ACHONDRITIC COSMIC SPHERULES FROM THE SØR RONDANE MOUNTAINS, EAST ANTARCTICA: PROBING THE ASTEROID BELT BEYOND THE METEORITE INVENTORY

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Introduction: Achondritic micrometeorites represent a rare subpopulation (<1 to 1.6%) of the cosmic dust flux to Earth [1-2]. They commonly display vitreous textures due to their lower Mg content, facilitating the melting process of precursor particles during atmospheric entry. As unmelted achondritic micrometeorites are exceptionally rare [3-5], the majority of achondritic micrometeorites will not retain its primary textural, chemical and isotopic properties. However, achondritic materials systematically display higher Fe/Mg ratios (for similar Fe/Mn ratios) relative to chondritic materials [1-2, 6-8]. This can be attributed to a range of planetary differentiation processes (e.g., development of crust, core-mantle segregation) taking place on achondritic parent bodies. Achondritic cosmic spherules (i.e., fully molten micrometeorites) are furthermore characterized by elevated CaO and Al_2O_3 contents (up to 11.6 wt% and 12.4 wt%, respectively), enriched REE contents (up to 11.6x CI chondrites), variable REE patterns and siderophile element contents (e.g., Ni: 0.17-131 ppm and Co: 1.3-68.1 ppm), reflecting their precursor mineralogy [2,7]. Based on their triple-oxygen isotopic compositions, the majority of achondritic cosmic spherules is related to Vesta-like parent bodies [2]. Here, we present new data for five vitreous, achondritic cosmic spherules from the Sør Rondane Mountains (Dronning Maud Land, East Antarctica) with unique major, trace element and triple-oxygen isotopic compositions, possibly expanding the diversity of planetary bodies in the Solar System.

Methodology: Hundreds of vitreous cosmic spherules were extracted from non-magnetic sediment fractions in the Widerøfjellet 18 Mt #01 deposit. Particles were placed on a double-sided sticky-tape and analyzed with SEM-EDS at the Vrije Universiteit Brussel. The achondritic parentage of 5 cosmic spherules (i.e., AC#01-05 representing <1% of the cosmic spherules found) could be determined based on their distribution in the Fe/Mg versus Fe/Mn diagram [6]. The achondritic spherules were embedded in epoxy resin and polished prior to major and trace element analysis. Three replicate analyses with a spot size of 35 µm were performed using a Teledyne Cetac Technologies Analyte G2 excimer-based laser ablation system coupled to a Thermo Scientific Element XR double-focusing sector field ICP-mass spectrometer at the Department of Chemistry (Ghent University). Triple-oxygen isotopic compositions were determined with a Cameca IMS 1270 E7 ion microprobe at the CRPG in Nancy (CNRS - Université de Lorraine) with a spot size of ca. 15 µm. Typical analytical uncertainties are ca. 0.5‰ (2σ) for ^{17}O, ca. 0.5‰ (2σ) for ^{18}O, and ca. 0.6‰ for $\Delta^{17}O$.

Results and Discussion: The five achondritic spherules range between 526-341 µm and display a homogenous, vitreous texture that often contains a dissolution rim due to terrestrial alteration. Four particles are closely positioned near the 4-Vesta/Mars line (Fe/Mn ≈ 32), while one particle (AC#02) is positioned next to the Lunar line (Fe/Mn ≈ 70) in the Fe/Mg versus Fe/Mn diagram. The CaO and Al_2O_3 contents range between 2.7-15.2 wt% and 0.98-25.5 wt%, respectively. Average REE contents are clearly enriched and range between 8.7-20.1x CI chondrite values. The REE patterns are generally flat, except for a positive Eu-anomaly in particle AC#04, a negative Eu-anomaly in particle AC#03, and negative Ce-anomalies in particles AC#02, AC#03 and AC#04. The latter are attributed to the volatile behavior of Ce during atmospheric entry of the precursor particle [9]. The concentrations of Ni and Co range from 6.1 to 75.2 ppm and from 0.85 to 18.7 ppm, respectively, compatible with metal-poor precursor bodies. Triple-oxygen isotopic compositions for particles AC#01 ($\delta^{18}O$: 17.99‰ and $\Delta^{17}O$: -0.47‰) and AC#03 ($\delta^{18}O$: 12.09‰ and $\Delta^{17}O$: -0.53‰) are similar to HED-like spherules found in the Transantarctic Mountains [2]. Particles AC#02 ($\delta^{18}O$: 21.85‰ and $\Delta^{17}O$: -0.39‰), AC#04 ($\delta^{18}O$: 24.38‰ and $\Delta^{17}O$: -0.76‰) and AC#05 ($\delta^{18}O$: 43.44‰ and $\Delta^{17}O$: -0.65‰) display more ambiguous triple-oxygen isotopic compositions and cannot readily be assigned to a specific achondritic parent body. The latter particles may thus sample planetary bodies currently not represented in the meteorite inventory. However, to verify this hypothesis, an accurate assessment of atmospheric reprocessing effects will be required.

Conclusions: Five achondritic spherules were discovered in sediment traps from the Sør Rondane Mountains displaying unique major, trace element and oxygen isotopic compositions, possibly representing new planetary materials. These results will be complemented with stable Fe isotope systematics to determine the extent of atmospheric alteration processes on the precursor particles, allowing a more refined assessment of their parent bodies.

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