GLACIER RECESSION STUDIES IN MOUNT RAINIER NATIONAL PARK

1944

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Summary:

Plane table maps of the termini of the Nisqually, Paradise, Emmons, Carbon, and South Tahoma glaciers were made for the second consecutive year. Recession values, based on the averages of a number of measurements along the active portion of the terminus of each glacier, were as follows:

Nisqually Glacier ---------- 79 feet

Paradise Glacier ---------- 83 feet (two years)

Emmons Glacier ---------- 296 feet

Carbon Glacier ---------- 35 feet

South Tahoma Glacier ------ 114 feet

Measurements of the rate of movement of the ice of the Nisqually Glacier at a mean elevation of 6800 feet were made from July 11 to October 18. Maximum movement near the center of the glacier was 73.4 feet in this period, or an average of 8.9 inches per day, or about 22 feet per month.

GLACIER RECESSION STUDIES

Mount Rainier National Park

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A new method of determining recession values for the glaciers of Mount Rainier National Park was used this year. In the past the recession values were determined by one or at most two linear measurements from a fixed point to a rather indefinite point on the terminus. The result varied within wide limits from year to year, and it was suspected that the values arrived at were influenced as much or more by fluctuations in the rate of melting along the glacier front as by the over-all recession for an individual year. This year the recession value is an average which considers the over-all melting across the terminus.

When recession values for several years in the past are averaged, there is a close correlation with the average value for the present year. There is poor correlation, however, between the average recession for 1944, and recession for this one year when determined by the same methods as in the past. The tentative conclusion is that past values are most accurate when several consecutive years are averaged together.

For comparison, various recession figures are tabulated below. In the tabulation, the "A" column represents the average recession as determined this year; "B" is the value for the present year determined on the same basis as in former years; "C" is the average for several prior years when recessions were determined by simple linear measurements; and the "D" column shows the maximum and minimum recessions during the "C" period.

	A	B	C	D
Nisqually	79'	42'	84' (10 yrs) 76' (20 yrs)	43' - 155'
Paradise	41.5*	42.5*	37' (10 yrs)	7' - 212'
Emmons "A"**	296'			
Emmons "B"	60'	Indet.	80.8' (13 yrs)	2.5' - 193'
Carbon	35'	10'	34.5' (11 yrs)	12' - 62'
So. Tahoma	114'	70'	52.5' (12 yrs)	Advance - 45' Recession 244'

* - Average for two years

** - "A" - includes re-entrant in terminus of Emmons Glacier
"B" - includes only the portion of front west of re-entrant

Methods

1. A point of origin is selected - All yearly measurements are made from the same reference point. Each year the new measurements begin at this point of origin, and are carried upward to the glacier front. This avoids cumulative errors which might result from measurements starting each year from the position of the terminus the preceeding year.

2. The direction of the axis of the glacier is determined, and indicated on the plane table sheet. All measurements are made parallel to the glacier axis. Where the axis is not a straight line, measurements should be made only along the axis in carrying distances from the point of origin to the vicinity of the glacier front.

3. The portion of the terminus which will yield representative recession data is selected in the field. Generally speaking, the middle half to two thirds of the terminus is considered for recession data. In Mount Rainier some glaciers have long, narrow wings of ice extending far down canyon on each side of the glacier. These, while physically attached to the glacier, are most probably stagnant ice which, covered with debris, will persist for several years. Their slow melting correlates in no way with the over-all recession, and to include these would influence recession averages far in excess of their importance. Similarly, in case of some glaciers, re-entrants develop laterally just above the terminus cutting, as it were, the support from behind that portion of the terminus. The portion of the terminus fronting on such re-entrants are excluded in recession determinations.

4. Top of the terminal face selected as the line to which recession measurements are made. The terminal face, for most of the glaciers of Mount Rainier, is essentially a steep, sometimes cliff-like wall of ice, breaking sharply at the top to the lower slope of the till-covered glacier surface, and with the base more-or-less covered withtill. This accumulation of rock debris at the base not only makes it difficult or impossible to determine accurately the lower limits of the ice, but also results in much irregularity in the melting of this ice.

