ROCPS/46MA-P01

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

ROCPS/46MA-P28

November 8, 1946.

Dr. Francois E. Matthes, Chairman,
American Geophysical Union,
U. S. Geological Survey,
Washington 25, D. C.

Dear Dr. Matthes:

Enclosed is a copy of the report on Tyndall and Andrews Glaciers in Rocky Mountain National Park for 1946 prepared by Park Naturalist Gregg.

Mr. Gregg has made certain corrections in meteorological data used in the 1944 and 1945 reports to better integrate these data with figures used in reports since 1936. This matter is discussed in the appropriate place in the report.

Photographs are used again as they were in reports through the year 1942. Apparently no photographs were made by the survey parties in 1944 and 1945 so to pick up the story pictorially, photographic comparisons in the enclosed report are made for 1942 and 1946.

Very truly yours,

David H. Canfield

David H. Canfield,
Superintendent.

Enclosure: 1946 Glacier Report.

ROCPS/46/MA-P02

GLACIER REPORT

ROCKY MOUNTAIN NATIONAL PARK

1946 - H. R. Gregg, Park Naturalist

November 5, 1946.

1946 GLACIER STUDIES - ROCKY MTN. NATIONAL PARK

Measurements of Andrews and Tyndall Glaciers in Rocky Mountain National Park have been made annually since 1932 with a few exceptions when weather or absence of personnel prevented. Prior to that time sporadic recorded observations and measurments as well as attempts to study rate of motion were made. In addition, old photographs available in park files were valuable for appraisal of subsequent shrinkage of these glaciers. An excellent photograph of Andrews Glacier made by Major R. G. Coffman of Colorado A. & M. College about 1909 indicates that probably three times more linear recession at the snout took place between that time and 1932 than has taken place in the ensuing period. Photographs of Tyndall Glacier made in 1888 by Frederick H. Chapin show it to be vastly greater in volume than it has been at any time since recorded observations were begun. Comparative study of Chapin's 1888 photographs of Rowe Glacier in the Mummy Range with modern ones indicate comparable recession of this glacier.

The 1946 studies are integrated with the almost continuous series of surveys made since 1932. This year it was possible to make satisfactory photographs at both glaciers. Good comparative measurement was made at Andrews Glacier. It was determined satisfactorily, if not accurately, that there was a recession in Tyndall Glacier since 1945.

DATE

September 6, 1946. 6:00 a.m. to 4:00 p.m.

WEATHER

It was clear with light westerly wind at 6:00 a.m. the time

of departure for the survey party. Clouds gathered by mid-morning, the skies becoming predominantly overcast by 1:00 p.m. Conditions were ideal for the survey throughout the time spent at Andrews Glacier.

At Tyndall Glacier, except for occasional breaks, drifting clouds swept eastward over the divide, obscuring the summit of Hallett Peak and the rim of the gorge above the glacier. At times, visibility of the glacier was extremely poor due to fog rolling into the gorge. By use of supersensitive film, satisfactory photographs were obtained despite poor light conditions.

No precipitation occurred during the period of the survey.

PARTY

The party consisted of Mr. James P. Gilligan, Refuge Manager, U. S. Fish and Wildlife Service, Valentine, Nebraska, and Park Naturalist Raymond Gregg of Rocky Mountain National Park.

GENERAL NOTES

The trip was made via Loch Vale to Andrews Glacier, thence northerly along the continental divide surface to Tyndall Glacier, with return down Tyndall Gorge to Bear Lake.

Measurements were made by cord line. Points of reference used were the same as in 1942.

Location of Station X' at Tyndall Glacier was established with little difficulty. It is obvious to the writer from review of 1944 and 1945 glacier reports that Station X' was not accurately located by the parties for those years. The doubtful similarity of points used for measurement make it improbable that data for 1944 and 1945 can be related to measurement in 1946 at Tyndall Glacier.

Photographs used in this report compare conditions in 1942 to those in 1946 from identical or nearly identical positions. The only interim photographs in park files are two made at Tyndall Glacier on September 20, 1945, when much new snow so covered the glacier as to detract from their usefulness. Future reports can be prepared with comparative photographs based upon 1946 appearance of the glaciers.

