33	17.84
For Glacier Year 1939-39	Av.	38.9	97 1/2"	7.60	13.10
For Glacier Year 1937-38	Av.	39.4	115.20"	11.56	21.86
For Glacier Year 1936-37	Av.	37.5	93.19"	6.65	17.22
For Glacier Year 1935-36	Av.	40.7	80.00"	7.11	18.16

PLATE I



ANDREWS GLACIER

Looking west across lakelet at foot of glacier, showing comparative appearance in 1939 and 1940.

Above: 1939

Below: 1940

Identified points assist visualizing alteration of the position of glacier front. In 1939 it was possible to measure forward from Station X''', located on Rock B, 23 feet. In 1940 the front of this section of the glacier was 16 feet 9 inches behind Station X''' (at a point hidden behind Rock A in the lower photograph).



PLATE II



LOOKING SOUTH ACROSS FRONT OF ANDREWS GLACIER

Above: 1939 photograph, showing position of ice front with relation to indicated points. Note that the south edge of the ice front, and the extended "apron" extend well out toward Rock A, which is a reference point for checking Station X', on a rock at the edge of the lakelet nearby.

Below: 1940 photograph, showing complete disappearance of the 1939 "apron," and such marked recession on the main ice front that the snout is now invisible behind Rock D, with only the mud delta visible at the water's edge. Dotted line overlay indicates position of ice in 1939, as it appears in the upper picture.

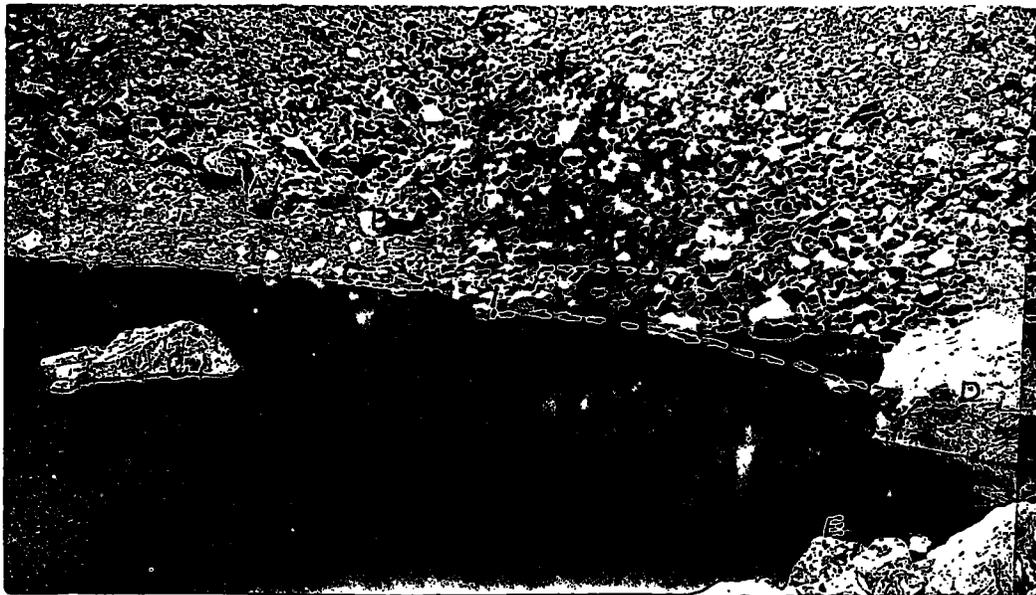
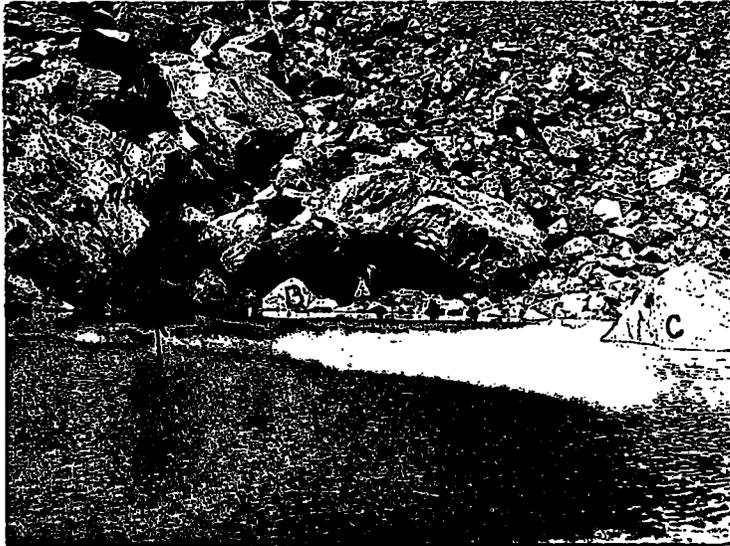