   This line at the top of the terminal face, however, is generally well defined and quite easily mapped; but locally where no ice is exposed on the terminal face, it also may be obscured for short distances. Furthermore, if the two maps now available are an indication, the recession of this line is more consistent and without wide fluctuations shown at the base.

   The above considerations to not apply to glacier such as the Paradise which are free of surface debris, and remain uncovered to the extreme lower ice limits. The Paradise glacier is most easily mapped on the actual ice limits.

5. The average position of the terminus is determined. It is most convenient to represent the position of the terminus by a straight

line normal to the glacier axis. The position of this graphic representation of the terminus is determined in the following manner. A construction line is drawn on the plane table sheet normal to the glacier axis and just below the top of the terminal face where it projects farthest downstream. Measurements are then made at short, equal intervals, parallel to the glacier axis, between the construction line and the top of the terminal face. The average of these scaled distances, is then laid off along the axis above the construction line. Through this new point a line is drawn normal to the axis to represent graphically the average position of the terminus.

6. Average recession for the period is determined by subtracting the distance from the point of origin to the graphic or average terminal position at the beginning of the period from the corresponding distance at the end of the period, measuring in both cases along the glacier axis.

On the 1944 map the "A" lines represent the average positions of the terminus, and they extend across the portion of the glacier to which they apply. Positions for 1944 are drawn in solid lines on the map where definite, and by dotted lines where indefinite, or where sketched in. Positions for 1943 are indicated by dot-and-dash lines. Areas of exposed ice, till-covered ice, and glacier surface are indicated for 1944 only. In addition to the average recession value for the period 1943-1944, linear measurements are also given on the maps. These are the values obtained by the methods previously employed, and are included for purposes of comparison.

General Notes

NISQUALLY GLACIER

The Nisqually glacier was mapped by stadia measurments, and recession values are based on the positions of the top of the terminal face.

The terminal ice face was more spectacular in appearance, with more ice exposed than at any time in the past four years. Above and to the east of the outlet of the Nisqually River, the ice face is very steep, the lower half overhanging somewhat. Westward the slopes decrease, and the base becomes more covered with rock debris.

A lateral wing extends down canyon from the east margin of the terminus a distance of about 400 feet. This ice is quite impressive on the map, but is actually quite thin, and is merely "plastered" against the canyon wall. Similarly, on the west side is a more flattened ice mass extending downward from the terminus proper. This ice escaped notice in 1943 because it was so completely covered with till and talus. Melting has since revealed its approximate extent. Actually this ice, although quite large in mapped area, is thin, and small in volume.

A most interesting feature of the terminus this year is a long ice cave which has developed along the sub-glacial course of the small stream which flows beneath the glacier a short distance above the terminus on the west side. At the time the terminus was mapped in September, no cave was apparent from below. By mid-December, through the breaking up of this portion of the base of the glacier, a cave about ten feet high and 20 feet wide was revealed. This was explored for a distance of 250 feet to a point where it became too shallow for further progress. Its direction at this point was directly toward the inlet of the tributary stream. Back of the terminus, rising directly above the re-entrant developed by this stream, is a high, conspicuous ice face which, with further deepening of the re-entrant and collapse of the cave, will doubtless become the terminal face in future years.

During the summer of 1944 measurements of the rate of flow of the ice of the Nisqually Glacier were made at a mean elevation of 6800 feet. The results are tabulated below.

Distance from east margin of glacier	65'	340'	460'	750'	950'	1220'	1490'
Movement down glacier from line of sight							
July 11	0	0	0	0	0	0	0
July 25	0	71"	93"	129"	120"	106"	65"
August 11	23"	151"	242"	292"	300"	236"	186"
September 7	62"	329"	444"	511"	520"	353"	190" (?)
October 18	90"	612"	724"	881"	809"	756"	552" (?)

PARADISE GLACIER

This glacier was mapped by stadia measurements from two instrument stations, one of which was at one end of the base line. The average recession value of 83 feet is for a period of two years. In 1943 not enough of the terminus was exposed to give a fair average, the rest being covered with snow. Since the Paradise glacier is free of surface debris, with the terminus fully exposed, it was mapped to the extreme limit of the ice, and not, as in case of the other glaciers, to the top of a terminal face.

