Rock glacier velocities, Selwyn Mountains, Yukon and NWT, Canada, Version 1

USER GUIDE

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Abstract

In this study, we compare surface velocities of 9 rock glaciers over decadal and millennial timescales using independently derived velocities. We obtained surface velocities on fifteen rock glaciers in the Selwyn Mountains by surveying marker arrays in 1983 and1995. Millennial-scale velocities were also determined from lichenometric ages and rock glacier length on 9 of the 15 rock glaciers for which lichenometric ages were available. The mean surveyed velocity of the 9 rock glaciers was 0.20 + 0.11 m/yr, and the mean age/length-based velocity was 0.20 + 0.13 m/yr. These two independently derived sets of velocities are not significantly different from each other. Given that measures of rock glacier thickness, surface velocity, and lichenometric ages have inherent errors, the primary point of the results is that these two sets of velocities are of the same order of magnitude as each other. These results indicate that on these rock glaciers in the Selwyn Mountains, (1) decadal and millennial scale velocities are the same order of magnitude, and (2) either method apparently can resolve long-term velocity in this area. The velocity data are available for viewing on this CD ROM.

Introduction

Surface velocities were measured in fifteen rock glaciers in the Selwyn Mountains of the southeastern Yukon Territory at stations occupied in 1983 and 1995 (Figure 1). Nine of these rock glaciers had been lichenometrically dated in an earlier study (Dyke, 1990a). Here we (1) present observations of surface velocities on 15 rock glaciers averaged over 12 years in the Selwyn Mountains, (2) calculated long-term velocities using rock glacier length and lichen age, and (3) compare the velocities determined using these two methods.

1 DATA DESCRIPTION

1.1 Site Maps, Figures, and Additional Documentation

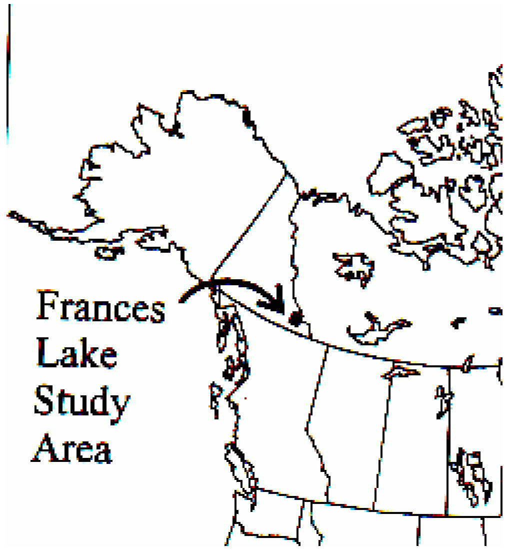

Figure 1. Map of study area in Selwyn Mountains, SE Yukon.

Figure 2. View of the Selwyn Mountains.

Figure 3. Photo of a rock glacier in the Selwyn Mountains.

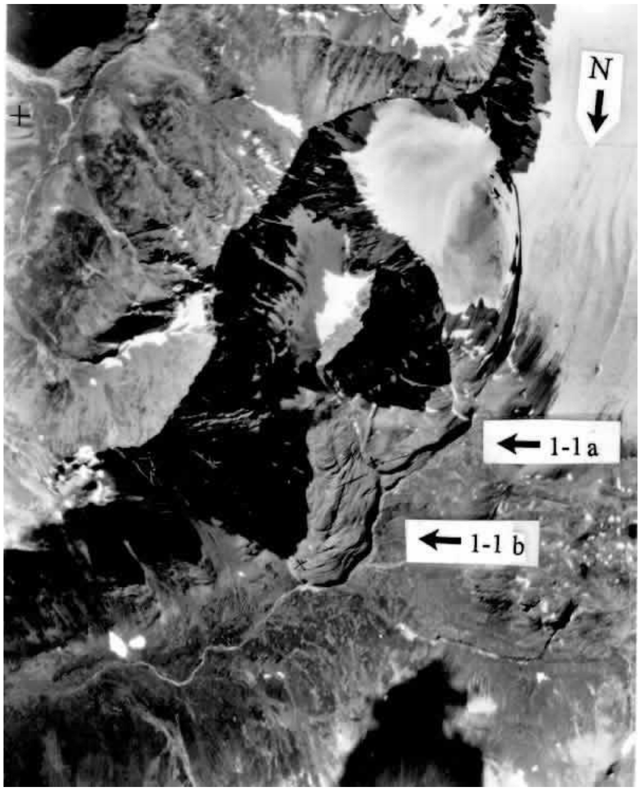

Figure 4. Aerial photo of rock glacier 1a, 1b in this study.

