ISOTOPIC MEASUREMENTS OF <100 ng CARBON AND NITROGEN THROUGH EA/IRMS AND ITS APPLICATION TO EXTRATERRESTRIAL MATERIALS.

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Introduction: Carbon and nitrogen abundance and their isotopic compositions in the extraterrestrial materials provide crucial information for its origin and history. Furthermore, they have stimulated our discussion on the origin of life. To precisely measure these chemical properties with a small sample amount, we have improved the commercial system of continuous-flow elemental analyzer/isotope-ratio mass spectrometer (EA/IRMS) system, and applied it to various extraterrestrial samples. In this presentation, we introduce the instrument and some applications of this sensitivity-improved nano-scale EA/IRMS [1].

Nano-scale EA/IRMS: We have modified automated EA/IRMS system (Thermo Flash EA1112-Conflo III-Delta Plus) to improve the sensitivity for the precise determination of quantity and the stable isotopic compositions of carbon and nitrogen from very small amount of samples [1]. The usefulness of the EA/IRMS is by its wide analytical capability over carbon and nitrogen characteristics (Figure 1). The commercial EA/IRMS system usually requires more than 50 µg of carbon or nitrogen to obtain reliable results, which is often limits the sample kind. For example, meteorites generally contain trivial amount of organic matter with less combustible form, which is often beyond oxidation capacity of the commercial EA/IRMS system. However, by improving the EA/IRMS to reduce its required sample amount to <100 ng as carbon or nitrogen, it becomes possible to obtain reliable quantity and isotopes of carbon and nitrogen from very tiny amount of meteorites (generally, <0.1 to 3 mg) with keeping the quality of the data (Figure 2). Furthermore, with the combination of isolation/purification of target compounds by HPLC, and its high-temperature oxidation method (Ox-flash combustion) of EA, the nano-scale EA/IRMS is able to determine the quantity and isotopic compositions of organic matters with wide ranges of polarity and molecular weight (Figure 1). This is a strong contrast to the GC/IRMS (gas chromatograph-combustion/reduction-IRMS) whose application is practically limited to relatively low polarity, low molecular weight (~600 Da) organic compounds. We are planning to apply this technique to analyze organic matter in the samples recovered from asteroid Ryugu through Hayabusa 2 project [4].

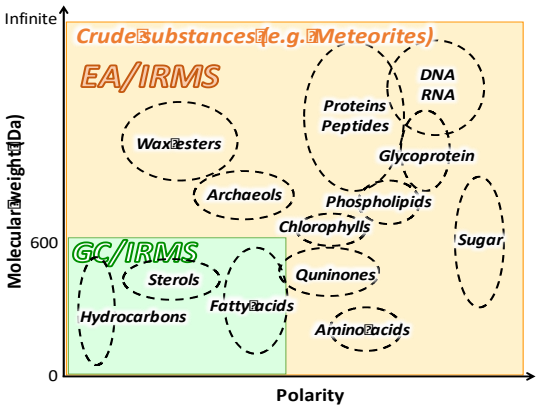

Figure 1 Schematic illustration of organic substances and the type of IRMS analysis. Having an EA as a sample preparation system to IRMS, EA/IRMS has broader analytical capability.

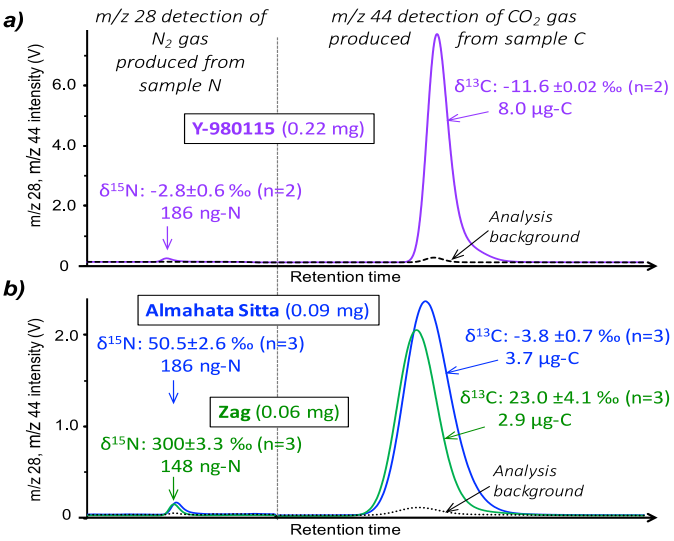

Figure 2 The IRMS chromatograms from nano-scale EA/IRMS analysis of meteorites. a) 0.22 mg of the CI chondrite Y-980115 [2], b) 0.093 mg of chondrite Almahata Sitta 671 and 0.055 mg of carbonaceous clast in the Zag meteorite [3]. Numbers indicate C and N quantities and their isotopic compositions determined by this method.

References:

[1] Ogawa N. O. et al. (2010) in *Earth, Life, and Isotopes* (eds N. Ohkouchi, I. Tayasu, & K. Koba) 339–353 (Kyoto University Press). [2] Chan M. S. et al. (2016) *Earth, Planets and Space* 68:7. [3] Kebukawa Y. et al. (2019) *JpGU2019*, Abstract #PPS07-05. [4] Naraoka et al. (2019) *JpGU2019*, Abstract #PPS03-P14.