The ice caves which formed at the outlet of the Paradise River, near the west side of the terminus some four or five years ago, have completely disappeared through collapse this season. Recession has progressed along this side of the glacier to a line parallel with the longest of these caves. At the time the measurements were made, September 9, 1944, this cave was in a badly collapsed condition, and formed the lower boundary of firm ice of the glacier.

The mass of ice to the southwest, although connected with the glacier by ice bridges, was also considerably broken through the collapse of smaller caves, some of them tributary to the large one mentioned above. By mid October the complete collapse of the large ice cave separated this ice from the main body of the glacier, and further collapsing of the smaller caves broke this mass into three smaller fragments. There is no prominent cave at the outlet of Stevens Creek.

The terminus of the Paradise Glacier is now wholly within the Stevens Creek Drainage, the recession of the past two years having carried the terminus back of the rather low divide between this drainage and that of the Paradise River. It seems probably that the Paradise River will receive no water from the glacier for the next several years. However, no great difference in flow will be observed for the contribution of the glacier to the flow of the stream has been negligible for several years, and the Paradise River has been fed almost entirely by melting snow in the basin below the glacier. Diversion of water from the Stevens Creek drainage into the Paradise River will be increasingly difficult for the next several years, but should be facilitated by a recession of the glacier sufficient to bring the outlet of Stevens Creek to a level above the Paradise river-Stevens Creek divide. Much will depend, however, upon the nature of the topography of the vally uncovered as the glacier recedes.

Markers were placed near the middle of the glacier some 1500 feet above the terminus on a line between fixed points on the sides of the valley. An attempt will be made next season to locate these markers, and to determine the total movement of the glacier in a one-year period.

EMMONS GLACIER

This glacier was mapped by stadia measurements, except for the top of the terminal face between stations 4508 and 4563 which, being inaccessible because of deep crevasses, was mapped by intersections.

The terminal face is quite low, and considerably covered with till although more ice is exposed than at anytime during the past four years.

The major feature of the terminus is the deep re-entrant which is now fully developed to include approximately the eastern half of the terminus. Where the re-entrant now exists, a large sink in the ice was mapped in 1943. Since no account was taken of this sink in computing the average position of the terminus for 1943, the recession values for 1944 include the total effect of this re-entrant. Actually, the re-entrant is the result of several years surface ablation, cave development, and collapse. Two average recession values are given, the one which at present is considered the value

to be used for the year, included the total width of the glacier including the re-entrant, but excluding the inactive margins. The second "B" average is computed from the active portion of the glacier excluding the re-entrant.

On the east margin of the glacier, a long, narrow wing of ice, largely till-covered, projects some 300 feet down stream. This is essentially stagnant ice forming a comparatively thin sheath along the lower canyon wall. The west margin is hidden by till, but it appears certain that the ice on this side does not extend far beyond station 4565 and that it does not fill the full width of the valley at this point.

A series of long, wide, and deep crevasses have developed parallel to the west side of the re-entrant extending from the vicinity of station 4475 to station 4456. These will doubtless facilitate melting and collapse, and will result in the rapid widening of the re-entrant in the next year or so. These crevasses are sketched, and are not accurately mapped.

CARBON GLACIER

The crest line was mapped by intersections from stations on the base line. The base, east of the river, was mapped by stadia measurements. Between stations 3630 and 3635 the map indicates an apparent advance at this point, and suggests a possible error in the 1943 map. However, in plan, the crest line may move downstream even as marked recession of the face is taking place. This could be produced by excessive local surface ablation, as through the melting of an ice ridge. Thus, while the terminal face itself is receding, the line marking the junction of the terminal face and the glacier surface may advance. In determining recession value, it is assumed that the map is correct.

The ice face at the terminus, as was the case last year, is prominent, steep, and but little covered with till.

A strong re-entrant has developed on the east side just above the terminus producing, in effect, an ice ridge projecting outward at about 135 degrees from the terminus proper. The margins of the glacier (above the re-entrant on the east side) are similar in character, being talus-covered at the base, sloping downward and outward from the glacier which is strongly arched toward the axis.