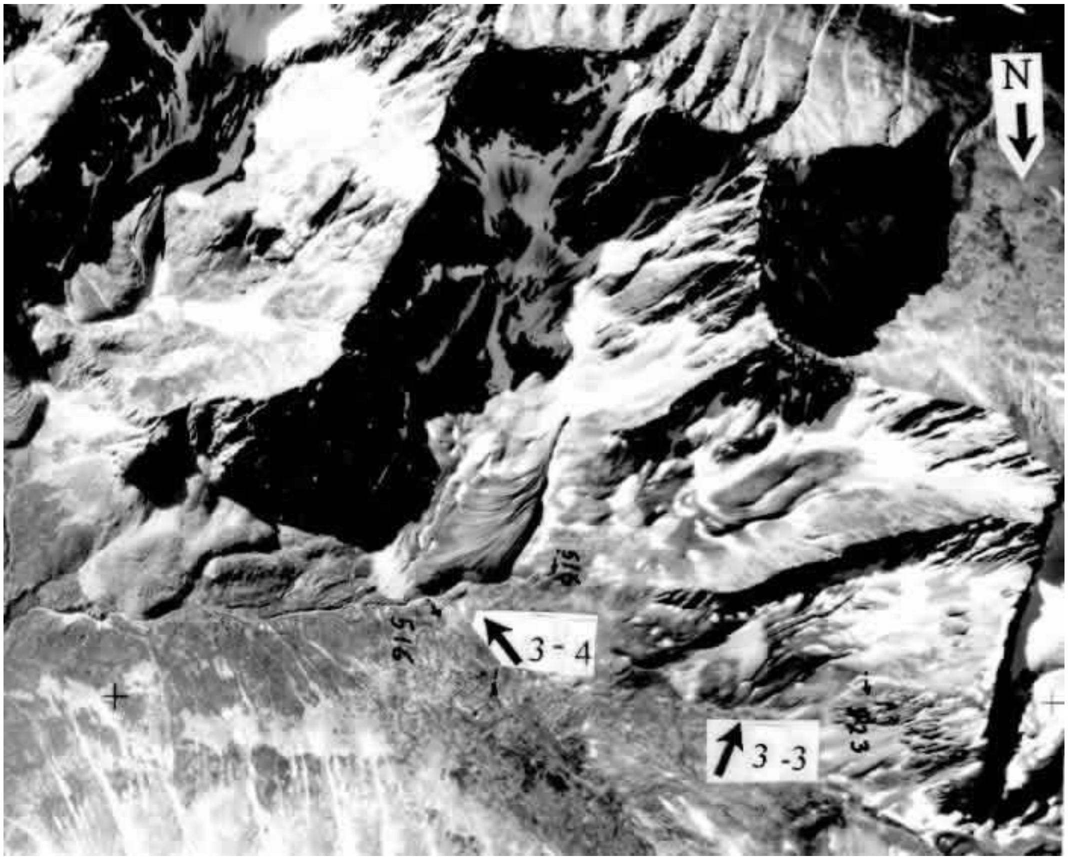

Figure 5. Aerial photo of rock glaciers 3-3 and 3-4.

