Zena Robert - Project Profile

2023 AGeS-Grad awardee
Project Title: Constraining the Timing of Primary Loess Deposition and Geomorphic Processes on Permafrost-Rich Hillslopes in Interior Alaska
Lab: USGS Luminescence Lab
Lab Mentors: Shannon Mahan and Harrison Gray

What scientific question(s) does your research address and what motivates this work?
Sub-Arctic regions are susceptible to abrupt changes in climate, especially in landscapes underlain by permafrost. Past climates have influenced the geomorphic evolution of hillslopes within Interior Alaska through the airborne transport and deposition of glacially derived silt (loess), ice growth during glacial periods, and erosion resulting from permafrost thaw during interglacial periods. Today, those hillslopes are mantled by ice-rich, massive loess deposits (Fig. 1). Relationships between sediment burial and ice formation act to stabilize hillslopes, which may change rapidly during periods of thaw. The stratigraphy of subsurface ice and sediment thus holds important records of past climatic, environmental, and geomorphic processes. These latter insights are significantly less studied, especially in a hillslope context, and have important implications for how permafrost landscapes may change in the future. Therefore, this project asked the following questions: What is the timing of loess deposition, stability, and redistribution on ice-rich permafrost hillslopes in Interior Alaska, and how do they correspond to known climate transitions?

What chronometric tool did you employ and why?
I used Infrared-stimulated luminescence (IRSL) to determine the deposition and sediment transport history along loess-mantled hillslopes in Interior Alaska. IRSL dates the last time a feldspar grain was exposed to sunlight. Buried feldspar grains accumulate ionizing radiation and free electrons within their crystal lattice over time, but when the grain is exposed to sunlight, it loses those electrons and becomes “bleached” of its luminescence signal. The luminescence signal of a grain is proportional to the ionizing radiation absorbed in the absence of sunlight, and this is the signal used to date the burial age. This method was ideal for our study because the massive loess deposits are aeolian formations, and the continuous transport and burial of loess over time would create a high-resolution record of primary deposition and redistribution. Therefore, we sampled frozen loess (Fig. 2) from upper and lower slope positions to compare the timing of loess burial and erosion in a hillslope context.

Figure 1: Excavating down to frozen loess along a hillslope in Interior Alaska. Samples taken from this trench were used for IRSL analyses.

Figure 2: A block of frozen, ice-rich loess similar to those used for IRSL dating. Once excavated from the subsurface, these large chunks of loess were wrapped in foil to shield them from sunlight and transferred to a cooler to preserve their structure. They were then brought to the Luminescence Lab for processing, where we removed the outermost loess that may have been exposed to sunlight during sampling and used the inner core for IRSL analysis.

What were some of the key takeaways of your research?

1. IRSL is a valuable tool in permafrost-rich systems and can be used to reconstruct aeolian depositional events at higher latitudes.
2. The loess deposits along hillslopes are old! IRSL burial ages from samples taken within the upper meter of the loess ranged between 20 and 90 ky (Fig. 3).
3. Discontinuities in loess burial ages observed between upslope and downslope positions indicate that geomorphic events, such as sediment transport or thermokarst, affected this hillslope during and since primary loess deposition.

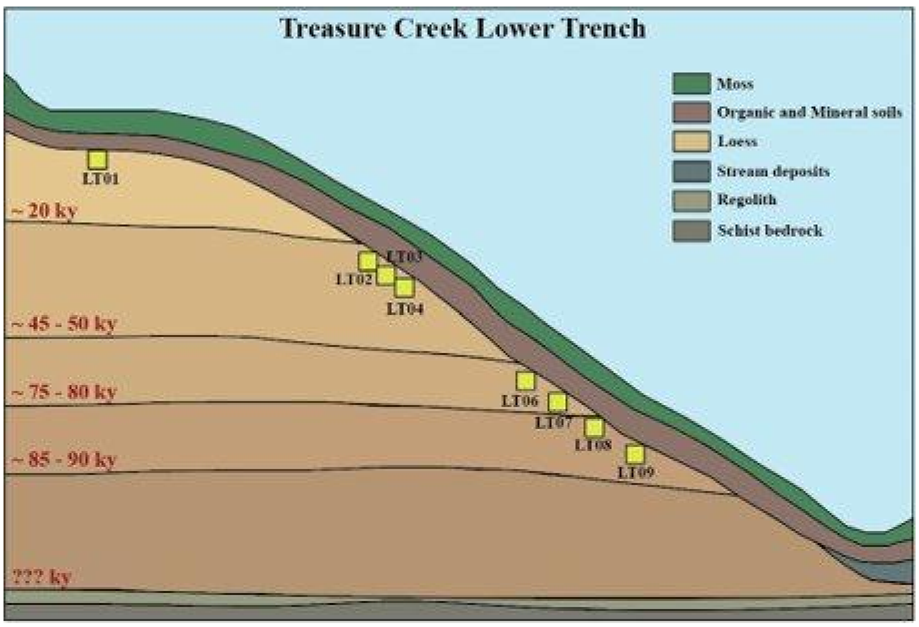

Figure 3: Conceptual model of the lower slope position sample locations and loess burial age stratigraphy based on IRSL results. The burial ages at this sample location continuously got older with depth along the slope, which likely represents undisturbed, primary loess deposition.

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

The AGeS-Grad award allowed me to gain knowledge and training in IRSL methodologies and applications, create valuable new collaborations, and obtain data that enhances our understanding of permafrost-rich hillslopes. Through hands-on lab experience and discussions with my lab mentors, I learned and applied a new geochronological method to my research that might only have been possible with the award. My lab mentors were invaluable to this experience as they provided guidance and knowledge throughout the process, which helped foster future research collaborations. Finally, the AGeS-Grad award helped me collect data that is crucial for my research and our understanding of how permafrost-rich hillslopes have evolved over time. The IRSL dates obtained from this project aided in preserving records of past geomorphic events related to the formation and thaw of permafrost, which will help us to better understand how these landscapes may respond to similar thaw events in the future.

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

Learn as much as you can from your lab mentors! They are a wealth of knowledge and can provide critical insights into your research.