Timing and Extent of Holocene Glaciation in the Northeast Brooks Range, Alaska

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Earth's climate history plays a large role in our collective ability to understand current and past climatic trends. Establishing a framework of past glacial advances and retreats is one important avenue of studying Earth's climate history. My study examines the timing and extent of glacial advances and retreats in the northeastern sector of the Brooks Range, Alaska since the end of the last major ice age, approximately 11,700 years ago, during a time known as the Holocene. I worked to answer when piles of glacial sediment which mark the maximum extent of previous glacial advances, known as moraines, were deposited using a technique called cosmogenic exposure dating. This study is a continuation of a field research expedition that I was a part of in the northeastern Brooks Range during the summer of 2021 funded through Dartmouth College. I worked as a field assistant to Dr. Michelle Fame (former visiting faculty member at Bowdoin College). Together we made field observations of the study area and collected samples from moraines which can be dated to allow us to determine the timing of past glacial advances (Figure 1).

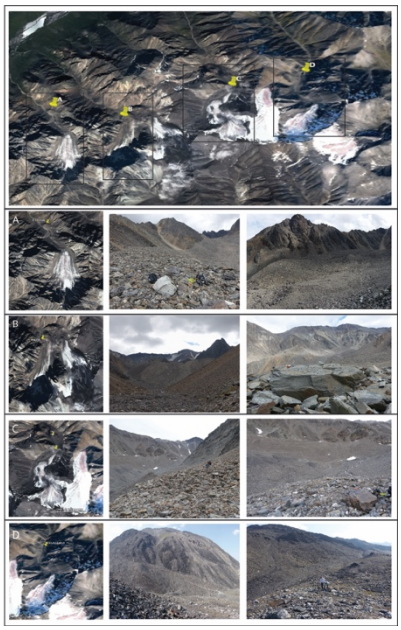

Figure 1. Study area in the Brooks Range with sample locations: a) C17 and C18 valley; b) C14, C15, and C16 valley; c) C04, C05, C06, and C07 valley; d) C11, C12, and C13 valley; Aerial images taken from Google Earth Pro, sample photos taken by Dr. Michelle Fame.

Little to no research on Holocene glaciations has previously been done on the northeastern sector of the Brooks Range. However, previous studies done in the Central Brooks Range have found that Holocene maximum glacial extents were reached by 3.5 and 2.6 thousand years ago (ka), prior to the Little Ice Age (1300-1850 AD) when glaciers reached their Holocene maximum in other places in Alaska (Pendleton et al., 2017). If the Holocene glacial extent reached its maximum in the Brooks Range prior to the Little Ice Age, it would mean that across the Brooks Range local climate allowed for cooler temperatures, increased precipitation, and increased ice cover earlier than in the rest of Alaska (Calkin, 1988). This possible departure from larger scale climatic trends is interesting because it allows us to investigate the impact of topography and regional climate on the limits of glaciation. In this project, I tested the hypothesis that Holocene maximum glacial extents in the northeastern Brooks Range occurred between 3.5 ka and 2.6 ka, prior to the Little Ice Age. I also determined the magnitude of temperature change required for glaciers to reach their Holocene maximum extent in the Brooks Range. By examining and reconstructing Equilibrium Line Altitudes (ELA) using GIS and prior fieldwork done in July of 2021 (Figure 2), I was able to measure the magnitude of temperature change. The result puts the moraine ages in context of the broader climatic trends impacting glacial extent in the northeastern Brooks Range.

Figure 2. ELA reconstruction methodology using ArcMap: a) outlining glacial extents, b) creating centerline up the drawn glacier, c) shape factor segments splitting up the glacier, d) creating 50-meter ice contours, e) calculating area between each elevation band, f) calculate which elevation has 58% of the total glacial area located above it to determine the ELA.

Over the course of the 2021-2022 academic year, I completed ELA and temperature reconstructions using GIS (ArcMap) program. I worked in Dr. Meredith Kelley's cosmogenic lab in Hanover, NH over winter break to process boulder samples and send them to PRIME Lab to determine the timing of glacial extent for the study area. The magnitude of change in ELAs and temperature for each of the 4 valleys within the study area demonstrated the local topographic influence on climate with temperature change in line with post-1880 temperature changes (approximately 1 ℃) (NASA Goddard Institute 2022). Unfortunately, I am still waiting on the ages for boulder samples to determine when exactly glaciers were at their furthest extents and subsequently retreated.

Faculty Mentor: Dr. Michelle Fame

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