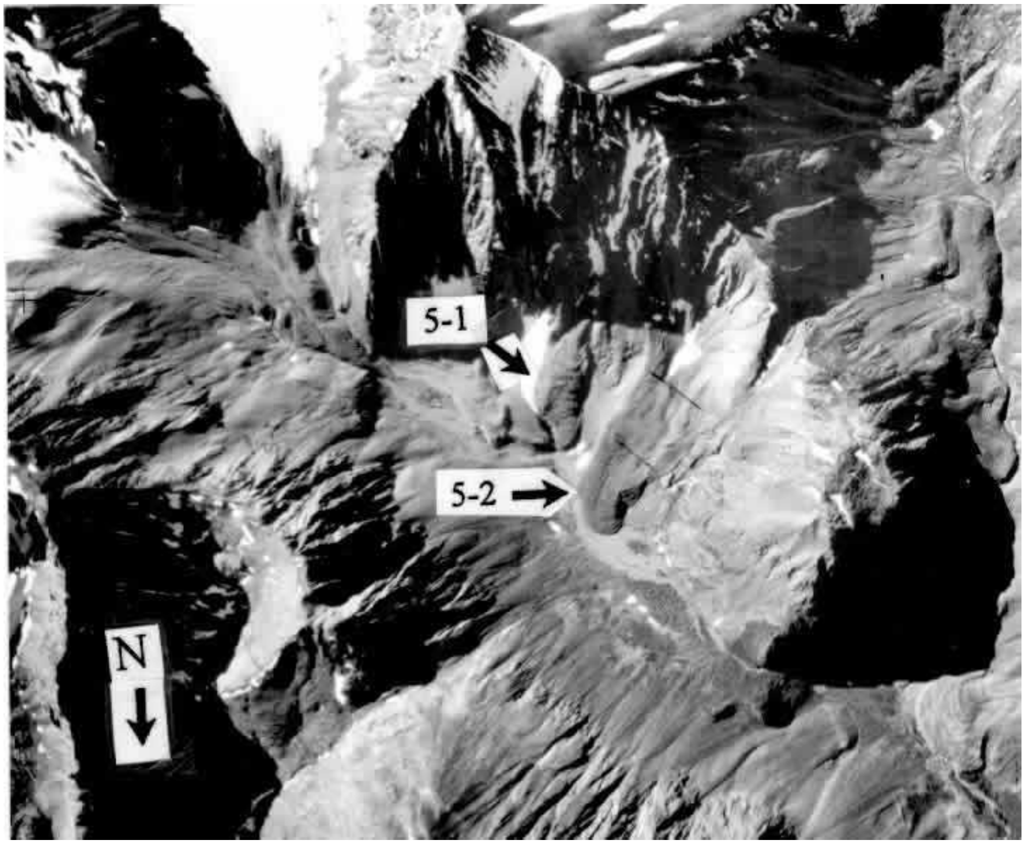

Figure 6. Aerial photo of rock glaciers 5-1 and 5-2.

1.2 Study Area

The Selwyn Mountains were covered by a northern extension of the Cordilleran Ice Sheet during the last glacial maximum, and is currently an alpine environment that is characterized by sporadic permafrost (Dyke, 1990b). More than 1100 rock glaciers and 125 small cirque glaciers occupy an area 100 km x 100 km, and almost all of the rock glaciers are observed to be active. A detailed lichenometric study on rock glaciers and small moraines distal to cirque glaciers indicates that the rock glaciers predate Little Ice Age moraines by thousands of years, and that glacial advances and episodes of rock glacier development are not coeval (Dyke, 1990a).

1.3 Methodology

In 1983, we established survey arrays on 22 rock glaciers in the Frances Lake area of the Selwyn Mountains. In 1995, we successfully re-surveyed 15 of the 22 rock glaciers, obtaining a 12-year record of rock glacier surface movement on rock glaciers of varying dimensions, site conditions, lithologies, and ages. The variability in marker location is the single largest source of variability in the velocity data because velocity varies considerably with location on the rock glacier surface.