In pre-war years, Dr. Francois E. Matthes, of the U. S. Geological Survey, has commented on the value of photographs for interpretation of changes in the glaciers. Partly due to weather conditions, such photographs were not included in the 1944 and 1945 reports, reducing their value as a part of the continuity established in 1932. It is recommended future surveys be conducted the first week of September to avoid early season snows that interfere with accurate determination of the ice front, and reduce the value of photographs for interpretation. It is the opinion of the writer that photographs mean a great deal more than the measurements obtained, especially in the case of Tyndall Glacier.

At some future time, barring marked advance of Andrews Glacier which might obliterate it, the mud delta forming at the west end of the lakelet may reach to the large "island" rock identified as "C" on the plates. At such time, a station can be established from which a direct line measurement can be made annually to the true snout of the glacier. Until that time it is suggested that measurements continue to be conducted from Station X' to the nearest ice, which will be approximately on a line with Station X' and the conical pinnacle appearing in Plate 6 of this report. Irrelevant figures will be obtained if measurement is made from Station X' to an ice apron sometimes present along the southwest shore of the lake which is not a true part of the glacier. The point for measurement on the visible ice front should be selected north or northerly of a line between the rocks identified as "E" and "T" in Plate 6 of this report. It is probable that these points may be covered in a year of heavy snow overlay, making it difficult to find the actual border of the true glacier. However, by referring to Plate 1, lower photograph, in this report, the person conducting the measurement can determine a point to the right of the arrow indicating rock "E" and run the line of measurement from Station X' to that point. If this guide is followed, it is very likely that the ice measured will be a part of the glacier proper. It is recommended that a copy of this report or a subsequent report containing similar photographs be used by the survey party for reference in the field.

Should the mud delta area remain substantially as it was in 1942 and 1946 in front of Andrews Glacier, it is recommended that beginning in 1947 a second measurement be made as described in the following paragraph.

Referring to photographs in Plate VIII, note the rocks (which appear to be quite stable) indicated by an arrow to show changes in water level. By establishing a visual reference point on the near side of rock "A", visible from the rocks referred to above, a sight-line between these points could then be determined. Standing on the mud delta at a mid-point on this line, one could run a line westerly directly to the nearest ice, regardless of the amount of recession, and obtain an accurate measurement of the position of the glacier front. This line would not be subject to the error inherent in X'-based measurement lines, which are at an angle to the axis of the glacier. However, X' measurements should be continued in view of the fact that the measurement herein proposed would be impossible in case ice advanced, to a position east of the point described for the new measurements.

Station X''' is useless now because of its position well to the north of the axis of the glacier. Should the glacier advance and spread at its front to equal or exceed its advanced position in 1938 Station X''' would be useful. By use of X''', it could be determined whether some future advance is greater than that of 1938, the largest recorded since 1932.

Weather data are again based upon Estes Park and Grand Lake station readings. There is no advantage in the use of data from Lewes-Kirkwood or Longs Peak weather stations, since reports from 1932 to 1942 were based upon Estes and/or Grand Lake data. Continued use of Estes Park and Grand Lake data will provide a consistent relationship to glacier increment or diminution.

The average between Estes Park and Grand Lake readings is a better index figure than readings for either station alone for correlation with the condition of the glaciers. Weather data not taking into account precipitation at Grand Lake are deficient because prevailing westerly winds add importantly to glacier volume through eastward drifting of west slope snowfall.

The writer has obtained these data from the monthly Cooperative Observer's sheets on file in the office of the Chief Ranger, rather than from the printed Climatological Data reports, since the latter do not contain all of the information available in the former reports. Grand Lake observations are made by District Ranger Fred D. McLaren and Estes Park measurements are made by H. J. Poling.

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Through 1942 the "weather year" used was from October 1 to September 30. The 1944 and 1945 reports used the "weather year" September 1 to August 31. The latter is a better period for reference and its use is retained in the 1946 report.

