

## SHORT NOTES

### FLUCTUATIONS OF COLEMAN GLACIER, MT BAKER, WASHINGTON, U.S.A.

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**ABSTRACT.** Thickness variations above an ice fall in the terminal tongue of Coleman Glacier on Mt Baker, Washington, have been quite small ( $\pm 5$  m) in contrast to the rapid expansion and shrinkage of the tongue itself during the last 20 years. The tongue has not responded as actively to recent, larger thickness changes above the ice fall as it did during its period of most active expansion between 1954 and 1956. There is no apparent relationship between the glacier thickness and the type of flow in the terminal tongue.

**RÉSUMÉ.** *Fluctuations du Coleman Glacier, Mt Baker, Washington, U.S.A.* Les variations d'épaisseur en amont d'une zone de séracs dans la langue terminale du Coleman Glacier sur le Mt Baker (Washington) ont été particulièrement faibles ( $\pm 5$  m) en comparaison des rapides avancées et retraits de la langue elle-même au cours des vingt dernières années. La langue n'a pas répondu aussi vigoureusement aux récents et plus importants changements d'épaisseur en amont du rapide de glace, qu'elle ne l'avait fait pendant sa période d'avancée la plus active entre 1954 et 1956. Il n'y a pas de lien apparent entre l'épaisseur du glacier et le type d'écoulement de la langue terminale.

**ZUSAMMENFASSUNG.** *Schwankungen des Coleman Glacier, Mt Baker, Washington, U.S.A.* Die Dickenänderungen oberhalb eines Eisfalls in der Zunge des Coleman Glacier am Mt Baker, Washington, waren im Gegensatz zu den raschen Vorstößen und Rückzügen des Gletscherendes während der letzten 20 Jahre sehr gering ( $\pm 5$  m). Die Gletscherzunge reagierte auf junge, grössere Dickenänderungen oberhalb des Eisfalles weniger aktiv, als während der Periode ihres grössten Vorstosses zwischen 1954 und 1956. Zwischen der Gletscherdicke und dem Fliessverhalten der Zunge gibt es keine unmittelbare Beziehung.

RELATIONSHIPS between the ice thickness of the Coleman Glacier on the north-west side of Mt Baker, Washington, and movement at its tongue during a period including retreat and re-advance suggest that the tongue is responding to forces generated higher in the glacier, not to the thickness and surface gradient at or immediately above the terminus. The Coleman Glacier tongue is the lowest tongue below the peak of Mt Baker in Figure 1. The portion of the glacier on the left with a higher, double-tongue terminus is known as Roosevelt Glacier. Both glaciers descend over a series of lava flows which influence the surface topography and produce a number of ice falls. The surface-slope relationships of the Coleman tongue are shown clearly in the longitudinal profiles in Figures 2 and 3. Above the brink of the lower ice fall, the surface has a uniform, low gradient until it reaches the base of a higher ice fall. This surface feature is barely visible in the photograph, but is indicated by an arrow pointing to a horizontal line marking a change from lighter-colored ice to the darker, crevassed area of the ice fall.

The data for thickness variations between 1958 and 1965 in Figure 3 augment the results published by Harrison (1961[b]), which are repeated in Figure 2 for comparison with changes since 1958. The profile for 1958 is shown in both illustrations to facilitate the comparison. The terminus advanced rapidly between 1954 and 1958 without any appreciable change in the thickness at the top of the ice fall. The terminus acquired a smooth convex shape after 1955, typical of plastic deformation. This shape was retained until June 1958.

Unusual ablation occurred during the summer of 1958. The thickness was reduced more than 15 m in some areas. The terminus assumed a feather-edged appearance. The loss was particularly high in the upper ice fall area above the low-gradient region. While no velocity measurements were made, it was apparent that forward motion of the terminus had virtually ceased. The reduced flow allowed the front to retreat between 1960 and 1962, although the ice level at the brink of the ice fall had regained its former thickness. A small re-advance to approximately the 1961 position occurred in 1963, and the front became visibly thicker.