PLATE III



ANDREWS GLACIER

Looking north from Station X' to north edge of ice front -

Above: 1939

Below: 1940

Dotted overlay between rocks A and B on 1940 photograph indicates position of ice front in 1939, as seen in upper photograph. This ice had completely evacuated the space between the rock A and the walls of the valley, to a point 16' 9" behind Station X''', indicated on the large stable boulder on the valley wall, behind rock A. In 1939, it was 23' in front of X'''. The 1940 front is concealed behind rocks in the lower photograph, at the point indicated.

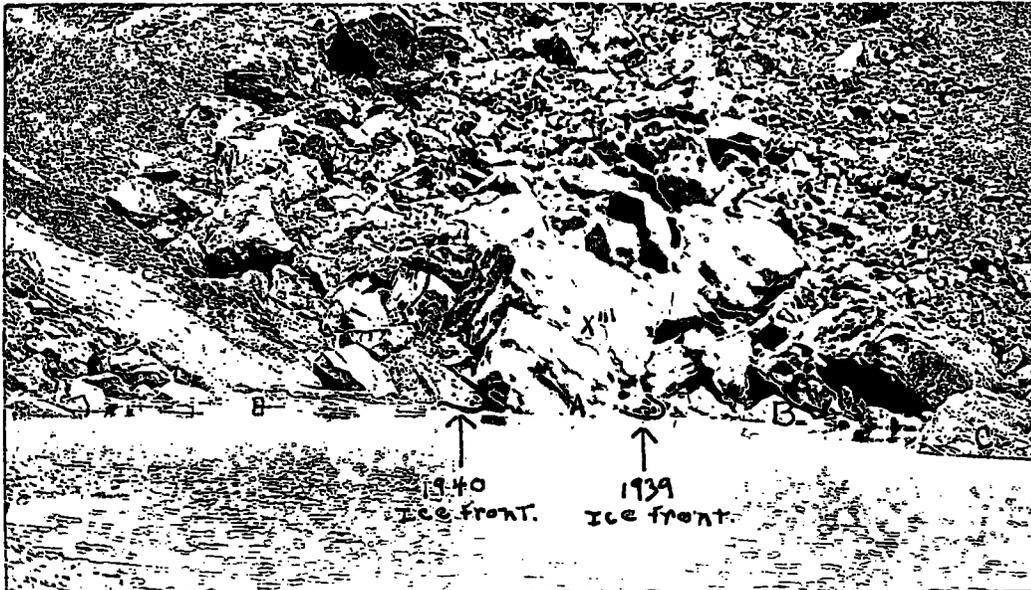


PLATE IV



ANDREWS GLACIER

Above: View of south edge of Andrews Glacier, showing position of ice margin and south front in 1939.

Below: Similar view of Andrews Glacier, 1940, showing marked shrinkage in main body of front, and complete disappearance of the "apron" along the south front. Dotted overlay indicates 1939 position of ice.



PLATE V



ANDREWS GLACIER
1940

Above: Looking north at foot of glacier. Large rocks at center are new deposit at terminus.

Below: Crevasse opening toward upper end of glacier (looking SW).



PLATE VI



ANDREWS GLACIER

Above: 1939

Below: 1940

Note increased amount of ablation mud on surface in lower photograph, and exposed delta in lakelet where ice front receded from 1939 position.

