Oxygen Isotope Variability among Unmelted Micrometeorites from the Sør Rondane Mountains, East Antarctica

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Introduction: Micrometeorites (10-2000 µm) make up the main fraction of extraterrestrial material reaching the earth's surface. Micrometeorites are classified as either cosmic spherules, scoriaceous micrometeorites or unmelted micrometeorites depending on the degree of melting during atmospheric entry [1]. Triple-oxygen isotopic data is a common tool to identify the parent bodies of extraterrestrial materials [2], but the study of unmelted micrometeorites is challenging because these particles are generally rare and small. Cosmic dust and specifically unmelted micrometeorites are key to understanding the nature of the interplanetary dust complex. Unmelted micrometeorites mostly preserve the primary mineralogies and textures of their parent bodies because the thermal alteration experienced during atmospheric entry is limited [3]. Here, we present triple-oxygen isotope data for 50 unmelted micrometeorites recovered from high-altitude sediment traps in the Sør Rondane Mountains (East Antarctica) during the 2017-2018 BELAM (Belgian Antarctic Meteorites) expedition.

Results and discussion: Sediment from the Sør Rondane Mountains was processed by sieving into 6 size fractions (< 125 µm, 125-200 µm, 200-400 µm, 400-800 µm, 800-2000 µm and > 2000 µm). Based on optical microscopy, surface texture and compositional characteristics determined using a JEOL JSM-IT300 scanning electron microscope equipped with an energy-dispersive X-ray spectrometer at the Vrije Universiteit Brussel, Belgium, 50 unmelted micrometeorites ranging in size between 100 and 400 µm containing various refractory phases (e.g., spinel group minerals, CAI) and relict minerals (e.g., olivine and pyroxene) are selected for oxygen isotope analysis. For every sectioned micrometeorite triple-oxygen isotope ratios are obtained for both matrix and sufficiently large crystals (> 20 µm) using a Cameca IMS 1207 ion microprobe at the CRPG in Nancy (France) [2]. Compared to cosmic spherules from the Sør Rondane Mountains, all major oxygen isotope groups (Group 1 to 4) observed for cosmic spherules and linked to chondritic precursors are identified [4]. Of the particles for which the parentage could be determined, roughly two thirds display affinities to carbonaceous chondrites, while about 4% of the particles appear to be related to ordinary chondrites. Five particles have $\Delta^{17}O$ values lower than -13‰ confirming the presence of relict and refractory minerals. One particle exhibits $\delta^{18}O$ values higher than 20‰ and $\Delta^{17}O$ values of approximately ±2.5‰ representing the ^{16}O-poor group (cosmic spherule Group 4) among these unmelted particles [3-4]. About 20% of all particles are shifted towards $\delta^{18}O$ values left of the chondrite groups, most likely due to Antarctic alteration [5]. This observation suggests that unmelted micrometeorites are more susceptible to alteration than previously thought. Seven particles exhibit ambiguous oxygen isotope signatures (i.e., multiple possible parent bodies). Individual minerals and phases with an offset to lighter oxygen isotope values are studied using the JEOL JXA-8500F electron microprobe analyzer at the Museum für Naturkunde Berlin (Germany) to refine the parentage and alteration history of these micrometeorites and the micrometeorites containing refractory and relict minerals. The elemental compositions and phases recognized (e.g., the formation of iron hydroxides) support extensive terrestrial alteration of unmelted micrometeorites at the mineral scale.

Conclusion: Preliminary oxygen isotope composition results of a large number of unmelted micrometeorites from the Sør Rondane Mountains suggest that ca. 66% of the particles in the 100-400 µm are related to carbonaceous chondrites, which is consistent with previous MMs studies [2,4]. Less than 10% of the particles are related to ordinary chondrites. A single particle is identified as a ^{16}O-poor micrometeorite (< 2%). Approximately 20% of all analyzed particles show an offset to oxygen isotope values lighter than the meteorite fields, suggesting unmelted micrometeorites are more susceptible for alteration than previously assumed.

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