SOUTH TAHOMA GLACIER

Mapped by stadia measurements, and checked by intersection from primary control stations on the base line.

More ice appears on the terminal face than at any time during the past four years, but the glacier in general is more covered, and

its terminus more obscured by till than any of the other glaciers under observation. Between the well defined ice faces of the terminus, in some places the position of the top of the terminal face is difficult to judge, the glacier surface merging on a gradual curve with the covered terminus. This is true between stations 5134 and 5193.

A prominent ice face is developing trending approximately S. E. from station 5128. The glacier to the south is very thin, and probably this face will become the edge and terminus of the glacier within the next few years.

A long wing of till-covered ice extends over 400 feet downstream along the south margin of the glacier, and is actually not far from the center of the valley occupied by this glacier. Southward the valley is apparently deserted by glacial ice, but is deeply covered with moraine. The north 300 feet of the terminal face is nearly detached from the main glacier mass. As indicated on the map, the north margin turns northeastward at station 5218, leaving an anvil-shaped (in plan) mass to the north which will doubtlss soon become separated.

Measurements for computing average recession value, were restricted as indicated by the "A" lines on the map in order to avoid the influences of the south lateral wing, and the half-detached "anvil" on the north.

No open caves were present at any outlet.

Acknowledgement: The writer is indebted to Chief Ranger Ward Yeager, District Rangers Gordon Bender and Leonard Volz, and to Ranger Paul Shorrock for assistance in the field.

