ELEMENTAL AND OXYGEN ISOTOPIC FRACTIONATION RECORDED IN HIGHLY VAPORIZED COSMIC SPHERULES FROM WIDERØEFJELLET, SØR RONDANE MOUNTAINS (EAST ANTARCTICA).

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Introduction: Upon passage through Earth's atmosphere, micrometeorites undergo variable degrees of melting and evaporative processes [1-2]. Amongst the textural and chemical groups of cosmic spherules, i.e. fully melted micrometeorites, a subset of particles displays anomalously high degrees of vaporization, as deduced from their chemical and isotopic composition. Previous research proposed a classification scheme for such cosmic spherules, based on the extent of evaporative loss undergone ('Normal chondritic' – 'CAT-like' – 'High Ca-Al') [3]. Although originally developed for vitreous cosmic spherules, this classification can also be applied to other petrographic types [4]. We have characterized a selection of refractory element-enriched cosmic spherules from Widerøefjellet (Sør Rondane Mountains, East Antarctica) for their textural features, major and trace element concentrations, as well as oxygen isotopic composition. The chemical modifications that these particles underwent upon atmospheric entry have been investigated in detail, and potential overlaps with other classification systems, based on textural rather than chemical characteristics [5], are also addressed in this study.

Methodology: The cosmic spherules characterized in this study were collected from Mount Widerøe (Widerøefjellet), Sør Rondane Mountains (Dronning Maud Land, East Antarctica) during a field campaign in 2018. In total, 78 particles were picked from non-magnetic sediment fractions based on their white to transparent colour, a typical characteristic for highly vaporized cosmic spherules. A more refined selection was made following SEM-EDS analysis at the Vrije Universiteit Brussel, based on elevated major refractory element (Al, Ca, Ti) concentrations. Reliable major and trace element compositions were obtained for 35 cosmic spherules using a Teledyne Photon Machines Analyte G2 ArF* excimer-based laser ablation system coupled to a Thermo Scientific Element XR double-focusing sector-field ICP-MS unit at the Department of Chemistry of Ghent University (Belgium). For the assessment of the oxygen isotopic composition in the cosmic spherules, a total of 23 pre-characterized samples were analysed using a CAMECA IMS 1270 Secondary-Ion Mass Spectrometer (SIMS) at the Centre de Récherches Pétrographiques et Géochimiques (CRPG, Nancy, France).

Results and discussion: The sample set consists of 12 vitreous, 1 cryptocrystalline, 14 barred olivine, 1 porphyritic, 1 scoriaceous and 6 mixed cryptocrystalline/barred olivine particles. In a Fe/Si vs $CaO+Al_2O_3$ diagram, 25 particles plot as 'CAT-like' and 10 particles plot as 'Normal chondritic', while no 'High Ca-Al' particles are identified in the sample set studied. The 'CAT-like' ($8‰ < \delta^{18}O < 59‰$;) and 'normal chondritic'($13‰ < \delta^{18}O < 52‰$) spherules show a remarkably wide spread in oxygen isotopic data, covering and even extending the range in $\delta^{18}O$ previously reported in literature for cosmic spherules [6], thus illustrating the severe evaporation that most particles underwent. This hypothesis is further strengthened by anomalously high enrichments in refractory elements (e.g., Al, Ti, Y, Zr and Hf) and REEs (enrichment factors up to 10^2). Based on their geochemical composition and $\Delta^{17}O$ values, the samples analysed were found to derive from ordinary chondritic (OC) or carbonaceous chondritic (CC) precursors, in proportions that are in general agreement with those reported in literature (30% OC – 70% CC) [3]. The low Fe contents (Fe/Si < 0.04 for 77% of the particles) generally observed amongst the particles studied and reported in literature [2-4] were found to originate from two distinct processes: while metal bead formation and subsequent ejection strongly affected the compositions of all chemical groups of cosmic spherules, evaporative loss of Fe (and other major elements) influenced the final compositions of the 'CAT-like' and 'High Ca-Al' particles to a larger extent. Through combining major and trace element concentrations with oxygen isotope ratio data, processes such as fragmentation, disproportional sampling of specific mineral constituents (including phosphates or refractory phases such as CAIs), differential melting, metal bead extraction, redox shifts and evaporation were identified.

Conclusions: Global trends observed in this work suggest that elemental and isotopic fractionation may co-occur in certain cases, but are decoupled in other. Based on specific element concentrations (e.g., Sr, Zr, Ba, Th, U) and ratios (e.g., Fe/Mg, $CaO+Al_2O_3/Sc+Y+Zr+Hf$), both 'CAT-like' and 'High Ca-Al' cosmic spherules may represent a continuum between the mineral endmembers, sampling a variety of both primitive and differentiated parent bodies that experienced variable degrees of evaporation.

References: [1] Rietmeijer F. J. (2000) *Meteoritics & Planetary Science* 35(5):1025–1041. [2] Lampe S. et al. (2022) *Geochimica et Cosmochimica Acta* 324:221–239. [3] Cordier et al. (2011) *Geochimica et Cosmochimica Acta* 75:5203–5218. [4] Goderis et al. (2020) *Geochimica et Cosmochimica Acta* 270:112–143. [5] Taylor et al. (2000) *Meteoritics & Planetary Science* 55:651–666. [6] Suavet et al. (2010) *Earth and Planetary Science Letters* 293(3-4):313–320.