COLLECTING FOSSIL MICROMETEORITES FROM MICROPALAEONTOLOGY COLLECTIONS: A CASE STUDY USING DEVONIAN RESIDUES FROM THE URAL MOUNTAINS.

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Introduction: Micrometeorites have been identified in deep sea sediments, polar regions, urban environments, and increasingly as relatively abundant fossilized particles in the geological record [1,2,3]. Fossil micrometeorites in ancient rocks can provide a record of the past extraterrestrial flux to Earth; while their chemical, textural and mineralogical features allow us to investigate atmospheric processes at the time of atmospheric entry and post-depositional and diagenetic processes after impact and incorporation into sediments [4,5].

In this project we utilized a collection of acid-digestion residues from a suite of late Silurian, Devonian and early Carboniferous rocks from the Ural Mountains, covering the period from ~420-350 Ma. The well-constrained chronostratigraphy from previous micropalaentological studies of this section provide insights into the extraterrestrial flux during this period and potential atmospheric changes across the Devonian.

Methods: Deep-sea limestones from the Komi River area of the Ural Mountains were collected as part of micropalaentological fieldwork between 2000 and 2002. Approximately 1 kg of each rock sample was dissolved in 10% acetic acid and the residual material retained and separated using heavy liquids (sodium polytungstage). For this micrometeorite project, these leftover micropalaentological collection materials were re-used to extract Iton-dominated micrometeorites (I-types) and other cosmic spherules. These resistant micrometeorite types were extracted using magnetic separation and visual identification. The extracted particles were analysed and confirmed as extrerrestrial [4,5] using a combination of scanning electron microscopy (SEM), quantitative energy-dispersive X-ray spectroscopy (EDS), and electron microprobe analysis (EMPA) techniques.

Findings: Thus far a total of 40 micrometeorites have been identified. Chemical analysis shows that these micrometeorites are primarily composed of magnetite and Mn-bearing magnetite, similar to previous studies of fossil micrometeorites from ancient sediments (e.g., [3]). Ongoing textural and geochemical analysis will be used to infer changes in the atmospheric oxidation during this crucial period in Earth's history. Evolution of plants and the colonisation of the land during the Devonian led to an increase in atmospheric O_2 concentrations and a decrease of CO_2 in the Devonian atmosphere[6]. Constraining the relative degree of oxidation in these meteorites will shed light on the atmospheric evolution during this period and potentially provide a new climate proxy based on micrometeorites. Comparison between these fossil micrometeorites, and prisine, geologically modern samples will provide constraints on the poorly-understood processes that may alter the micrometeorites during storage on the seafloor and during lithification [3].

Conclusions: Developing this fossil micrometeorite collection will enhance an existing world-leading repository of extraterrestrial material at the Natural History Museum; and this work shows that previously overlooked samples from micropalaeontological collections, can be easily repurposed to extract micrometeorites, unlocking a wealth of information and enhancing both collections simultaneously.

Future sample return missions such as Hayabusa2 and OSIRIS-REx [7,8] will also return small particulate material from asteroids, and hence there is additional benefit to establishing a dedicated micrometeorite collection to study both modern and fossil micrometeorites as analogues and prepare protocols for future sample return material.

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