Variability in velocity from decade to decade has been observed on rock glaciers elsewhere (Barsch, 1996), and is not captured by this 12-year record. Nonetheless, the intent here is to record an order of magnitude measurement. Lichenometric ages of rock glaciers were obtained from Dyke (1990a) using size- frequency of green and black Rhizocarpon species on samples of 400 individuals for each site. A lichen growth curve characteristic of dry alpine areas was adopted and constrained using a single datum of the 1200-year old White River Ash. Linear growth rates of 3 mm/century have been calculated for the Colorado Front Range (Benedict, 1976), Cumberland Peninsula of Baffin Island (Miller and Andrews, 1972), and the St. Elias and Wrangle mountains of Alaska (Denton and Karlën, 1973). In West Greenland, the observed linear growth rate is 2 mm/century (Ten Brink, 1973), and in Swedish Lapland, it is 4 mm/century (Denton and Karlën, 1973). The curve used by Dyke (1990a) is constrained by the White River Ash datum, and assumes a "great period" of three centuries and a long term linear growth rate of 3 mm/century. Dyke (1990a) used the diameter of the largest one percent of samples of about 400 lichens rather than the single largest lichen as a measure of the oldest, largest lichen. This curve is described by the equation:

$$\text{Age} = 0.03\text{mm/yr} \times \text{Diameter} + 21 \qquad (1)$$

An assumption in this analysis is that the rock carrying the lichen originated at the head of the rock glacier, with an initial distance of 0 m. Rock glacier surfaces have been observed to flow more rapidly than the snout (Wahrhaftig and Cox, 1959, Jackson and MacDonald, 1980), and so the surface velocity does not necessarily indicate the rate at which the snout of the rock glacier advanced down slope. It is assumed that the lichen started growing on a clast located at the head of the rock glacier. It is possible that the clast was located further downslope when the lichen started growing, a factor that would lead to an over-estimation of the long-term average velocity. It is also possible that the lichens were established before the onset of flow. Using incorrect lichen growth rate curves will introduce age errors of approximately 23 to 30%. If the lichen ages are under- estimated, surface velocities will be over-estimated, and if the lichen ages are over-estimated, the velocities will be under-estimated. Although these uncertainties may vary amongst rock glaciers, the data together indicate a mean surface velocity of 0.20 m/yr for the nine rock glaciers over a period of approximately 3000 years. These velocities ought to be considered more as an indication of the order of magnitude of the velocities than as absolute and accurate long-term velocities on account of these uncertainties.

1.4 Results: Comparing Decadal and Millennial Velocities

A summary of surveyed velocities is shown in Table 1, and of rock glacier lichen ages and lengths, and lichen-age-based velocities for the rock glaciers are shown in Tables 2. A comparison of the maximum velocities surveyed between 1983 “ 1995 and the longer-term velocities show that they are on the same order of magnitude. The mean surveyed velocity for the nine rock glaciers was 0.20 + 0.11 m/yr, and the mean lichen- based velocity for the same nine rock glaciers is 0.20 + 0.13 mm/yr. A t-test between the surveyed and lichen-based velocities shows no significant difference between the two sets of numbers at the 0.05 level of significance.

1.5 Conclusions

The difficulty of measuring a geomorphic process over different time scales has been a significant issue in assessing contemporary rates of geomorphic processes. Generally, it has been observed that long-term rates far exceed measured rates. In this study, we compare rates of processes, rock glacier velocities, over two different timescales, decadal versus millennial. In other studies, long-term rates have been observed to far exceed measured rates (e.g. Rapp, 1960). In a comparison of long-term versus short-term rates of talus accumulation, Luckman and Fiske (1995) found that even the maximum 50-year rates of talus accumulation determined by lichenometry for the last 300 years were an order of magnitude too small to have produced the talus slopes during the Holocene. Whalley et al. (1995) found that long-term rates of one rock glacier in Iceland were one order of magnitude greater than decadal velocities in a similar comparison of lichen and length-based velocities and surveyed velocities. By comparison, the difference between decadal and millennial scales observed on the rock glaciers in this study is small. Two conclusions can be drawn from these data: (1) either method of determining appears to resolve long-term velocities in this area, and (2) for these rock glaciers, millennial and decadal scale rock glacier velocities are of the same order of magnitude. It would be interesting to further test these conclusions by using another dating method such as cosmogenic exposure to obtain millennial scale velocities.

2 CONTACTS AND ACKNOWLEDGMENTS

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