MAJOR AND TRACE ELEMENTS AND OXYGEN ISOTOPES IN DIFFERENTIATED COSMIC SPHERULES RELATED TO VESTA-LIKE ASTEROIDS.

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Cosmic spherules (CSs) are extraterrestrial particles < 2 mm in size, captured by the Earth's gravitational field and melted during atmospheric entry. Generally, CSs have geochemical affinities with chondritic material [1]. The ongoing investigation of large and unbiased collections of CSs from the South Pole Water Well and the Transantarctic Mountains (TAM) have, however, led to the identification of new types, including 9 differentiated CSs [2,3]. Here, we define the geochemical characteristics of this new type of CSs from the TAM collection [4] in terms of major (n=11, EPMA), trace element (n=6, LA-ICP-MS) and oxygen isotope (n=15, IRMS) compositions.

The 11 differentiated CSs have high Fe/Mg ratios (0.6 to 1.6) and homogeneous Fe/Mn ratios (31 ± 4). Oxygen isotope compositions ($\delta 18O$ = 14.37 ‰ to 20.12 ‰ and $\Delta 17O$ = -0.47 ‰ to -0.65 ‰) suggest a Vesta-like parent body. Systematic variations in refractory major and trace elements result from differences of the mineralogy of the spherule precursors. Type-1 spherules (n=4) are akin to bulk eucrites, with high CaO and Al_2O_3 contents, flat REE patterns and high REE contents (La/Yb_N = 0.4 to 1.0, REE_N = 8.5 to 14 x CI). They derive from fine-grained precursors with typical eucritic mineralogy. Type-2 spherules (n=4) have lower CaO and Al_2O_3 contents, higher MgO, FeO, and Sc contents, and strong LREE depletions (La/Yb_N < 0.2) relative to eucrites. These compositions suggest large amounts of pigeonite in their precursors. Type-3 spherules (n=2) have flat REE patterns with chondritic REE abundances (REE_N = 1.5 to 2.2 x CI), and are enriched in Co (> 50 µg/g) and Ni (> 17 µg/g) relative to eucrites. Their composition suggests they derive from howardite-like precursors rich in orthopyroxene. The mineralogies proposed for the differentiated precursors are consistent with those expected for micrometeoroids deriving from the regolith of Vesta-like asteroids [5].

The combination of elemental and isotopic data shows that the elemental ratios and contents (Fe/Mg and Fe/Mn, REEs, Ni and Co, V, Zn) previously proposed to identify the differentiated CSs and their parent body [3] are suitable, provided that the mineralogical control is understood. Differentiated CSs deriving from pigeonite-rich precursors (Type 2) tend to have slightly lower Fe/Mg and Fe/Mn ratios and higher V contents than basaltic eucrites, whereas large amount of opx in spherule precursor may result in lower Fe/Mg and higher Ni and Co contents.

The relative frequency of Vesta-like micrometeorites in the TAM micrometeorite collection (1.6 %) is consistent with the proportion amongst meteorites of eucrites and howardites (1.8 %), which are the main constituents of the regoliths of Vesta-like asteroids.

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