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Characterisation of unmelted micrometeorites using synchrotron-based X-ray analysis

Flore Van Maldeghem (1), Steven Goderis (2,3), Brecht Laforce (3), Bastien Soens (2), Ella De Pauw (3), Jussi-Petteri Suuronen (4), Matthias Van Ginneken (2), Luigi Folco (5), Vinciane Debaille (6), Laszlo Vince (3), and Philippe Claeys (2)

(1) Department of Geology, University of Ghent, Geology, Belgium , (2) AMGC, Vrije Universiteit Brussel, Brussels, Belgium , (3) Department of Analytical Chemistry, Universiteit Gent, Ghent, Belgium, (4) ESRF, European Synchrotron Radiation Facility, Grenoble, France, (5) Department of Earth Sciences, Università di Pisa, Pisa, Italy, (6) Lab G time, Université Libre Bruxelles, Brussels, Belgium

Yearly, the Earth accretes approximately 40,000 metric tons of extra-terrestrial material, mostly in the form of micrometeorites (Love & Brownlee, 1993), particles ranging from 10 – 2000 μm (Rubin & Grossman, 2010). Generally recovered from deep-sea sediments, seasonal lakes in Greenland, Greenland and Antarctic ice and snow, and continental sands, micrometeorites have also been found concentrated in sedimentary traps near mountain summits in the Transantarctic (e.g., Rochette et al., 2008; Suavet et al., 2009) and Sør Rondane Mountains (e.g., Goderis et al., forthcoming; Soens et al., 2017; Van Ginneken et al., 2017). The sedimentary traps in the Transantarctic and Sør Rondane Mountains have proven to be among the most proficient deposits in the world, since large micrometeorites (400 – 1000 μm), among which unmelted particles, are more frequently observed than in other collections. Unmelted micrometeorites, generally rare and small, represent unique material that largely preserved the original petrographic, mineralogical and geochemical properties of the precursor (Van Ginneken et al., 2012). The collections of the Transantarctic and Sør Rondane Mountains contain well-preserved and relatively large specimens compared to more conventional micrometeorite deposits, thus providing a unique opportunity to study the characteristics of a set of unmelted micrometeorites from distinct locations across the Antarctic continent.

The ID16B Nano-Analysis beamline at the European Synchrotron Radiation Facility (ESRF) was used to non-destructively characterize the micrometeorites by obtaining nanoCT, XRF and XRD data on 2 samples from the Transantarctic and 6 samples from the Sør Rondane Mountains, with a size ranging from 100 to 400 μm, to provide information on mineralogical, textural, structural, and chemical variations in these particles, and to trace and characterize primary parent body features. The results of this work enable the comparison of samples from the two different Antarctic collections, establish a distinction between scoriacious and fully unmelted micrometeorites and provide a set of tools to analyze micrometeorites in a non-destructive way, recognizing the needs of future asteroid sample-return missions.