ANDREWS GLACIER

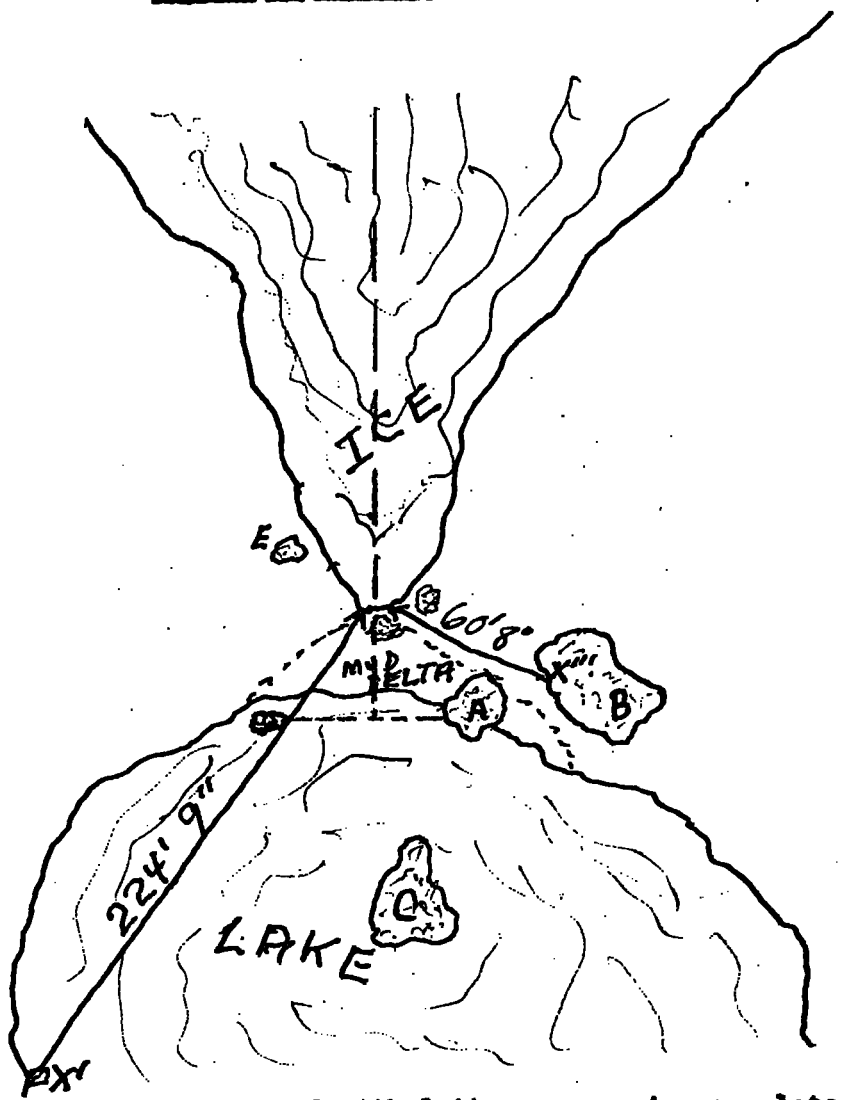
Measurements were made from both Station X' and Station X'''. Only the former is a valid measurement for indicating the condition of the glacier. The 1945 tapeline from Station X''' to the ice front measured 65' 7" obliquely backward from the station. The 1946 measurement along approximately the same line was only 60' 8". Rocks which lie between Station X''' and the ice make it impossible to extend a tapeline directly. In stretching the line over or around rocks; in making allowance for the difference in elevation levels of the station and the ice front, or for angularity of the line, it is highly improbable that consistent measurements can be obtained from Station X'''. This is especially true as long as the ice is at a point other than directly or nearly directly forward from the station. Therefore, the possible interpretation of measurements from Station X''', that there has been an advance of 4' 11" is disregarded in this report. The Station X''' figures are tabulated on page 6 merely as a matter of record. Elsewhere in this report it is recommended that this measurement be discontinued.

Distance from Station X' to the ice front in 1946 was 224' 9" compared with 210' 6" in 1945. Since these are almost identical lines of measurement, the differential of 14' 3" is a valid measure of recession in Andrews Glacier in 1945-46. The angle of the line of measurement to the axis of the glacier is sufficient to make this figure slightly inaccurate. Since the error is consistent from year to year, figures for advance or recession are clearly indicative of the condition of the glacier.

A sketch of the glacier and tabulated data on recession and advance since 1932 follows:

ROCPS/46MA-P07

SKETCH OF ANDREWS GLACIER



Rocks are identified to correspond with letters appearing on plates contained in this report. Orange lines describe proposal for a second set of measurements to be initiated in 1947, replacing valueless measurements from Station X'''.