A long late winter in 1964, followed by an exceptionally cool summer, provided an accumulation excess which was greater than any during the previous hundred years, with the possible exception of 1916 and 1917. The glacier had advanced slightly the previous year, and now pushed ahead 35 m/year for two years. This advance was considerably less than the rate in 1954 and 1955, when the thickness at



Fig. 1. Mt Baker and Coleman and Roosevelt Glaciers from Lookout Mountain on 27 July 1958. An arrow indicates the location of the brink of the lower Coleman ice fall.

TABLE I. FRONTAL VARIATIONS AND ICE-FALL THICKNESS OF COLEMAN GLACIER

<i>Interval</i>	<i>Advance of front during interval</i> m	<i>Elevation at brink of ice fall at end of interval</i> m a.s.l.
1953-54		1 500
1954-55	+99	1 503
1955-56	+76	1 503
1956-57	+58	1 503
1957-58	+40	1 495
1958-59	0	1 495
1959-60	+2	1 495
1960-61	-39	1 500
1961-62	-3*	1 503*
1962-63	+3*	1 505*
1963-64	+35	1 511
1964-65	+35	1 512
1965-66	+2*	1 510*
1966-67	+17*	1 510*
1967-68	+1*	1 510*
1968-69	-4*	1 507*

\* Values for these years are estimated, since photogrammetry was not completed in 1962, 1963, 1966 and 1968.

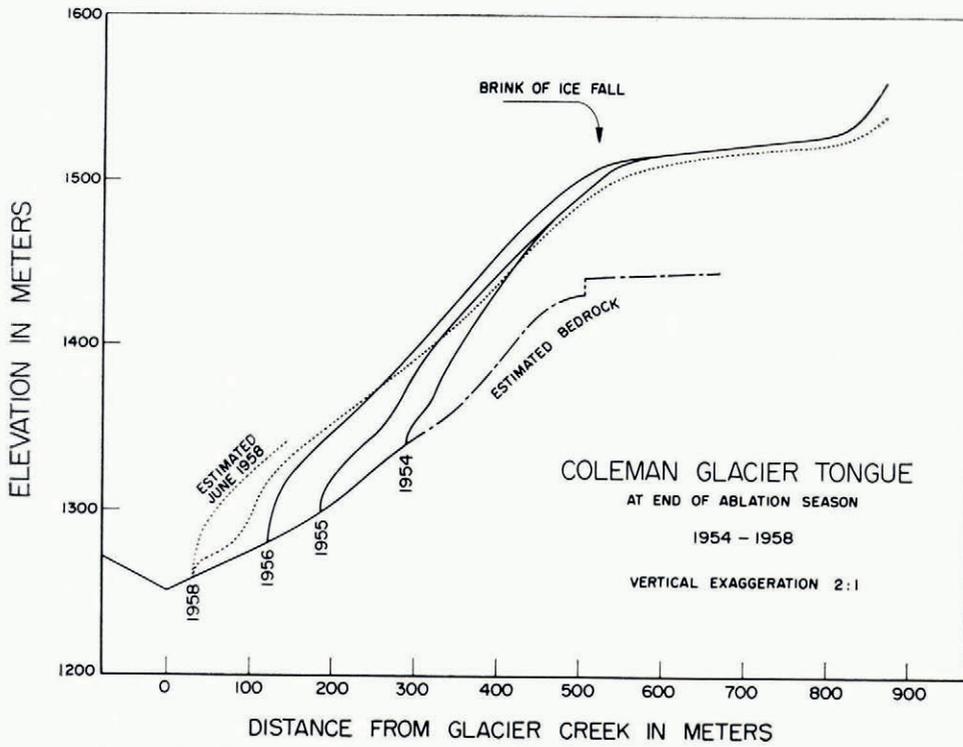


Fig. 2. Variations of terminus and thickness of Coleman Glacier tongue during interval 1954-58.