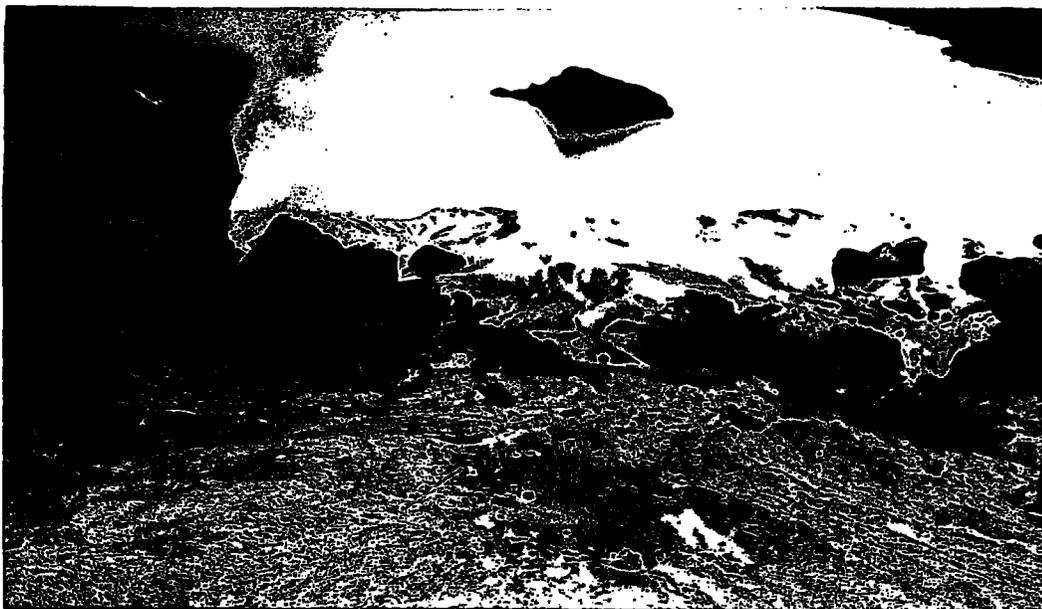


PLATE VII

ANDREWS GLACIER

Both photographs 1940

Left: Looking up the glacier from the delta in front of the terminus. Note mud accumulation near terminus, and boulder debris near point where "snout" is constricted.

Below: Surface stream on the south edge of the "snout", showing structure of ice in Andrews glacier.

