Tristan Bench - Project Profile

2023 AGeS-Grad awardee
Project Title: X-Ray Mapping for Enhancing Luminescence Surface Exposure Dating Scanning Techniques
Lab: University of Massachusetts Amherst Geosciences Electron Microprobe/SEM Facility
Lab Mentors: Michael Jercinovic

What scientific question(s) does your research address and what motivates this work?
I research applications of rock surface exposure dating using optically stimulated luminescence (OSL). OSL is generally measured from quartz when used as a geochronometer. However, current measuring techniques for exposure dating often measure the OSL coming from non-quartz minerals in samples, which increases depth profile data scatter and reduces age fitting precision. Recently there have been advancements in acquiring spatially resolved OSL from rock surface exposed samples. This invites the opportunity to identify and filter non-quartz OSL from samples, which can improve data resolution issues. The goal of this AGeS proposal was to attempt a novel OSL filtering approach that would use X-ray mineral mapping to identify and filter out non-quartz minerals in OSL scanned data. A successful procedure would then hopefully offer more precise OSL data for age calculations.

I proposed using X-ray mineral mapping instruments at the University of Massachusetts-Amherst to perform OSL mineral filtering on samples from the Foothills Erratics Train in Alberta, Canada. These samples were previously OSL exposure dated to determine erratic settlement chronology, and interpret the opening of the ice-free corridor between the Laurentide and Cordilleran ice sheets. The samples hosted significant OSL depth profile scatter, however, and it was proposed that mineral filtering could potentially improve age calculations.