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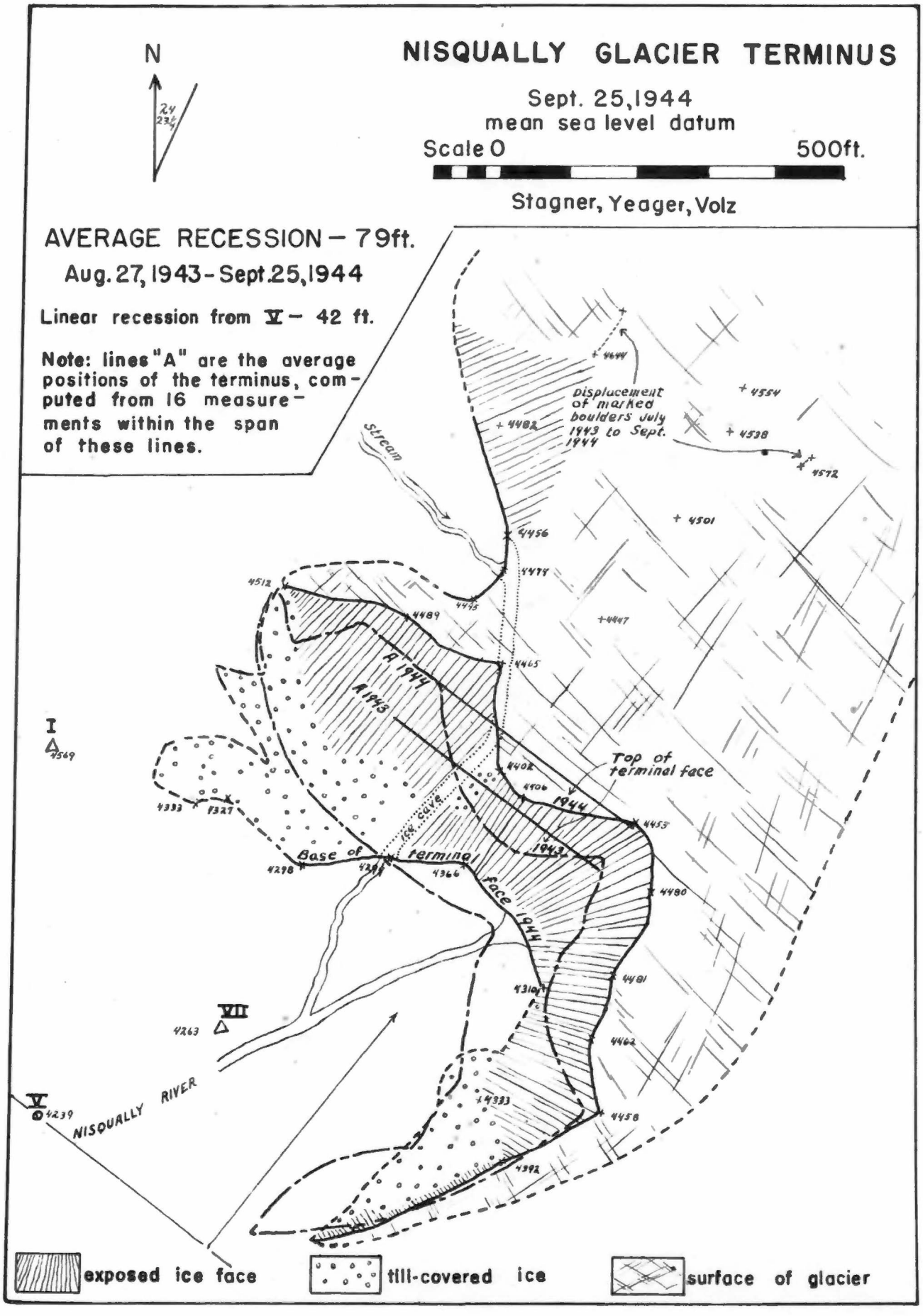