CUMULATIVE MEASUREMENT DATA
ANDREWS GLACIER

Station X' to nearest ice		
1946	224'	9"
1945	210'	6"
1944	253'	0"
1942	155'	8"
1941	212'	5"
1940	170'	(est.)
1939	92'	0"
1938	32'	3"
1937	96'	10"
1936	No measurements	
1935	66'	0"
1934	139'	0"
1933	58'	10"
1932	48'	7"

Station X''' to nearest ice		
1946	-60'	8"
1945	-65'	7"
1944	-79'	2"
1942	-49'	1"
1941	-54'	3"
1940	-16'	9"
1939	23'	0"
1938	48'	11"
1937	Station not established	

BASED UPON STATION X'

Apparent Recession, 1945-46
14' 3".

ROCPS/46MA-P08

TYNDALL GLACIER

From Station X' on a westerly line indicated on the left photograph of Plate XVI, the nearest ice positively identifiable as continuous with the main body of the glacier was at a distance of 112' 11". An average of measurements from Stations A and B, used for the 1945 report, probably would have been about the same as a measurement from X' to nearest ice. Therefore, the 1946 measurement of 112' 11" is compared with a 1945 figure of 54' 4", to record a recession of 58' 7" for the current glacier year.

On a southwesterly line from Station X', there was a small debris-covered terminus at a distance of only 105', but this ice is off the line used in measurements carried on since 1932, and is not as useful for comparison as the figure obtained on a westerly line.

Large rocks in the terminal ridge continue to shift (one toward the south end moved several feet while measurement was being made). This supports the belief that there is stagnant ice, probably continuous, under the heavy debris cover in the basin between the ridge and the nearest clear ice of the glacier body. As stated in previous reports, this condition makes all measurements on record of dubious value. However, photographs show that there are changes in the condition of the glacier from year to year, and it is probably worthwhile to continue measuring and photographing Tyndall Glacier for record purposes.

Tabulated data on recession and advance since 1932 follow:

CUMULATIVE MEASUREMENT DATA
TYNDALL GLACIER

Station X' to nearest ice.

1946	112'	11"
1945	54'	4"
1944	56'	3"
1943	No measurements	
1942	0'	0"
1941	No measurements	
1940	56'	0"
1939	105'	4"
1938	62'	4"
1937	201'	11"
1936	No measurements	
1935	38'	6"
1934	72'	5"
1933	63'	4"
1932	30'	3"

Apparent Recession, 1945-46
58' 7"

METEOROLOGICAL DATA

For some reason, the 1945 glacial survey included only data for the Estes Park weather station. The 1944 report used data from Longs Peak weather station (Howes-Kirkwood) and Grand Lake. There was no 1943 glacier measurement. In 1942 and in previous years back to 1937, the writer conducted measurements, and used data expressed individually and as average for the Estes Park and Grand Lake weather stations. It is believed that these two figures give the best constant index of reference. Some snowstorms will come from the east, providing a reading at Estes Park excessive to that at Grand Lake. More frequently, snows on the west slope, recorded at Grand Lake, exceed snowfall on the east slope. Probably, in view of prevailing westerly winds, the snowfall on the west slope is of more effect upon the condition of the glaciers than snowfall east of the continental divide. However, an average of the Estes Park and Grand Lake stations does provide maximum coverage of probably influencing snowfall, and if used annually, will give a constant index.

For the benefit of other persons who may make measurements in the future, the failure of Acting Park Naturalist Crater to find data on Grand Lake for 1944 was that he used the printed U. S. Weather Bureau Climatological Data files, and in some years Grand Lake data apparently were not included. However, in the Chief Ranger's office files, there is a month-by-month report prepared by the District Ranger at Grand Lake, which is continuous since 1936. The data are on file, and can be used, although it involves a little extra effort in calculating the averages for the glacier year. It is recommended that in the future, the practice followed here be continued.