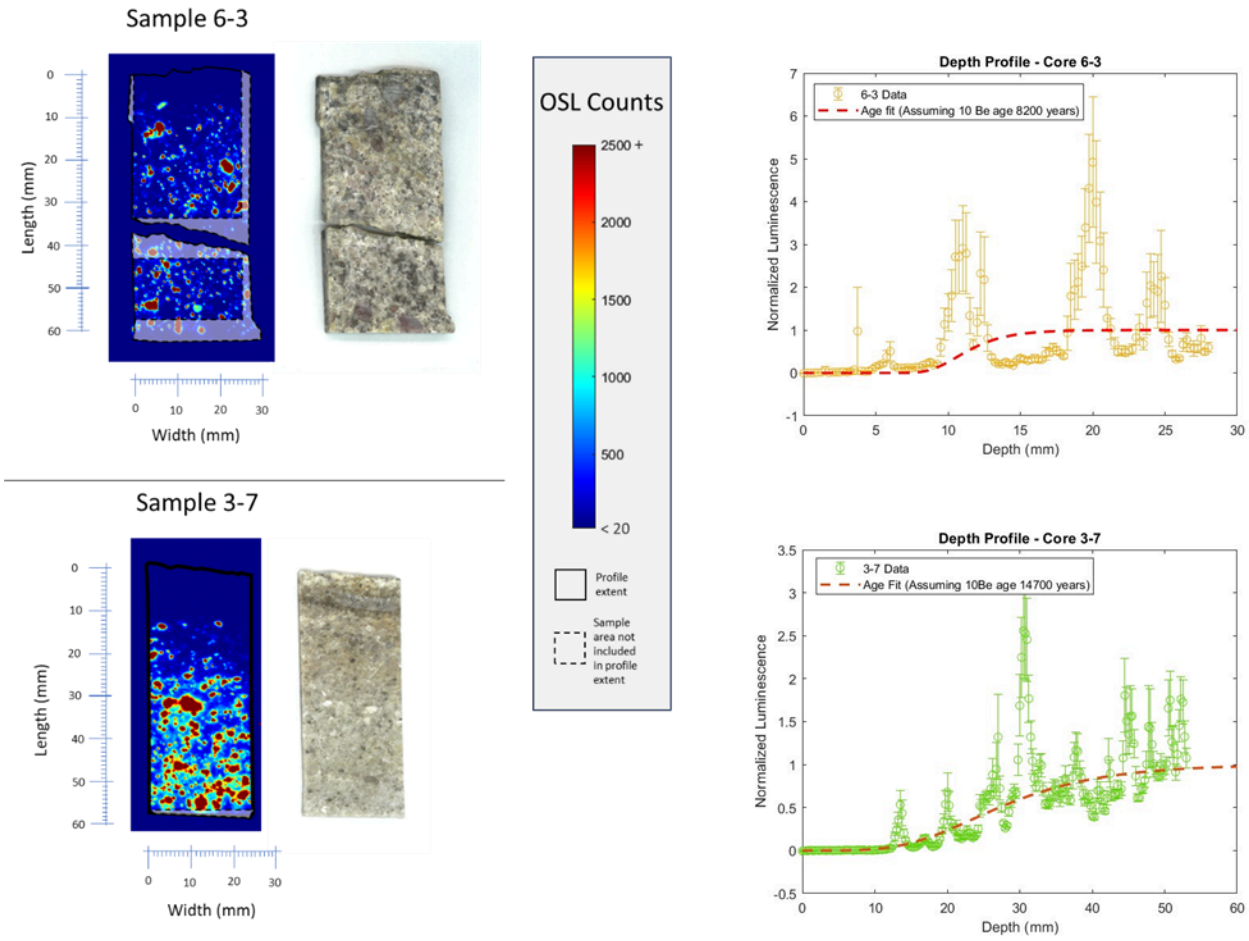

Figure 1. OSL scanned datasets of Foothills Erratics Train surfaces (left) and depth profiles (right). You can see there are anomalous regions of high OSL (red areas). These anomalous regions promote scatter to the depth profile form, which should closely follow an s-shape.

What chronometric tool did you employ and why?

The tool I used to perform the mineral mapping was a Cameca SX100 electron probe, hosted at the UMass Geosciences Electron Microprobe/SEM Facility. This instrument can spatially document the concentration of elements in each rock sample measured for luminescence, which can be compiled to produce element and mineral map images for measured samples. In obtaining mineral maps of the Erratics Train samples, OSL datasets of the rock samples would be filtered based on where quartz was documented from the mineral maps. The OSL depth profiles processed from the data would then be

solely from quartz. Unfortunately, the thin sections of the samples produced for the mineral mapping were not made correctly, and mineral maps could not be made and linked to the OSL maps as proposed. Still, the maps that were produced were able to show that there was a significant percentage (>20%) of non-quartz material in each sample, which may explain why OSL depth profile data scatter was so present from the samples.

