MPERG Report 2008-4

Interim Report on the Recent Deglacierization of the Wheaton River Watershed, YT

By

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1/31/2008

Abstract

Over the past several decades, the rate of temperature increase in the Arctic has been twice that of the rest of the planet. Climate modeling suggests that this region will experience greater climate warming over the remainder of this century than other parts of the world. We are studying the effects of recent, rapid and significant warming on physical environments of southern Yukon Territory, which is within sub-Arctic Canada. In this paper, we document rapid glacier retreat in the Wheaton River watershed, which presently supports the only glaciers on southern Yukon Plateau. Our research involves study of the largest of the glaciers in the Wheaton watershed, hereafter referred to informally as "Wheaton Glacier". It addresses three questions: How has Wheaton Glacier changed over the past century? What is the relationship between historic activity of the glacier and regional climate? What have been the effects of climate warming and glacier retreat on the watershed? Wheaton Glacier has shrunk in area by 41% since the first photographs of it were taken in 1948. Glacier retreat has accelerated in the past 40 years, and the glacier is now so thin and short that it may disappear within the next 20 years. The main cause of glacier thinning and retreat is an increase in mean temperature; average winter snowfall has gradually increased over the period of record. Warming and glacier recession are altering sediment delivery in the upper Wheaton River watershed. A pulse of sediment is moving downstream from the Wheaton Glacier forefield and affecting the fan at the mouth of the valley. Large, out-of-channel debris flows are spilling across the fan, aggrading and shifting the stream channel. Evidence from cores and ground-penetrating radar surveys suggest that debris flows have dominated sedimentation on the fan during the last half of the Holocene, coincident with Neoglacial advances culminating in the Little Ice Age and the period of rapid glacier retreat following the Little Ice Age. Triggers identified for some of the debris flows include the draining of a proglacial lake, a rockfall possibly caused by permafrost melt, increased sediment availability associated with glacier retreat; and rock glacier activity.

Progress to Date

Fieldwork was completed in the summer of 2007 on Wheaton Glacier and in its forefield, along the tributary valley between the glacier terminus and the Wheaton trunk valley, and on the fan and wetland at the mouth of the tributary valley.

Geodetic control, required to produce accurate DEMs of Wheaton Glacier from aerial photographs (see below), was obtained by conducting a differential GPS survey of the area around the glacier. Precise geographic locations were obtained for features identified on aerial photographs.

Measurements of lichen thalli (*Rhizocarpon geographicum*) were made on moraines and other features throughout the glacier forefield to date glacier retreat over the past century. One hundred maximum thalli diameters were measured at each site to obtain a sample of the population as well as the largest specimens.

A lichen growth curve for subalpine environments in southern Yukon will be created to estimate the ages of landforms of interest in the Wheaton watershed. Lichens on surfaces of known age (the Carcross-Tagish First Nations cemetery in Carcross and the Montana Mountain access road at the Buddhist monastery site) have been measured. Pre-existing growth curves for the St. Elias, Brooks Range, and Alaska Range will be employed to complement this work.

The fan at the mouth of the glacierized tributary comprises a series of debris flows. The surface of the fan was mapped, with emphasis on discriminating recent debris flows of different age using lichens. The long axes of 50 clasts on each flow were measured to provide estimates of debris flow competence. Lithology and angularity were also recorded. Lichen sizes and clast characteristics were documented throughout the glacier forefield and along the tributary valley to link the debris flows to their sources. Triggers identified for some of the debris flows include the draining of a proglacial lake, a rockfall possibly caused by permafrost melt, increased sediment availability associated with glacier retreat; and rock glacier activity.

A large historic debris flow dominates the upper part of the fan. A tree scarred by this debris flow was sampled to determine the age of the event. The flow may coincide with the draining of a proglacial lake in the Wheaton glacier forefield. Examinations of the tree rings from the scarred tree indicate that the debris flow occurred in the latter half of 1968. A possible peak associated with this debris flow has been identified on the Wheaton River Water Survey of Canada hydrograph records. To estimate the peak discharge of the debris flow, I measured 20 topographic transects at 10 m intervals across the flow path from 80 m above the apex of the fan to the lower edge of the surface exposure of the deposit.

I collected five cores, each approximately 2 m long, from the distal fringe of the fan by pounding PVC pipe into the sediment with a sledgehammer. The pipe was extracted using a come-along attached to a strong ladder. A core catcher prevented the core from sliding out of the PVC pipe during recovery The lowest 30 cm of one core was lost due to impact against a coarse cobble layer at depth, but all other cores are complete. Cores have been logged, dated and photographed (Figure 1). The sediment records preserved in the cores appear suggest that debris flows have dominated sedimentation on the fan during the last half of the Holocene, coincident with Neoglacial advances culminating in the Little Ice Age and the period of rapid glacier retreat following the Little Ice Age. These Neoglacial advances appear to correlate well with work undertaken in the St. Elias Mountains, YT (Rampton, 1970) and the Garabaldi Mountains, southern BC (Koch et al., 2007).