MONTH	STATION OR AVERAGE	MEAN TEMPERATURE	SNOW DEPTH	INCHES PRECIP.	TOTAL PRECIP.
1945					
September	E.P.	53.5	2.0	.30	1.20
	G.L.	47.1	3.0	.35	1.40
	Av.	50.3	2.5	.32	1.30
October	E.P.	46.9	3.0	.25	.60
	G.L.	39.2	4.0	.50	.65
	Av.	43.0	3.5	.37	.72
November	E.P.	36.6	1.0	.27	.67
	G.L.	23.8	17.0	1.55	1.55
	Av.	29.9	9.0	.92	1.11
December	E.P.	27.9	7.0	1.11	1.11
	G.L.	15.1	29.0	1.85	1.85
	Av.	21.5	18.0	1.48	1.48
1946					
January	E.P.	26.3	9.0	.91	.91
	G.L.	13.8	11.5	.65	.65
	Av.	20.0	10.2	.78	.78

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1946					
February	E.P.	29.9	9.5	.96	.96
	G.L.	13.5	10.0	.55	.55
	Av.	21.7	9.8	.75	.75
March	E.P.	38.1	7.2	1.46	1.46
	G.L.	28.1	14.0	1.30	1.30
	Av.	33.1	10.6	1.38	1.38
April	E.P.	47.2	3.0	.73	1.59
	G.L.	38.9	2.0	.30	1.45
	Av.	43.0	2.5	.52	1.52
May	E.P.	45.9	14.0	2.40	4.32
	G.L.	42.2	3.0	.25	2.05
	Av.	44.0	8.5	1.32	3.18
June	E.P.	59.5			1.11
	G.L.	50.7			1.20
	Av.	55.1			1.16
July	E.P.	65.1			6.09
	G.L.	55.6			1.65
	Av.	60.4			3.87
August	E.P.	62.2			4.03
	G.L.	53.9			1.80
	Av.	58.0			2.91
For Glacier Year 1945-46	G.L.	35.1	93.5	7.30	16.10
	E.P.	44.9	55.8	8.39	24.25
	Av.	40.0	74.7	7.84	20.10
		Comparative data			
1944-45	G.L.	30.4	138.7	11.77	21.45
	E.P.	42.7	105.5	9.30	20.45
	Av.	36.5	122.1	10.53	20.95
**1943-44	Av.	38.8	102.7	9.05	15.40
**1942-43	Av.	39.0	111.1	8.36	19.01
1941-42	Av.	37.6	127.1	9.64	16.62
1940-41	Av.	39.0	84.3	7.85	18.63
1939-40	Av.	40.2	73.1	6.33	17.84
1938-39	Av.	38.9	97.2	7.60	13.10
1937-38	Av.	39.4	115.2	11.56	21.86
1936-37	Av.	37.5	93.2	6.65	17.22
1935-36	*	40.7	80.0	7.11	18.16

*1935-36 computed for Estes Park only, prior to establishment of weather station at Grand Lake Ranger Station.

**Detail data:(replacing irrelevant data included in 1944 and 1945 reports)

1943-44	E.P.	42.8	87.0	9.05	15.68
	G.L.	33.9	118.5	9.05	15.13
	Av.	38.8	102.7	9.05	15.40
1942-43	E.P.	42.6	61.8	7.04	18.62
	G.L.	35.4	140.5	9.69	19.41
	Av.	39.0	111.1	8.36	19.01

CONCLUSION

Meteorological data for 1942 to 1945, when the writer was absent in military service, have been reconstructed in this report. Thus, figures for those years are at variance with those in the 1944 and 1945 reports. However, as now presented, the meteorological data provide a continuous record since 1936, computed on the same basis.

Table I represents graphically the position of the ice front with relation to Station X' for both Tyndall and Andrews Glaciers. On the plot for Andrews Glacier, ordinates are arranged so that graph lines for temperature and snowfall conditions can be compared with the condition of the glacier.