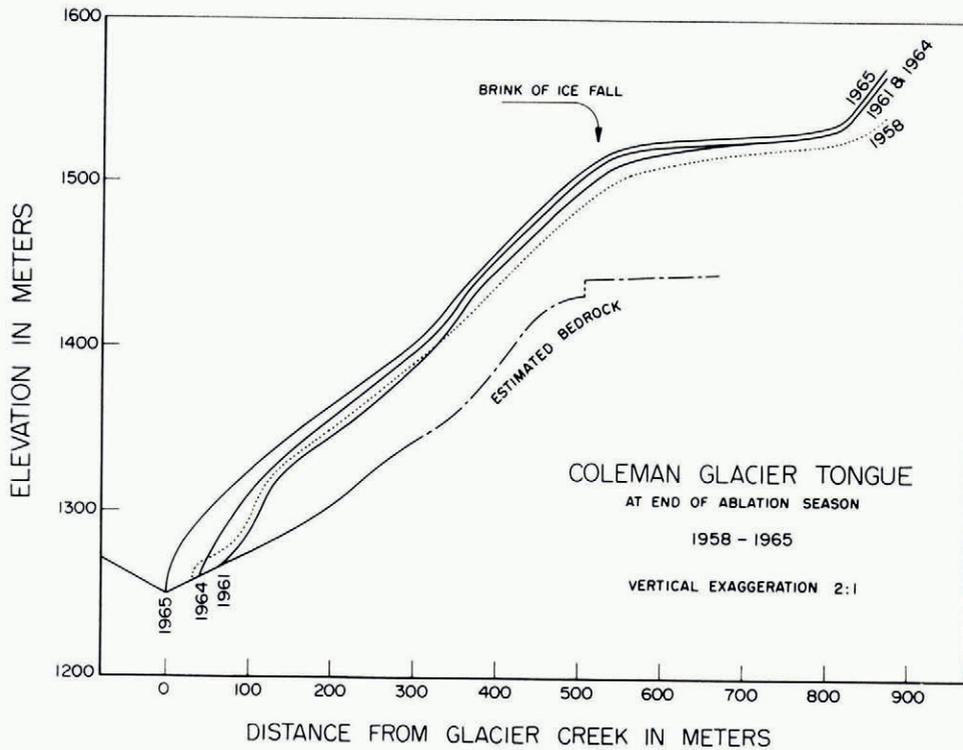


Fig. 3. Variations of terminus and thickness of Coleman Glacier tongue during interval 1958-65.

the top of the ice fall was several meters lower. The 1964 and 1965 advances appeared to be the result of movement by sliding and/or in shear rather than by plastic flow. Since that time, the front has hesitated and a retreat seems to be imminent.

This information cannot be presented satisfactorily in the form of profiles, even with a 2 : 1 vertical exaggeration, due to the number of coincident and overlapping lines. It has been summarized in Table I. Possible errors are  $\pm 2$  m in average terminal position and  $\pm 2$  m in differential elevation at the brink of the lower ice fall.

Zonal changes in volume (Harrison, 1961[a]) have not been computed from the maps plotted for 1961, 1964 and 1965. No maps have been prepared from the 1967 and 1969 photogrammetry.

Several conclusions regarding the behavior of Coleman Glacier can be obtained from these data. This glacier responds very rapidly to short-period changes in climate. The rapid reaction to the excess-accumulation period between 1953 and 1956, and again after 1964, was probably possible because the glacier already had sufficient flow to cause it to advance. It seems highly unlikely that the behavior of the front at these times were caused by similar variations in climate of short duration many years before. There is no apparent relationship between the glacier thickness and the speed of flow. It would appear that the volume and velocity of flow over the upper ice fall may determine the behaviour of the tongue, not the thickness or gradient of the tongue itself. More data on flow velocities are obviously needed to resolve this point.

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#### REFERENCES

- Harrison, A. E. 1961[a]. Fluctuations of the Coleman Glacier, Mt. Baker, Washington. *Journal of Geophysical Research*, Vol. 66, No. 2, p. 649-50.
- Harrison, A. E. 1961[b]. Ice thickness variations at an advancing front, Coleman Glacier, Mt. Baker, Washington. *Journal of Glaciology*, Vol. 3, No. 30, p. 1168-70. [Letter.]