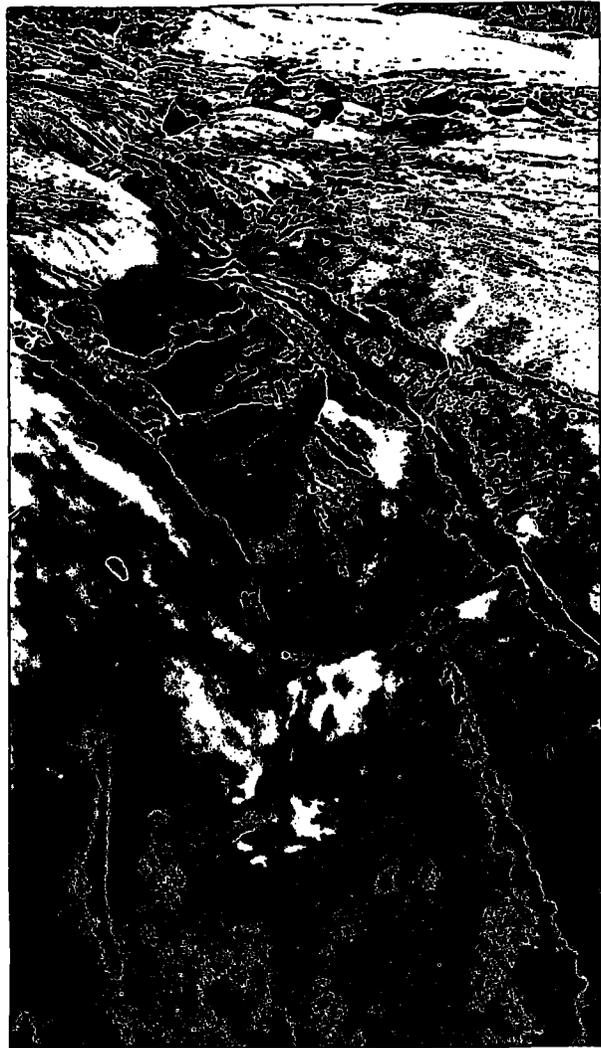


PLATE VIII



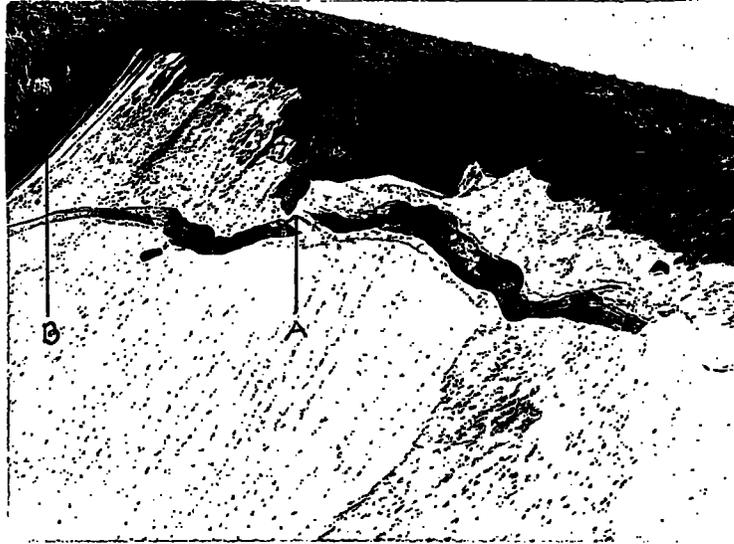
ANDREWS GLACIER

Above: 1939 Below: 1940

Looking down from headwall, showing north edge, with nevation, or ablation ridge, and position of snow overlay. Movement is indicated in relative position of parallel bands A and B.



PLATE IX



TYNDALL GLACIER

Above: 1939

Below: 1940

Looking southwest from Flattop side across bergschrund area. Dissipation of snow overlay on the surface of the glacier is very easily evident. Increased opening of bergschrund, and breaking down of the up-side in the center portion (left: upper; center: lower) can be seen at a glance. Identical points are indicated to aid comparison.

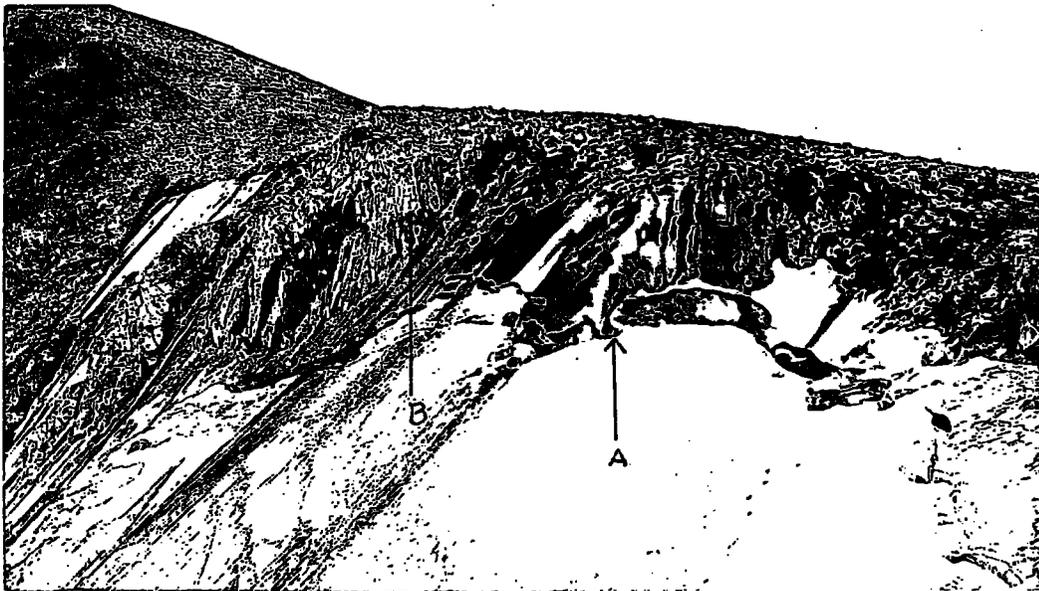


PLATE X



TYNDALL GLACIER

Above: 1939

Below: 1940

Looking down from headwall to ice front and melting basin in front of glacier. Shrinkage from the lateral ridge at the left seems more marked in the lower photograph, but debris cover on the ice front makes comparative study very difficult.