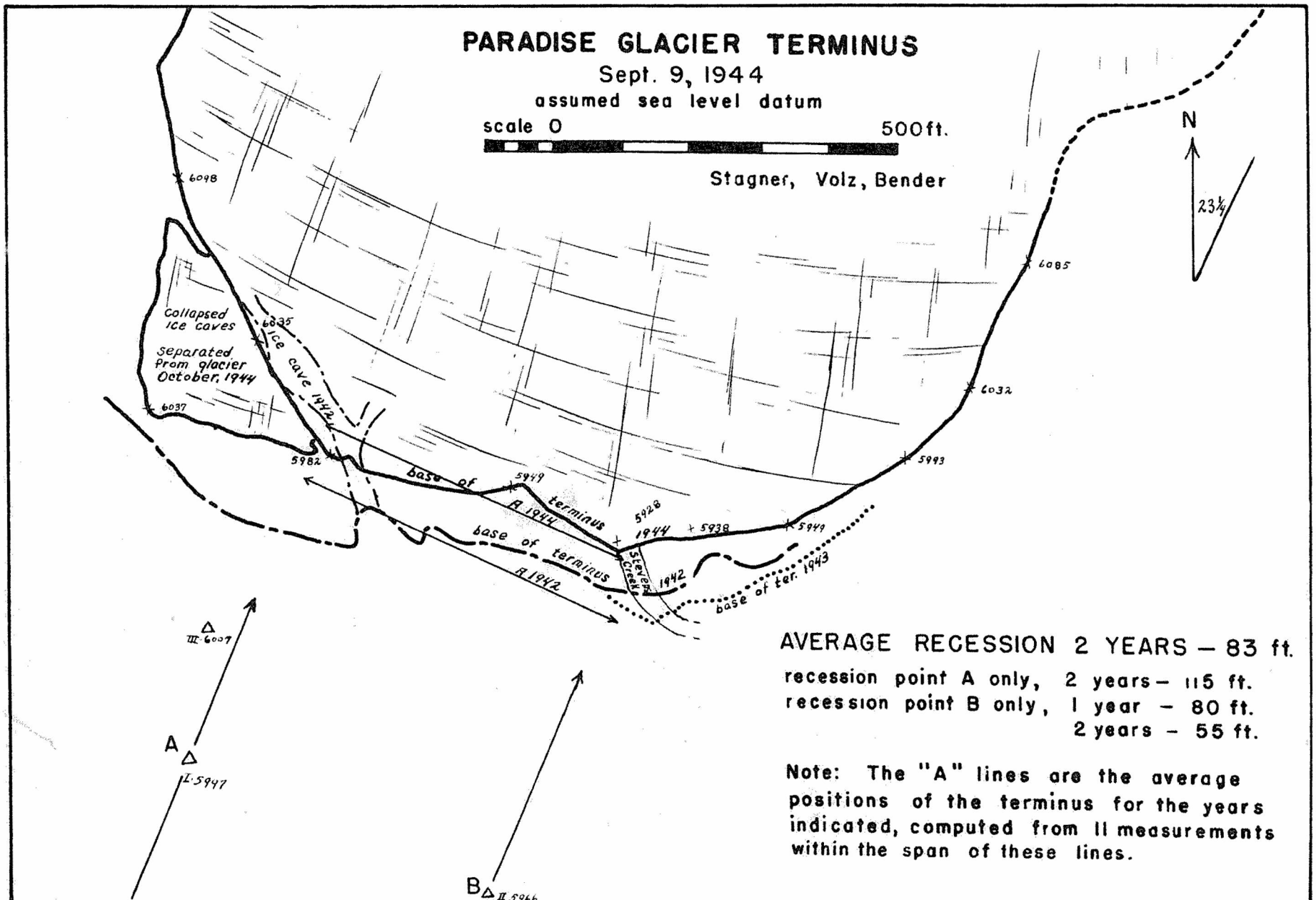
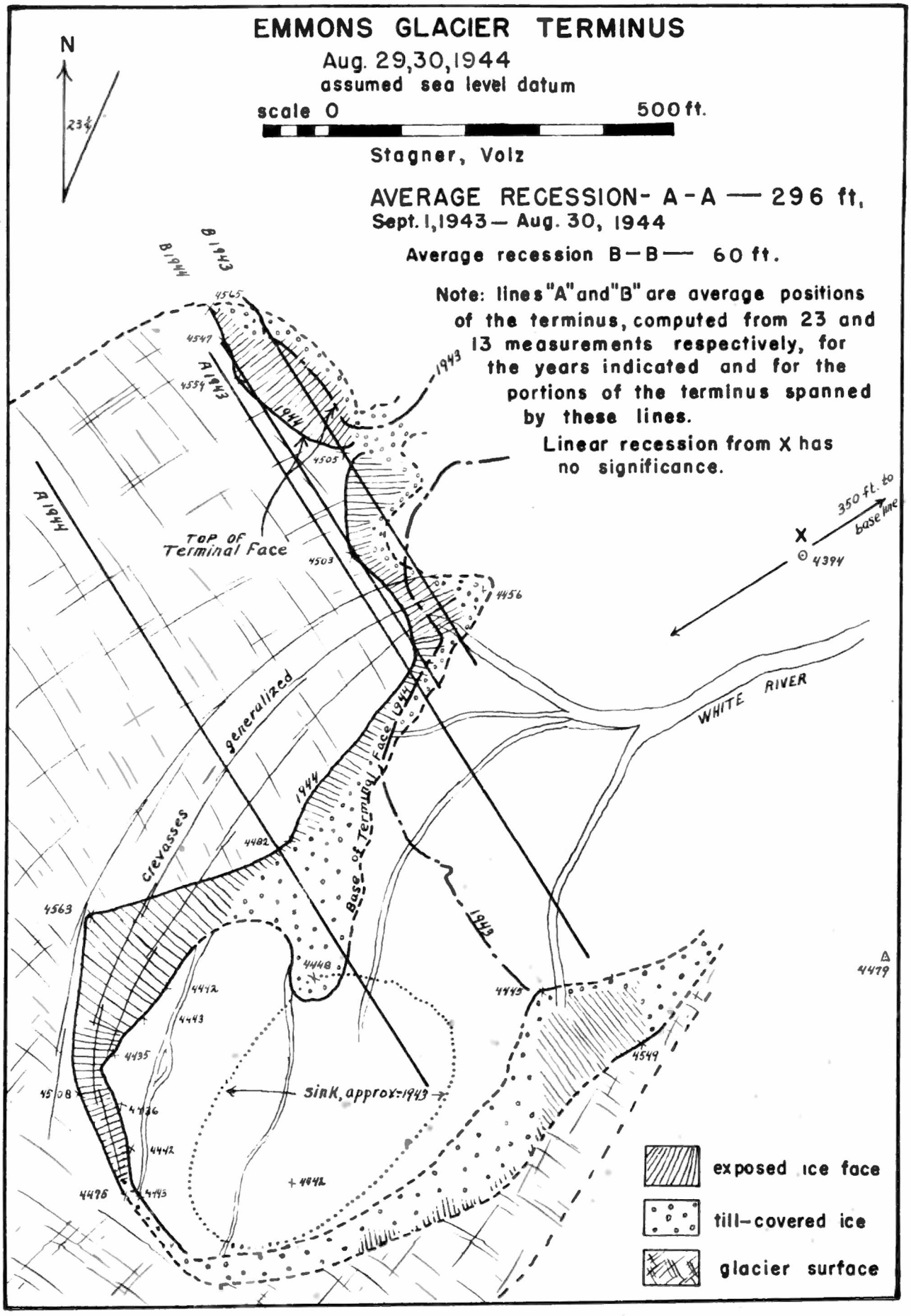

