Bailey Nordin – Project Profile

2024 AGeS-Grad awardee

Project Title: Targeting changes in sedimentation across a warming Arctic periglacial fan using Optically Stimulated Luminescence (OSL) dating

Lab: University of Texas Arlington Luminescence Lab

Lab Mentors: Nathan Brown

What scientific questions does your research address and what motivates this work?

Arctic landscapes are extremely vulnerable to climate change, with feedbacks between permafrost thaw and increasing slope instability leading to landslides, rockfall, and increased sediment supply to rivers. These processes have devastating impacts on proximal First Nations communities, and it is critical to develop the ability to relate changes in temperature to changes in rates and processes of landscape modification. In a continuous permafrost zone of Northwest Territories, Canada, I used Optically Stimulated Luminescence burial ages of sediments to quantify changes in sedimentation and erosion from decadal to millennial timescales across a warming alluvial fan system. My AGeS work involved developing depositional records from across the fan derived from paired OSL and ^{14}C dating, which I then combined with constraints on erosion and glacial retreat from the upslope catchment from thermochronology and cosmogenic nuclide dating. Our (U-Th)/He data constrain regional exhumation to ~0.07 mm/yr since 25 Ma, and our ^{10}Be exposure dates suggest the region was ice free for much longer than previously anticipated and is no longer experiencing postglacial instabilities. Through this multi-chronometer approach, we generate a record of landscape change across a rapidly evolving, dynamic system which can be scaled to other Arctic range-front environments.

What chronometric tool did you employ and why?

Understudied Arctic, periglacial alluvial fans are dominated by mass flow processes like debris flows and landslides, and will become increasingly unstable with warming temperatures and permafrost thaw. Using Optically Stimulated Luminescence (OSL) dating of quartz grains preserved in buried bedrock cobbles and sandy deposits, we constrained the timing and rate of formation of a warming, post-glacial alluvial fan, as well as its responses to past climatic conditions through time to better predict its response to rapid anthropogenic warming. These burial dates reveal that much of the instability we observe in this dynamic landscape has accelerated recently, over the past ~1000 years, rather than as an ongoing response to uplift and warming post-LGM. Temperate alluvial fans are also widely interpreted as archives of changing climatic influence, but we attempt to apply the same approach in periglacial regimes, where fan formation is dominated by mass flow events as opposed to gradual fluvial sedimentation. By comparing between both sediment and cobble OSL measurements and ground-truthing our OSL data with ^{14}C age calculations in locations where we were able to find buried organic material, this study also contributes to the methods development of OSL cobble dating in challenging Arctic environments.