Respectfully submitted,

H. Raymond Gregg,
Park Naturalist.

ROCPS/1464A-P12

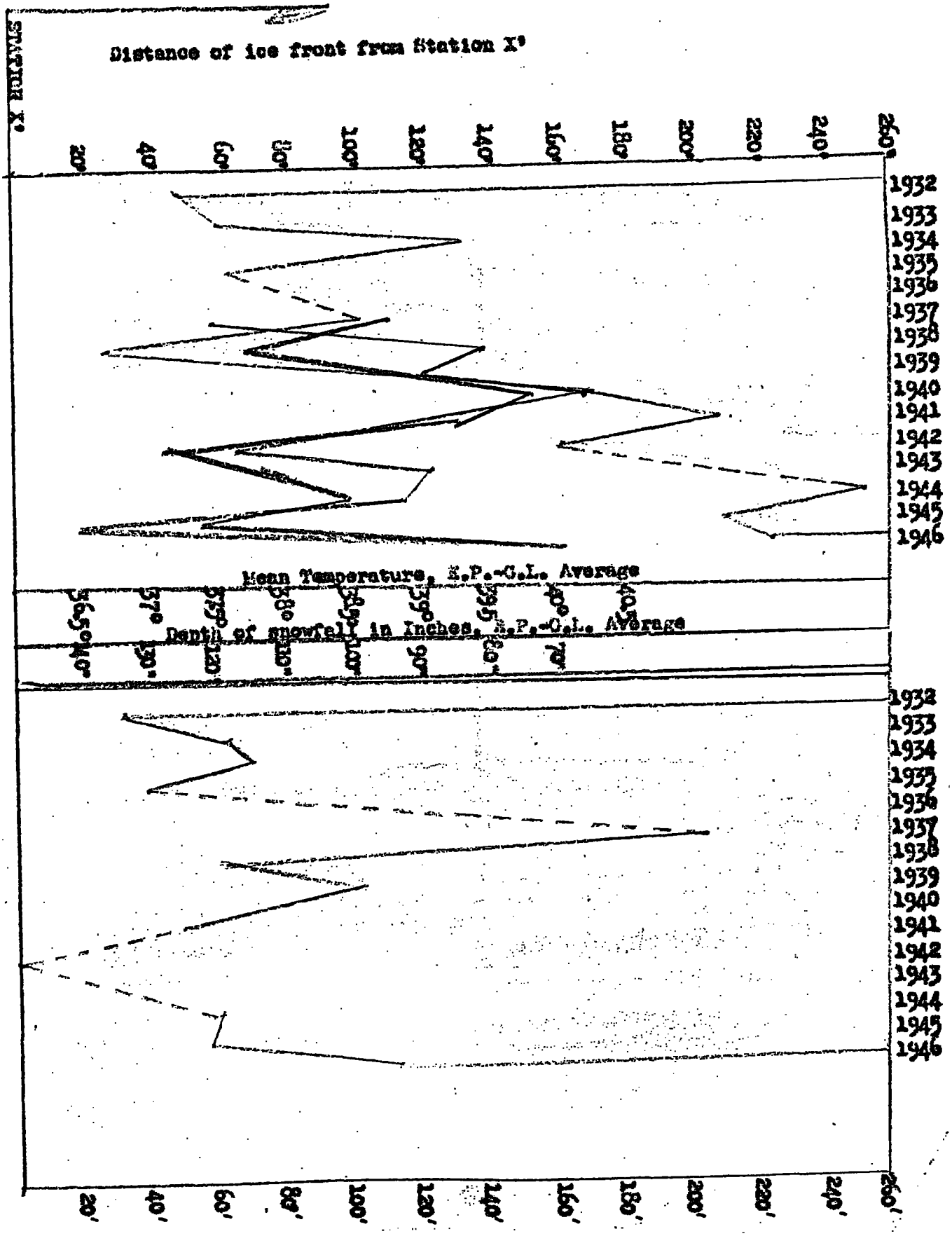


TABLE I

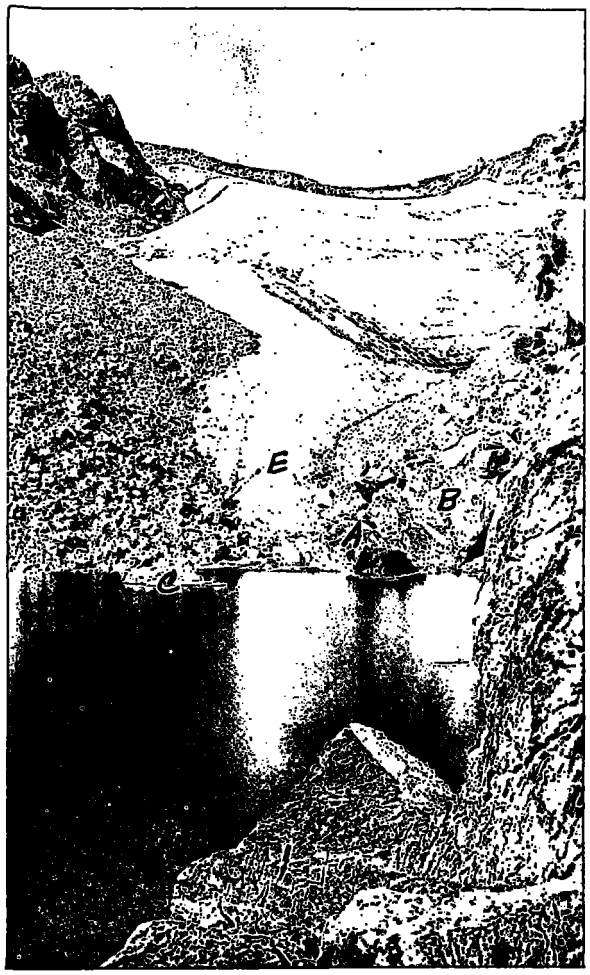
ROCPS/46MA-P13

ANDREWS GLACIER

Above: 1946 Below: 1942
Looking westward across lakelet, showing general appearance of the glacier. Identical points indicated assist visualizing changes in the frontal area of the glacier.

PLATE I

ROCPS/46 MA-P14



ANDREWS GLACIER

Left: 1946 Right: 1942

South edge of glacier, showing conditions in the two years. Marked snow overlay present in 1942 is completely absent in 1946. Photograph made from northeast side of the lakelet below the glacier.

