Exploring sedimentary micrometeorite traps in Western Greenland

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Introduction: Every year, large amounts of extraterrestrial material arrive on earth, ranging from large-scale projectiles impacting the terrestrial surface to a constant influx of cosmic dust and micrometeorites (< 2 mm). The study of extraterrestrial material allows to explore the first stages in the evolution of the protoplanetary disk using material accessible on earth and the effect of the extraterrestrial input on the global geochemical budget of our planet and the effect on the preservation and diversification of life [1]. The study of micrometeorites refines the source regions in the Solar System from where the material that arrives on the Earth today derives. Cosmic dust derives from a variety of meteorite parent bodies existing in the Solar System, today but also in the geological past. As such, this extraterrestrial material complements costly sample-return missions to primitive asteroids and comets. Large accumulations of micrometeorites were discovered in high-altitude sediment traps in the Transantarctic and Sør Rondane Mountains in Antarctica [2-4]. Pits and joints in high-altitude rock surfaces can trap extraterrestrial particles through direct infall and different concentration mechanisms [2-4]. Not only do these deposits contain micrometeorites, but they also capture particles formed during much larger events, such as fireballs, airbursts and impact events [5-6]. Based on the wide variety of extraterrestrial materials recovered in only a handful of sedimentary traps across Antarctica, the potential to find new and unexpected types of cosmic dust, not only in Antarctica but also in the Arctic is extremely promising. As each sedimentary trap is characterized by a distinct exposure history, comparing collections sampled in the Arctic to those from Antarctica [2-4], hot deserts, and urban environments [7] carries the potential to unravel the concentration mechanisms behind the accumulation of cosmic dust and to detect possible variations in the composition of the extraterrestrial flux with time. It should be emphasized that cosmic materials have not been collected from Arctic sedimentary deposits, but only from Greenland snow and ice mostly in the 1990s [8]. This was before the mechanisms and processes that lead to the accumulation of large volumes of extraterrestrial dust in Antarctica were fully understood.

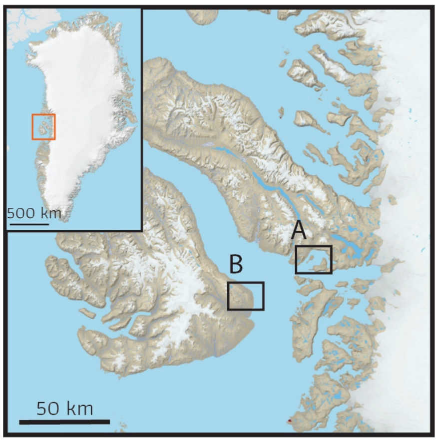

Figure 1: Sample localities.

Scientific aims: The main goal of this project is to study micrometeorites and/or cosmic spinel grains from similar types of sedimentary deposits in the Arctic. This first recovery of unique extraterrestrial material from sediment traps in Greenland allows to characterize this modern-day collection by state-of-the-art analytical techniques and comparison to similar material from Antarctica. This approach will document the occurrence of cosmic events in the North Pole area over the last few Myr and record possible changes in the extraterrestrial flux over extended geological timescales at the global scale.

Results and discussion: During a field campaign in the summer of 2023, S.G., W.R.H., W.V., and F.V.M. collected approximately 80 kg of sediment and samples for cosmogenic nuclide dating from two different locations in the Disko Bay area in Western Greenland. Firstly, we sampled 3 sites in the southeast of the Nuussuaq peninsula close to the village Qeqertaq (Figure 1A). The lithologies in this area consist of Precambrian orthogneiss [9]. Secondly, we sampled two sites on the southeast coast of Disko Island (Figure 1B). This area consists of plagioclase-phyric and aphyric tholeiitic basalts and plagioclase-phyric and aphyric basaltic andesites deposited as subaerial lava flows approximately 60 Ma ago [10]. Both areas have been covered by the Greenlandic Ice Sheet in the last 18 Myr and were periodically ice free [11], leading to the formation of high-altitude areas with potential for sediment traps (Figure 2).

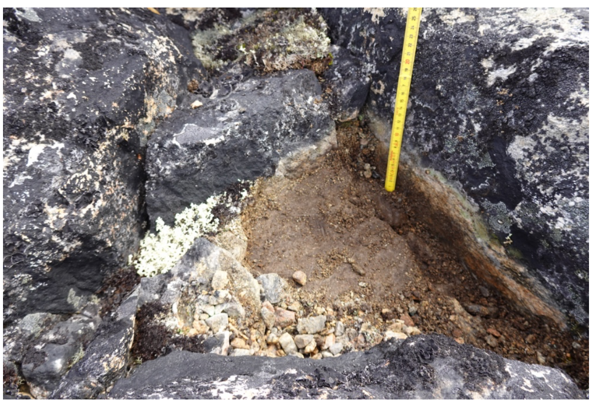
Figure 2: Example of a sediment trap in location A.

800 g of sediment was preliminarily examined. The collected sediment is washed and sieved into different size fractions (<63 µm, 63 – 125 µm, 125 – 200 µm, 200 – 400 µm, 400 – 800 µm, 800 – 2000 µm). Afterwards, a magnetic separation is applied relying on a handheld magnet. Micrometeorites are extracted

optically under a binocular microscope and imaged using a secondary electron microscope coupled to an energy dispersed spectrometer (SEM-EDS) for a first qualitative chemical characterization. The initial survey led to the identification and characterization of 5 cosmic spherules in 800 g of processed sediment. We will present the first results from this new Arctic micrometeorite collection from Greenlandic sediment traps and compare these to the physicochemical characteristics of the Antarctic micrometeorite collections.

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