N
24
23½
NISQUALLY GLACIER TERMINUS
Sept. 25, 1944
mean sea level datum
Scale 0
500ft.
Stagner, Yeager, Volz
AVERAGE RECESSION – 79ft.
Aug. 27, 1943 - Sept. 25, 1944
Linear recession from V – 42 ft.
Note: lines "A" are the average positions of the terminus, computed from 16 measurements within the span of these lines.
displacement of marked boulders July 1943 to Sept. 1944
stream
A 1944
A 1943
Top of terminal face
ice cave
1944
1943
Base of terminal face 1944
NISQUALLY RIVER
I
4569
VII
4263
V
4239
exposed ice face
till-covered ice
surface of glacier


PARADISE GLACIER TERMINUS
Sept. 9, 1944
assumed sea level datum
scale 0
500ft.
Stagner, Volz, Bender
N
23½
6048
6085
6032
6037
6035
5982
5993
5949
5928
5938
5949
Collapsed ice caves
Separated from glacier October, 1944
Ice cave 1942
base of terminus A 1944
1944
base of terminus A 1942
Stevens Creek
1942
base of ter. 1943
III 6007
A
I 5947
B
II 5966
AVERAGE RECESSION 2 YEARS — 83 ft.
recession point A only, 2 years — 115 ft.
recession point B only, 1 year — 80 ft.
2 years — 55 ft.
Note: The "A" lines are the average positions of the terminus for the years indicated, computed from 11 measurements within the span of these lines.


EMMONS GLACIER TERMINUS
Aug. 29,30,1944
assumed sea level datum
scale 0
500 ft.
Stagner, Volz
N
23½
AVERAGE RECESSION- A-A — 296 ft.
Sept. 1,1943 — Aug. 30, 1944
Average recession B—B — 60 ft.
Note: lines "A" and "B" are average positions of the terminus, computed from 23 and 13 measurements respectively, for the years indicated and for the portions of the terminus spanned by these lines.
Linear recession from X has no significance.
B 1944
B 1943
A 1944
A 1943
1944
1943
Top of Terminal Face
generalized
crevasses
Base of Terminal Face 1944
Sink, approx. 1943
X
350 ft. to base line
4394
WHITE RIVER
4565
4547
4559
4505
4503
4456
4482
4563
4448
4443
4435
4436
4442
4476
4443
4549
4479
exposed ice face
till-covered ice
glacier surface