Indicated identical points assist in making comparisons.

PLATE II

ROCPS/46 MR-P15

ANDREWS GLACIER

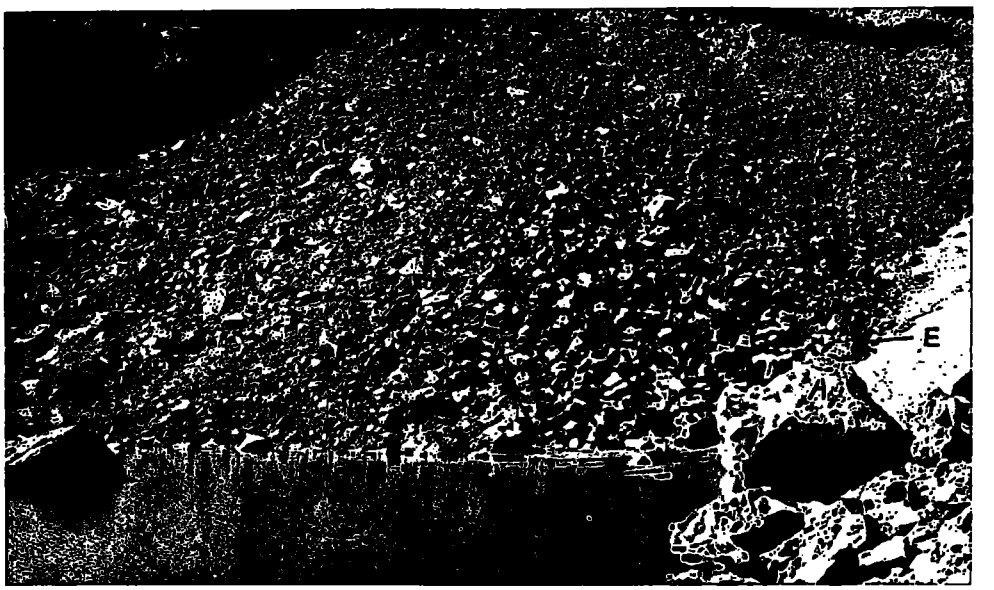
Above: 1946 Below: 1942

Closer view across frontal area, showing south edge of glacier near the ice front. Identical points are indicated, symbols conforming to same points in other views.

PLATE III

ROCPS/46 MQ-P 16

ANDREWS GLACIER



Above: 1946 Below: 1942

LOOKING SOUTH ACROSS FRONTAL AREA OF ANDREWS GLACIER

Identical points are identified, uniform symbols tying in with points appearing in other photographs of same area.

PLATE IV