COLLIER GLACIER

A rethink of its history and comments on its climatic status since 1975

By Keith R. Mountain

Introduction

As recently as 60 years ago Collier Glacier extended from the col between the Middle and North Sisters to the southern flank of Collier Cone — a distance approaching 3 kilometers. Today the ice is confined to a protected northwest-facing niche between the Middle and North Sisters, with a length of half its former extent. This remarkable and extremely rapid retreat has been documented through an invaluable sequence of photographs taken intermittently since the 1900s and sequentially since 1934 from the southern flank of Collier Cone (Hopson, 1960). From this photographic record it can be seen that this retreat occurred primarily from 1924, when the ice was still in contact with Collier Cone, to 1951, by which time the ice had retreated to the general area that it occupies today.

It is apparant, however, that the retreat undergone by Collier Glacier has not been consistent with other glaciers in the Three Sisters Wilderness area. Comparisons of the current condition of the major glaciers in the region to early descriptions (Williams, 1916; Hodge, 1925) indicate that their retreat has, for the most part, been gradual and consistent. It is of interest, therefore, to consider probable causes of the rapid retreat of Collier Glacier, to consider the glacier's current climatic setting and to place this glacier in its historical context.

Neoglacial History of Collier Glacier

There is no reasonable doubt that at earlier times what we presently know as Collier Glacier extended beyond the site now occupied by Collier Cone (Diagram 1). Collier Cone itself is a recent addition to the landscape with the date of its formation set between 600-1000 years before present (Y.B.P.) (Lund, 1977, 143). Thus, the ice that abutted Collier Cone must be a product of the advance undergone by Collier Glacier during the "Little Ice Age" or the Neoglacial (generally dated as having taken place between 1650-1860 A.D.).

Since the termination of the Pleistocene (10,000 Y.B.P.) there have been several major periods of Holocene climatic warming and cooling. The warmest period, the Climatic optimum (8000-5000 Y.B.P.), was known to be characterized by an average air temperature several degrees warmer than that measured today. Given the observed response of Collier Glacier to the overall warming trend that has taken place since the turn of this century it is reasonable to assume that the Pleistocene ice mass that occupied this site disappeared in it entirety, and Holocene ice reformed during the next major period of global cooling (6000-3000 Y.B.P.). The question is, "Has the site now occupied by Collier Glacier been consistently occupied by ice since this early Holocene advance?" Unfortunately, for Collier Glacier at least, there may be no direct way to determine this, for recessional evidence is easily destroyed by repeated glacial advance.

The retreat of Collier Glacier since the early 1920s can, in part, be attributable to the presence of Collier Cone. As the Neoglacial ice advance down the previously carved glacial trough it's progress was halted by Collier Cone. To the west of the lower portion of the glacial trough lies the Little Brother; to the east, the western flank of the North Sister. As the southern rim of Collier Cone was strong enough to resist the pressure exerted by the advancing ice the glacier was topographically confined and forced to thicken in it's lower reaches to accomodate the consistent input of ice from the accumulation zone. Only two relatively ineffective outlets provided for some pressure release at the snout of the glacier: a small lobe was forced to the east, possibly breaching the eastern lateral moraine where it is now possible to observe a substantial area of push moraine and collapsed morainal debris; and, to the west, down White Branch Creek (see Diag. 1)

With the onset of climatic conditions that led to the retreat of all glaciers in the Three Sisters Wilderness Area, Collier Glacier had to first undergo a considerable volume reduction before any change in the position of the glacier terminus could be observed. It would seem that this thinning was underway as early as 1916, as moraines that were as much as 100 feet above the glacier surface were described (Williams, 1916, 22).

