# PRE-LITTLE ICE AGE INTERSTADIAL DURATION BASED ON SOIL PROPERTIES AND GEOCHEMISTRY OF A BURIED FOREST AT THE HERBERT GLACIER, SOUTHEAST ALASKA

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## INTRODUCTION & BACKGROUND

Local responses to global climate change are key in reconstructing a chronology of glacial and interglacial activity. The most recent major advance, the so-called Little Ice Age, began in the mid-14th century; retreat commenced in the mid-18th century in the Juneau Ice Field glaciers and continues to the present. The Herbert Glacier and its surroundings offer a record of the glacial history of the area in the form of a preserved buried forest. During the penultimate interstadial, a coniferous forest developed and was overridden in the Little Ice Age. Retreat within the past decade exhumed the buried forest which appears as a thick peat mat and underlying mineral soil horizons formed in a Pleistocene till. An ablation till, deposited during the most recent retreat, overlies the forest; there is possible lodgment till present from the burial event but is undistinguishable from the ablation till.

The purpose of this study is to characterize the extent of pedological weathering occurring during the interstadial that separates the glacier's penultimate retreat and its most recent advance during the Little Ice Age. The latter occurred as recently as 770±40 years ago. Radiocarbon dates from the bottommost peat layer of a nearby location date the forest at ~8ka (Miller, unpublished data). Soil development can be used as a proxy for the amount of time between the penultimate retreat of the Herbert Glacier and the Little Ice Age advance in the 1300s. In the temperate rainforest climate of southeastern Alaska, vegetation begins to take root within five years after deglaciation (**Fig. 1**). Consequently, the extent of soil development approximates the length of time the area was ice-free during the interstadial. The well-documented ecological succession of the forest vegetation (Ugolini, 1966) helps date the soil and indicates length of soil development. The penultimate interstadial was likely one to two orders of magnitude longer than the duration of the last glaciation. It is also possible, as this paper will explore, that the buried forest records an interstadial interrupted by a pulse of glacial activity, causing an overlap of at least two soils.

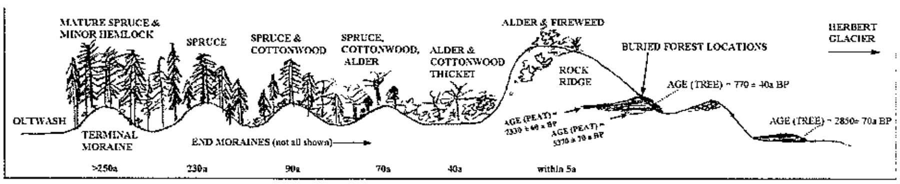


**Figure 1. Vegetation succession after deglaciation in SE Alaska.**

## METHODS

### *FIELDWORK*

Fieldwork was centered in two broad areas: a buried forest in front of the receding snout of the Herbert Glacier, and several moraines down-valley of the glacier, with more emphasis on the former. The buried forest sequence, composed of four sections, was described, sampled, and photographed. At each location, representative soil horizons were excavated and sampled. Descriptions included soil color (moist), estimated grain size, relative amounts of organic material and till clasts, presence of vegetation (both modern and buried forest), and parent material.

Soil structure was commonly lacking within the horizons. The soils are not very thick (~1m or less) and are often inundated with large cobbles of the till parent material, making sampling difficult. Large samples (at least ~1kg) of each described horizon were bagged and numbered for later analysis. Samples of the preserved forest mat and wood were wrapped in aluminum foil for radiocarbon dating.

certain areas allowed for close study of an extensive part of the old spruce forest. The soil in most cases is extensively disturbed due to the nature and mass of the overriding glacier as well as its duration in the area and speed of advance over it. The forest remnants were mainly studied at four locations: Locations 1 and 2 on the northeastern side of the roche moutonnée, Location 3 the flat area facing the glacier front, and Location 4 at a slightly lower elevation than Location 3.

While not laterally continuous, the extent to which the forest crops out can be traced around the rock ridge. Above the preserved forest section, woody debris clings to the ridge face, having been scraped from the forest and transported during the glacier's advance. The deformed trunks of several trees, still in situ and in the growth position, preserve the direction of the overriding ice. By examining preserved bark and wood, the trees were determined to be mainly old-growth spruce.

The soils, with the exception of the modern moraine soils, are all fairly similar, from location to location, with thick Oa horizons of organic-rich forest mat (peat) at the top, and A, Bw or Bs, and C horizons below. Colors range from black in the organic layer to reddish brown or brown in the B horizons, often with red or orange mottling. The weathered parent material tends to be olive grey or brown.

## THRUSTING

Of the four locations, Location 1 has the best preserved soils with the clearest horizons. At Location 3, the soil stratigraphy has been duplicated by thrusting, and the horizons show evidence of churning. Horizon contacts are uncertain. At the base of the overthrust soil, interfingering with forest vegetation, were ~20cm of grey clay and silt laminations possibly representing shear planes created by the thrusting that were filled in by the percolation of sediment-bearing glacial waters. An oriented sample (**Fig.4**) taken from this location was epoxied and thin-sectioned, to investigate any layering within the stringers. Location 2 shows thrusting similar to Location 1 but to a much greater degree. The forest mat occurs in the section three times, indicating triple thrusting. The horizons were disturbed by the glaciation and are not well preserved.

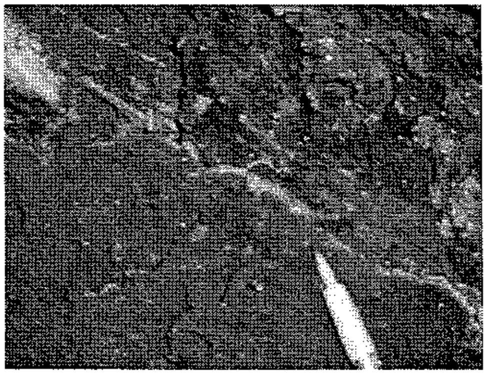

**Figure 4**. Grey stringers, pen for scale.

## DENDROCHRONOLOGY & RADIOCARBON DATES

Some trees with ages estimated by counting tree rings grew for as much as five hundred years. Dendrochronological data is not very reliable here as most often it could not be ascertained whether the tree was in its growth position or had been transported. The wood, in some cases, was extensively weathered around its circumference and/or deformed by the glacial movement.

The radiocarbon ages of three samples were determined, and the results proved interesting. Samples were taken from the top and bottom of the organic peat layer at Location 1. The top layer was dated as 7330 ± 60a BP while the bottom layer (~1m below the top) was dated as 5370 ± 70a BP. The radiocarbon age of a tree (with ~2m root still in situ) found at Location 4 is 2850 ± 70a BP.

## CLAY MINERALOGY

Clay minerals present in the majority of the buried forest samples include low-charge vermiculite, chlorite and illite. The x-ray diffractograms also show feldspar and quartz peaks. A soil sample was taken from the first moraine up-valley from the terminal moraine. This area, ice-free for ~250a, is covered by a first or second generation spruce forest. It has more chlorite (found in the parent material till) relative to illite than the other two soils shown above. The relative peak heights also indicate low Fe concentration in the chlorite, reflecting possible differences in parent material and its alteration. The chlorite peak heights of both the Lower Brown till and Soil 1b indicate slightly higher levels of Fe, indicating higher levels of leaching, than in the moraine soils. The diffraction patterns also support the presence of a mixed layer clay (likely illite/vermiculite) produced by the weathering of the biotite-bearing granodiorite parent material.

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