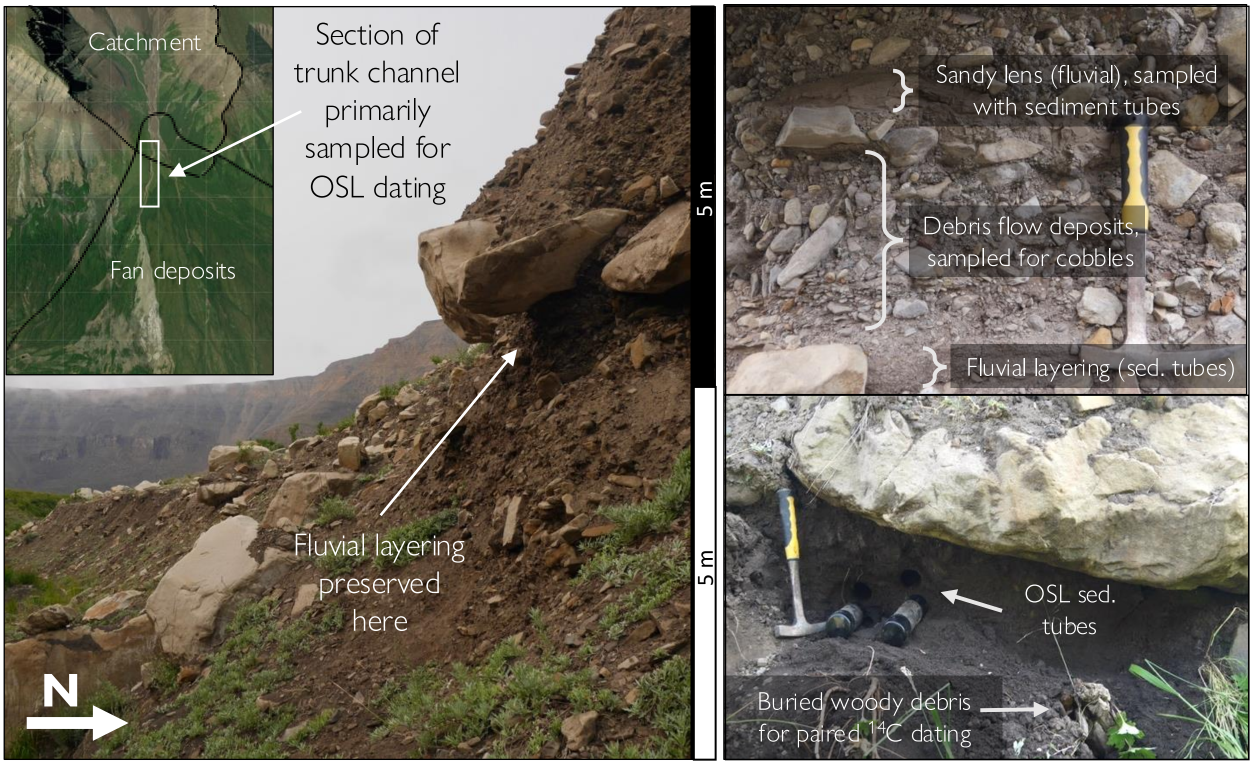

Figure 1. (Left) Field photo of the Northern wall of the alluvial fan's main active channel with interbedded debris flow and fluvial deposits, and imagery of the fan from ESRI. (Right) Examples of logged sections of fluvial and debris flow deposits targeted for OSL sampling, along with buried woody debris used for paired ^{14}C dating of the same horizon.

What were some of the key takeaways of your research?

- OSL and ^{14}C dates significantly postdate glacial retreat from the region, and imply deposition rates across the fan of 0.5-10 mm/yr since ~1.6 ka, with the oldest preserved alluvial fan deposits also coinciding with a local peak in Northern Hemisphere insolation at 9 ka.
- None of the OSL cobble samples, bedrock samples or feldspar grains we attempted to date were reset, which reveals some of the complications we might expect from Partial bleaching from low light, high energy environment
- Accelerated erosion rates across the region are driven by a combination of permafrost thaw and postglacial instabilities, and erosion along the Aklavik Range has increased by an order of magnitude or more from its background state and may be perturbed even further by anthropogenic warming.

What new experiences, opportunities, and collaborations did you gain as an AGeS-Grad awardee?

Receiving the AGeS-Grad award afforded me not only the opportunity to travel to a new lab and apply a novel technique to my master's project, but meant that I was able to learn a new type of geochronology that no one at my home institution of Dartmouth had attempted before or had any familiarity with. This allowed me to present my research to and familiarize other graduate students and undergraduate students with OSL burial dating, and several of them are now writing proposals to incorporate luminescence into their own research. This AGeS funding also meant that I was able to experiment with both cobble and bedrock luminescence dating, which otherwise would have been prohibitively expensive to attempt in a low-light, high-energy environment. Critically, AGeS has also provided me with so much mentorship, support, and community; because of this network I was able to make friends at new institutions, feel a sense of belonging in a discipline I previously had no familiarity with, and meet so many friendly faces at GSA and AGU!

Figure 1. It's difficult to take photos inside of a dark luminescence lab and can expose samples to unnecessary light contamination, so these are photos taken outside of the dark lab during my visit in the Spring of 2024. (Left) Photo of the Earth and Environmental Sciences building at UT Arlington surrounded by oak trees. (Right) Cork board posted outside the entrance to the dark lab, showing photos of the UT Luminescence Lab members and visitors.

What is one piece of advice that you have for future AGeS-Grad award applicants or awardees?

Get started on your project early and budget plenty of time in your host lab, which will allow you to take your time learning new procedures, accommodate any unforeseen issues that might arise with sample or lab equipment, and make strong connections with lab members (including other grad students and postdocs). Additionally, ask tons of questions! Everyone in your host lab is super knowledgeable and excited to help.