By the time the separation between Collier Cone and the glacier terminus occurred Collier Glacier was considerably out of equilibrium with the increasingly warming climate. Retreat rapidly ensued. The apparent rate of retreat must also be considered a function of the relatively gentle slope of the glacial trough, allowing the ice to retreat a considerable distance with only a slight elevational adjustment. thus, by 1951 and perhaps as early as 1949, Collier Glacier had retreated to its approximate current site. Subsequently, only minor changes in the position of the glacier terminus have occurred, although it is clear that considerable thinning has taken place.

Comments on the Current Climatic Setting of Collier Glacier

Glacial activity is controlled not only by the general meteorological environment but also by localized site-specific factors. The effects of surface slope, azimuth, shielding of solar radiation by the surrounding terrain — to mention a few — all combine to influence the behavior of an ice mass. These additional factors become particularly important for a glacier of the size and type of Collier.

Of the several energy sources available for melting at the surface of any glacier, in Collier's case it is the solar radiation that is most influential o both a seasonal and diurnal basis. During the winter solstice the maximum elevation that the sun can attain above the horizon is only 22 degrees, and if the glacier were not surrounded by the Middle and North Sisters, the surface would receive a total of 8.6 hours of direct-beam solar radiation. However, the importance of these two peaks upon the shading of the glacier can be gauged by the fact that the sun can only be seen from the glacier for 3 of these 8.6 hours. At this time of the year the glacier is also coated by fresh snow, which effectively reflects as much as 80 percent of the sun's rays. In addition, the glacier is angled away from the sun to the NNW at an overall angle approaching 12 degrees. The net result of these three relationships is that from approximately mid-September to late June the winter snowpack can be expected to remain over Collier Glacier. Thus for a period of approximately 8 months, energy input is not substantial enough to result in any significant melting.

As the summer months approach the glacier is subjected to more hours of solar exposure, with increasing day length and less protection from the surrounding terain. The extent to which the winter snowpack has built up now becomes important as the availalbe energy is used in the melting of this cover. As the winter covering can be expected to remain until late June or early July, this energy availability is effectively unusable by the glacier proper until the summer solstice is reached or even passed. When the critical balance between energy availability and melting is reached, the surface covering appears to be removed with extreme rapidity.

With the removal of the snow cover, a pronounced drop in surface reflectivity occurs, and combined with the factors outlined above, the glacier is particularly vulnerable to melting over its entire area. Meltwater flows freely over the surface of the ablation zone, while on the upper reaches of the glacier, meltwater percolates to the glacier base and is discharged at the snout. At times, it is possible to observe water flowing between the laminated layers exposed by the icefall. In this instance the percolating meltwater has come into contact with a relatively impervious layer of ice and flows through the body of the glacier. Thus, the ablation season, even though it is relatively short (typically late to early August), can result in considerable mass loss for Collier Glacier.

Conclusion

As always, it will be interesting to observe the changes that Collier Glacier will undergo in the near future for it is clear that the response time for this glacier to any climatic adjustment is relatively short. In the summer of 1975 the glacier indicated extensive internal activity as was evident from the sound of the ice as it moved over the bedrock and the consistent lateral displacement of surface rock debris to the flanks of the glacier. The summer of 1977 was severe in terms of mass loss for the glacier. Segments of the icefall decayed and collapsed, while crevassing was so well-developed that foot passage up the glacier on the eastern side of the icefall was impossible. The glacier did not exhibit any of its former signs of motion. This pattern appears to have continued until 1981. By 1983, however, it was apparent that the winters of the previous years had provided a sufficient supply of snow to substantially increase the bulk in the accumulation zone. All of the crevasses appeared completely filled and rock outcrops to the western side of the accumulation zone indicated that the buildup had been as much as two meters. This change is not yet observable in the ablation zone, but it is important to note that no substantial fluctuation of the glacier margins has occurred. should this build-up continue it is possible that some change will soon be reflected in the ablation zone. From the extensive period of observation undertaken by the author in 1977 it was concluded that Collier Glacier would continue to retreat and reduce in volume at a rapid rate. However, the issue is now not so clear.

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