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南極雪中から回収された宇宙塵の化学組成
Chemical compositions of cosmic dust samples recovered from Antarctic snow

海老原 充 [1*], 関本俊 [2], 白井直樹 [1], 辻本 真一 [3], 野口 高明 [3], 中村 智樹 [4], 岡崎 隆司 [5], 伊藤 正一 [6], 橘 省吾 [6], 薮田 ひかる [7], 寺田 健太郎 [7], 大久保 彩 [8], 永原 裕子 [8]
Mitsuru Ebihara[1*], Shun Sekimoto[2], Naoki Shirai[1], Shinichi Tsujimoto[3], Takaaki Noguchi[3], Tomoki Nakamura[4], Ryuji Okazaki[5], Shoichi Itoh[6], Shogo Tachibana[6], Hikaru Yabuta[7], Kentaro Terada[7], Aya Okubo[8], Hiroko Nagahara[8]

[1] 首都大学東京大学院理工学研究科, [2] 京都大学原子炉実験所, [3] 茨城大学理学部, [4] 東北大学大学院理学研究科, [5] 九州大学大学院理学研究院, [6] 北海道大学大学院理学研究院, [7] 大阪大学大学院理学研究科, [8] 東京大学大学院理学系研究科
[1]Department of Chemistry, Tokyo Metropolitan University, [2]Kyoto University Research Reactor Institute, [3]College of Science, Ibaraki University, [4]Department of Earth and Planetary Materials Sciences, Tohoku University, [5]Department of Earth and Planetary Sciences, Kyushu University, [6]Department of Natural History Sciences, Hokkaido University, [7]Department of Earth and Space Science, Osaka University, [8]Department of Earth and Planetary Science, University of Tokyo

We investigated four micrometeorites (MMs) recovered from Antarctic ice: D10IB034, D10IB103, D10IB179, and D10IB187. Bulk mineralogy was investigated by SR-XRD, TEM, FE-EPMA, and INAA. Analytical procedure for INAA was essentially the same as used for Itokawa grains [1]. The MMs were irradiated with neutron (total neutron fluence: 6.1 x 1018 n/cm2) along with reference standards at Kyoto University Research Reactor Institute (KURRI). After cooling for a few days, the MMs were measured for gamma-ray activiry by using germanium semiconductor detectors at KURRI.

A total of eight elements (Na, Sc, Cr, Fe, Co, Ni, Sm and Ir) were determined at least for one MM sample. Their abundances relative to CI chondrite and Fe contents of individual samples show that siderophiles (Co, Ni, Ir) are more variable and depleted compared with lithophiles (Na, Sc, (Sm)). Compared with literature data for bulk and matrix samples of CM and CR meteorites, an agreement is not good within the limited data set. Even in the comparison with MMs from Antarctic ice, the four dust MMs from Antactic snow seem to have distinct chemical features.

The FeO/Sc ratio can be used for judging the origin of planetary materials. When these ratios for the four MMs of this study are compared with data for bulk chondrites, Earth, Moon, Mars, olivine and pyroxene separates from ordinary chondrites and the Itokawa grain samples [1], the four MM samples along with chondritic matarials and Itokawa grains have higher FeO/Sc raios than those for terrestrial samples. This suggests that the four MMs are extraterresrial in origin although their compositions are not chondritic and are not similar to MMs from ice.

Two MMs (D10IB034 and D10IB179) yielded definite values for both Co and Ni. Their abundances and ratios give us reliable judgement for the origin of planetary materials. If their contents relative to Fe contents are compared with those for Itokawa grains [1] and some constituent minerals of L and LL chondrites, the two MM from Antarctic snow are on the line defined by the CI Co/Ni ratio, clearly indicating their extraterrestrial origin. This further suggests that these MMs contain tiny metal particles or primitive materials having high and unfractionated Co and Ni abundances. Crustal materials of differentiated planets like Earth and 4 Vesta (HED parent body) also plotted in lower left region off the CI line. One MM (D10IB103) seems to be also in such region.

Only one MM sample (D10IB034) was observed to have a distinct value of Ir. When its ratio relative Co and Ni is copmared with data for chondrules from oridinary chondrites (mostly unequilibrated ordinary chondrites; [2]), bulk chondrites and chondritic metals in addition to the Itokawa grain [1], bulk chondrites and chondritic metals mostly converge aroud the cross defined by CI ratios for Ir/Ni and Ir/Co. These elements are typical siderophile elements and, hence, they are not largely fractionated in bulk chondrites, chondritic metals and even in iron meteorites. Instead, chondrules show a large spread in Ir/Ni and Ir/Co raios [2]. CI-normalized Ir/Fe and Ir/Co ratios of chondrilues are arrayed on the line having a slope of 1, implying that chondrules have unfractionated (chondritic) Co/Ni ratios with a large variation of Ir abundances. The Itokawa grains also fit on this line [1]. It is observed that the MM D10IB034 also stay on the same line. The difference between the Itokawa grain and the Antarctic dust sample is on the Ir content. We interpret that the MM D10IB034 containts an early condensate in which Ir condensed but Co and Ni scarcely did.

References: [1] Ebihara M. et al. (2011) Science, 333, 1119-1121. [2] Grossman J. N. and Wasson J. T. (1982) GCA, 46, 1081-1099.

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