**Project Summary -** *Collaborative Research: Detrital cosmochronology of the Greenland Ice Sheet*


Understanding Greenland Ice Sheet (GIS) history, particularly being able to determine times when the ice sheet was substantially smaller than today, is critical as we enter a time of unprecedented atmospheric $CO_2$ levels and warming climate. Such information would allow us to associate previously diminished ice mass with other climate and environmental parameters and thus provide a foundation for predicting future behavior of the GIS. The measurement of *in-situ-produced* cosmogenic nuclides in samples collected from below the ice sheet has the potential to date past episodes of deglaciation through the analysis of isotopic ratios in a scheme commonly referred to as *burial dating*. When the ice cover diminishes, underlying rock and sediment are exposed to cosmic radiation, and radionuclides with differing half-lives ($^{10}$Be, $^{26}$Al, $^{36}$Cl and $^{14}$C) are produced. When ice returns, exposed surfaces are buried and cosmic rays no longer reach the once-exposed surfaces. The inventory of radionuclides is unsupported by production and begins to diminish by radio-decay; isotopic ratios change predictably because each isotope has a different half-life. Indeed, preliminary multi-isotope cosmogenic analysis of rock collected from the bottom of the GISP2 borehole (Nishiizumi et al., 1996) suggests that the summit area was deglaciated 0.5±0.2 ky raising the specter that when climate warms, the ice sheet can disintegrate completely (IPCC, 2001) and perhaps not reform (Tonniazzo et al., 2004). Coring ice to collect bedrock samples from under the GIS is complex and expensive. We propose here to investigate an alternative approach; by studying the products of subglacial erosion, we will identify times in the past when Greenland was ice-free or partially ice-free. The results of this investigation have the potential to tell us how the GIS responded to intervals of major climate warming over the past several million years.

***Intellectual Merit***

This study will rely on sub-glacial erosion to sample previously-exposed rock surfaces and sediment. It will provide previously unavailable information about the GIS by using isotope ratio analysis to identify times in the past when the rock and sediment beneath the GIS were exposed to cosmic radiation. Ice flow and englacial drainages deliver this sediment to the ice margin where we will collect and analyze individual clasts directly from outcropping ice. We will analyze populations of burial ages (in the same fashion that detrital geochronologists use single grain analysis in U/He, fission track, and detrital zircon-dating studies) to determine modes of initial exposure time from which we will infer times of major ice retreat in the past. To interpret isotopic data in glaciological context, we will use existing ice flow and thermal models to infer basal conditions and clast transit histories. In addition to identifying times when the GIS was smaller than today, isotopic data will indicate glacial erosion efficiency. Because the penetration depth of most cosmic radiation is only several meters, large numbers of clasts containing no cosmogenic nuclides would indicate efficient sub-ice erosion whereas many clasts with significant burial ages would indicate long subglacial residence times and low rates of bed erosion and sediment transport.

***Broader Impacts***

The methodology developed here should have wide application in other areas currently covered by ice. Model ages for GIS shrinkage will provide information for understanding a major driver of sea-level change and have important paleoclimatic implications. Isotopic data will guide future ice coring efforts, particularly those intended to sample sub-ice rock. Two graduate students will be trained together in an interdisciplinary fashion by junior and senior faculty mentors with complimentary expertise.