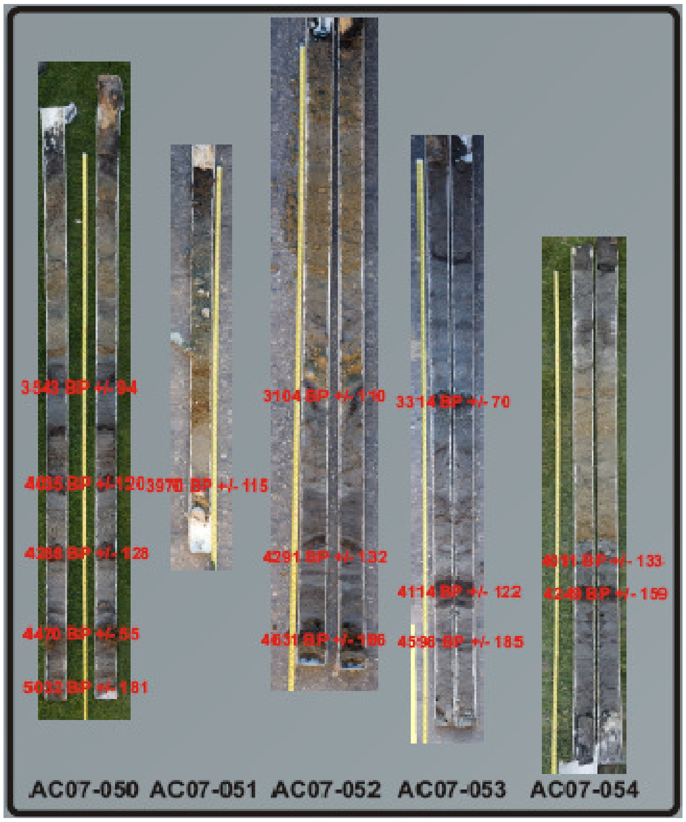

Figure 1. Photographs of correlated sediment cores from the distal edge of the Wheaton fan highlighting ages of various organic horizons.

A ground-penetrating radar (GPR) survey was conducted on the fan in September 2007 to elucidate the shallow subsurface structure of the sediments. One line, ca. 600 m long, was run across the fan near its margin. A second, shorter (200 m) line was run along the axis of the fan to a point where vegetation made further progress impossible. The GPR records will be linked to the cores.

DEMs of Wheaton Glacier and its forefield will be produced from aerial photographs flown between the 1940s and 1999, with geodetic control provided by the differential GPS survey completed in the summer of 2007. Aerial photographs will be scanned using a photogrammetric scanner. If available, camera calibration reports will provide detailed parameters for calibrated focal length, principal point offset, fiducial mark positions, and radial lens distortion. For aerial photographs lacking these data, corner image pixels will be used for fiducial-mark control in order to establish interior orientation. To assess glacier change, older DEM surfaces will be subtracted from more recent ones to generate raster datasets of elevation change over different intervals. PCI Geomatics software will be used to create the DEMs. These data will be augmented with maps of the Wheaton glacier terminus produced from aerial photographs and mapping by the Yukon Geological Survey. Loss of glacier area has been calculated, leading up to the production of DEMs. The Wheaton Glacier has lost 48% of its area since the Little Ice Age. 41% of this loss has taken place since 1948 (Figure 2).

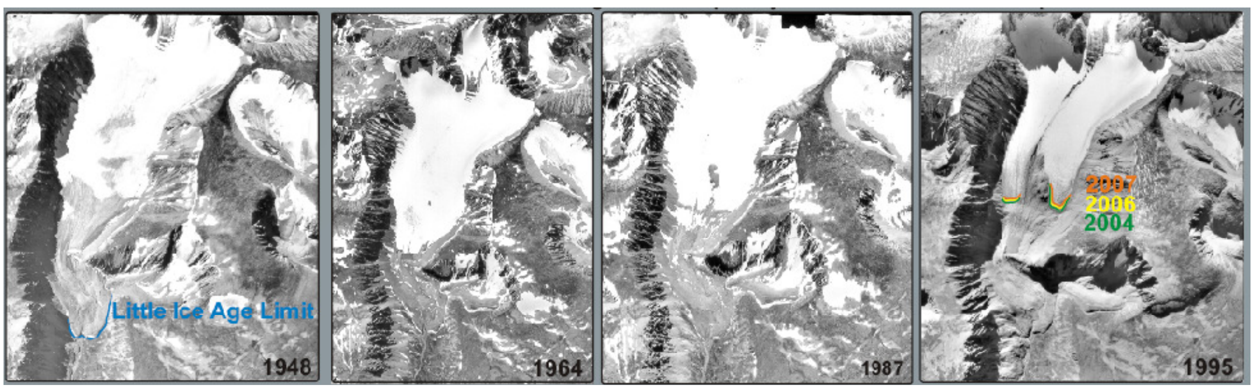

Figure 2. Aerial photographs of the Wheaton glacier. The 1948 photo highlights the location of the Little Ice Age moraine and the 1995 highlights the glacier margin in 2004, 2006, and 2007.

Climate data for Whitehorse will be obtained from Environment Canada. Additional climate data are available from Yukon Archives for stations along the White Pass and Yukon Railway, including Carcross, Bennett, and Log Cabin. Temperature and precipitation data will be examined in hopes of correlating these records with changes in Wheaton glacier.

References

Koch, J., Clague, J.J. and Osborn, G. 2007. Pre-Little Ice Age glacier fluctuations in Garabaldi Provincial Park, southern Coast Mountains, British Columbia, Canada. Submitted to The Holocene.

Rampton, V. 1970. Neoglacial fluctuations of the Natazhat and Klutlan Glaciers, Yukon Territory, Canada. Canadian Journal of Earth Sciences, 7: 1236-1263.