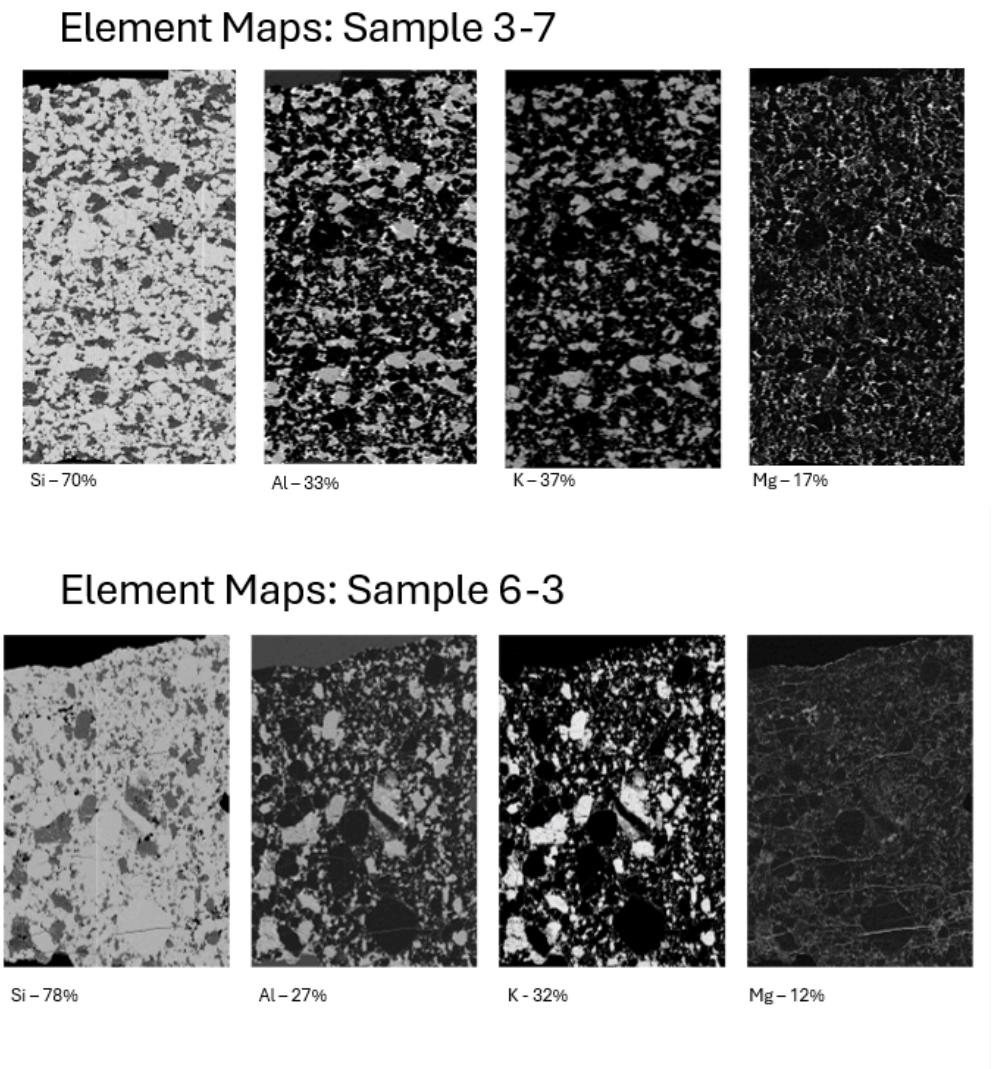

Figure 2. Composition maps of samples 3-7 and 6-3, with intensity of white pertaining to concentration of element. Percentage components of elements in each image are presented. There is a significant presence of K and Al bearing minerals in each sample, indicating non-quartz mineralogy contributes a significant amount of the measured OSL in the scan datasets.

What were some of the key takeaways of your research?

1. X-ray mineral mapping instruments certainly possess the resolution to help identify non-quartz OSL contributions in OSL scan data.
2. Ample care is needed when producing thin sections. Make sure the OSL scanned side of the sample is not damaged, and facing 'up' from the thin section glass.
3. Although the maps were unable to be compared to OSL scan dimensions, the maps still document potential sources of non-quartz OSL scatter, which is useful for interpreting age results.

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

The results of this AGeS funded study were included in a publication to *Quaternary Geochronology*, which discusses causes for depth profile evolution variations in OSL depth profiles. The maps from this AGeS study were used to show that the OSL scatter found in the Erratics Train likely came from significant non-quartz components. With better produced thin sections, the publication would have been able to directly present the impact of OSL filtering on depth profile data scatter and age calculated precision.

We also gathered from this experiment that the UMass Amherst lab can produce compositional maps with viable resolutions for OSL filtering studies. This still has the potential to make mineral identification a far more efficient process than the prior procedure, which was to individually identify the mineralogy of OSL anomalies in scan data using SEM-EDS assessments (Bench et al. 2023, *Radiation Measurements*). Although the execution of this AGeS experiment did not end with filtered OSL data, continued experiments can be conducted with correctly produced thin sections to better evaluate the benefits of mineral filtering using x-ray mapping for OSL exposure dating.

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

Experimental shortcomings still progress the field, and the observations can still get published!