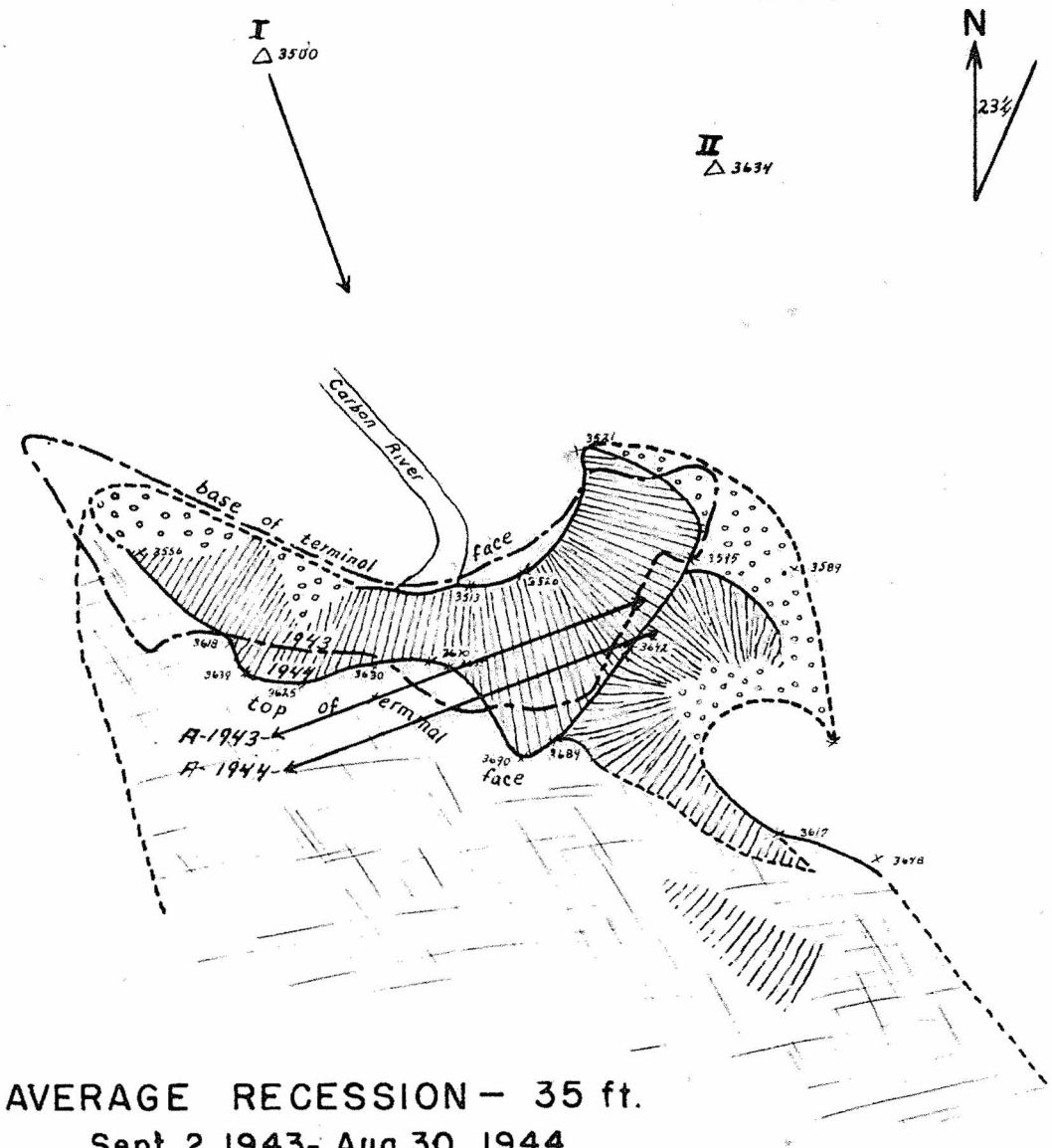
CARBON GLACIER TERMINUS

Aug. 30, 1944

assumed sea level datum

scale 0 300 ft.

Stagner, Volz



AVERAGE RECESSION — 35 ft.

Sept. 2, 1943 - Aug. 30, 1944

Linear recession from Pt. I — 10 ft.

Note: the "A" lines are the average positions of the terminus for the years indicated, computed from 17 measurements within the span of these lines.

exposed ice face

till-covered ice

surface of glacier

SOUTH TAHOMA GLACIER TERMINUS

Sept. 12, 1944

assumed sea level datum

scale 0 500 ft.

Stagner, Volz

N

23½°

AVERAGE RECESSION — 114 ft.

Sept. 3, 1943 to Sept. 12, 1944

linear recession line X - O — ~~120~~ 70 ft.

Note: "A" lines are average positions of terminus from 16 measurements.

exposed ice face

till-covered ice

glacier surface