PLATE XI

TYNDALL GLACIER

Left: 1939 photo Below: 1940 photo

North edge of Tyndall glacier, showing comparative identical points, as seen from X', the point of measurement.

Noticeable shrinkage near upper right, at a readily identifiable cornice is evident in 1940 over 1939, but it is difficult to determine from photographs whether continuous exposed ice is closer or more distant in 1940, as referred to Station X'.





TYNDALL GLACIER

Left: Vertical panorama, 1939

Above: 1940

View from north wall of gorge, looking at south edge of Tyndall Glacier, showing readily distinguishable shrinkage of glacier in 1940 from 1939 condition.

PLATE XIII

TYNDALL GLACIER

Wider view than Plate XII, showing "funnel" and main body of ice from brink of north wall of Tyndall Gorge.



PLATE XIV



TYNDALL GLACIER

Above, 1939

Below, 1940

Looking from lateral ridge north of glacier toward south body of ice. By comparison, it is immediately evident that there has been shrinkage as well as increased accumulation of ablation debris on this portion of the glacier.



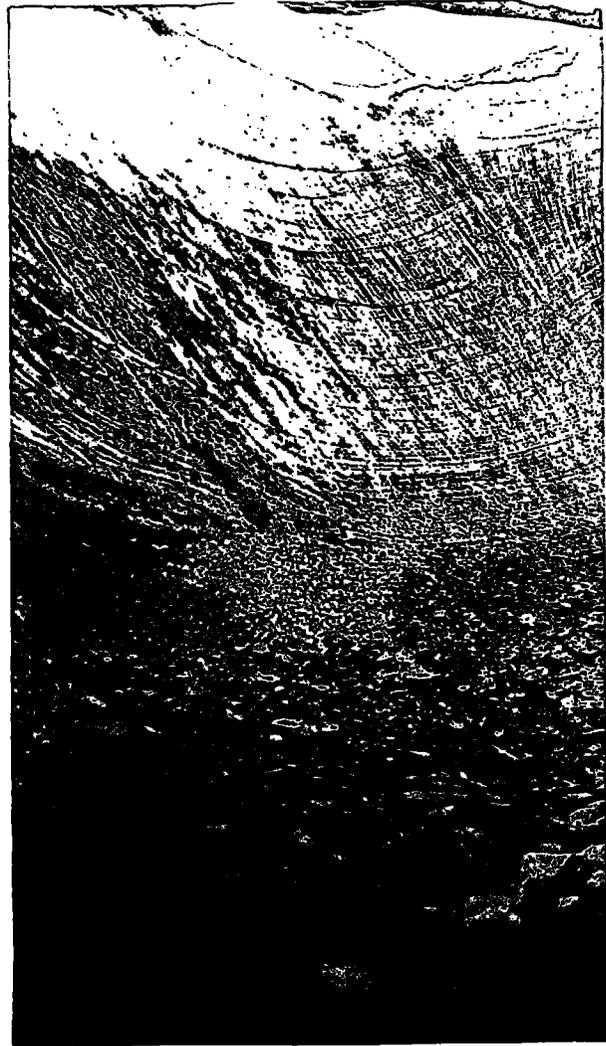
PLATE XV

TYNDALL GLACIER
Both photographs 1940



Left: Looking west, up south edge of glacier to headwall, showing a readily identifiable rock mass which will make possible easy comparison of this edge of the glacier in future years.

Below: Looking westward from direct center of melting basin in front of glacier, up to headwall over main body of ice. Oblique flow-streak is continuation of one seen near upper right of left photo.



67 layers

PLATE XVI



TYNDALL GLACIER

Above: 1939

Below: 1940

Looking southwest across abrupt terminus near south edge of main body of the glacier. The front here is easily determined, as far as an abrupt, definite ice end exposure is concerned, but there is ice beneath the debris at the left of the pictures, so that as elsewhere, it is impossible to determine the true front margin of this glacier. Dotted overlay indicates meltage as evident in comparison with the rock at upper left. Of course, this would not mean much re the advance or recession, since the embedded boulder probably would be moved equally with the forward movement of the ice.



PLATE XVII



ICE TABLE
in basin at foot of Tyndall Glacier.
Above - 1939 photograph.
Below - Same table in 1940.



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