

Project Description

Objectives/Research Questions:

The Ediacaran-Cambrian (E-C) transition (550-530 million years ago) marks a first-order change to Earth's biosphere and surface environments with the establishment of animal ecosystems. It has been a challenge to test the many hypotheses that link the early evolution and diversification of animals to changes in ocean geochemistry (e.g. oxygenation of marine environments and perturbations to the global carbon cycle). This is largely because there are few well-documented sections across the E-C transition that integrate high-resolution geochemical and paleontological data: many successions are marked by unconformities (missing sedimentary rock) across this interval or do not preserve appropriate lithologies for measuring paleoenvironmental proxies (shale and carbonates). This proposal seeks to constrain paleoenvironmental changes across the E-C boundary through novel investigation of sedimentary strata in the Canadian North. Northeastern Ellesmere Island, Nunavut preserves a thick succession of E-C strata in the central Ellesmere and Hazen fold belts, including >1000 m of sedimentary rocks beneath the first appearance of early Cambrian body and trace fossils. Previous stratigraphic investigation of some of these sections indicate the presence of well-preserved units of carbonate and black shale deposited on a NW-facing continental shelf, yet no geochemical data exist from any of these strata. This succession provides an exceptional opportunity to establish new high-resolution chemostratigraphic datasets during this critical time interval of Earth history. There are no existing repositied sample sets from any of these sections that can be used to produce these types of data sets. These new geochemical data will be linked to existing biostratigraphic data, as well as new paleontological investigation. The end result will be a robust understanding of changes in the carbon cycle and in marine oxygenation during the radiation of modern animal clades from strata that have not been investigated since field work in the 1990s. Importance of Project to Science and Society: The proposed research will further fundamental understanding of the geology of Ellesmere Island, likely leading to improved understanding of the tectonic evolution of Arctic Canada and the Proterozoic to early Cambrian stratigraphic architecture of the Canadian Arctic Islands. Detailed geologic mapping and stratigraphic data sets will be published and publicly accessible, improving understanding of geologic resource potential in the region. Because of its importance in the evolutionary history of animals, the Ediacaran-Cambrian boundary captures unparalleled public interest for its significance in our own origin story. For instance, Ediacaran localities in Newfoundland have been established as UNESCO World Heritage sites. Ellesmere Island contains thick stratigraphic successions of this same critical time interval, and yet comparatively little is known about the geology and paleontology of the region (the last geologic field expeditions to this area that I am aware of were in the 1980s and 1990s). Thus, there is ripe opportunity for new discoveries that will significantly advance knowledge of the geology of Arctic Canada. All advancements will be publicized in scientific journals, as well as through public media outlets, increasing general interest in the geology of this region. Ultimately, this will help to promote the North, Nunavut communities, and Quttinirpaaq National Park. Furthermore, summaries of scientific findings will be translated into Inuktitut and distributed within northern communities in outreach efforts. All field data and geochemical data will be made publicly available through online data repositories, and all collected samples will be archived at the Geological Survey of Canada and/or the Canadian Museum of Nature in Ottawa, working in coordination with the

Government of Nunavut (Nunavut Geoscience and Nunavut Department of Culture and Heritage), which currently does not host their own sample repositories.

Planned Field Methodology/Duration:

The proposed research plan will involve a field season of ~4 weeks during the summer of 2025 on Judge Daly Promontory in northeastern Ellesmere Island. The team will consist of three PIs: Drs. Peter Crockford (Carleton University), Keith Dewing (Geological Survey of Canada), and Lyle Nelson (Massachusetts Institute of Technology); two HQP trainees (one Carleton Ph.D. student and one undergraduate student [who we aim to recruit from Nunavut Arctic College]) and a wildlife monitor recruited from a Nunavut community. Two proposed field camps have been selected based on discussions with Dr. Keith Dewing and Dr. Darrel Long who conducted field seasons on the Judge Daly Promontory in the 1980s and 1990s. We propose accessing these via helicopter from Eureka, and a temporary field camp will be established at each study site, to target the well exposed stratigraphic section proximal to each camp. The research team will create a detailed geologic map of the area, incorporating structural and stratigraphic measurements and observations. Once complete composite sections have been identified, detailed stratigraphic sections will be measured of the E-C strata to improve understanding of the sedimentology and stratigraphy. Within the context of these sections, small thumb to fist-size samples of carbonate and shale will be collected at ~1- to 3-meter stratigraphic resolution for laboratory geochemical analyses. Data from multiple measured sections will be combined to establish sedimentological and geochemical transects across the ancient sedimentary basin, which will be used to distinguish a dataset that records global, temporal changes in ocean chemistry from lateral changes in local paleoenvironment.

Indigenous and local involvement and engagement:

Once logistics for the project are established (and pending funding), one of the HQP trainees at an undergraduate level will be specifically recruited from Nunavut Arctic College to join the project in order to provide specific training/educational benefits within a Nunavut community. This would be an opportunity for the student to engage in high-level geologic research, providing a potential springboard to graduate education/research in the geosciences and/or valuable field experience that would give the student an advantage in finding future employment in geoscience industry. In addition, we plan to recruit a Nunavut community resident as a wildlife monitor, providing an employment opportunity. Knowledge exchange among these members of Nunavut communities and the rest of the field team would provide the chance for the field team to engage with Indigenous knowledge of the region through mutually beneficial collaboration. For broader community engagement and education, posters communicating Ediacaran and Cambrian geology of Ellesmere (with Inuktitut translations) and a collection of representative rock samples will be provided as teaching/display exhibits to Inuksuk High School and Nunavut Arctic College in Iqaluit. To accompany these display materials, a secondary school level lesson plan and materials on Earth history will be created for science teachers, highlighting the spectacular geologic records of Arctic Canada. The PI and graduate students will coordinate with these schools to give public presentations disseminating research objectives and findings. In addition

to gaining experience in geologic field work, the student recruited from Nunavut Arctic College will be invited to join the research team will be involved in subsequent aspects of the research project with opportunities to visit labs at Carleton University and conduct geochemical analyses, and full involvement in research publications and dissemination. These planned outreach efforts to involve local residents and communities with our upcoming field season will be achieved and facilitated through working closely with Carleton University's Center for Indigenous Support and Community Engagement. Permits for field work and sample collection on the Judge Daly Promontory of Ellesmere Island will be applied to by submitting a project proposal to the Nunavut Planning Commission, a subsequent application to the Nunavut Impact Review Board, and an application for a physical and natural sciences license through the Nunavut Research Institute.