QUANTIFICATION AND ISOTOPIC MEASUREMENTS OF SUBMICROGRAM SCALES CARBON AND NITROGEN FROM EXTRATERRESTRIAL MATERIALS THROUGH NANO-EA/IRMS. N.O. Ogawa[1*], Y. Takano[1], N. Ohkouchi[1], M. Hashiguchi[2], E.T. Parker[3], H.L. Mclain[3], J.P. Dworkin[3], H. Naraoka[2], and SOM analysis team, [1]JAMSTEC (2-15 Natsushimacho, Yokosuka, 237-0061, Japan. *nanaogawa@jamstec.go.jp), [2]Kyushu University (744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan), [3]NASA GSFC (Greenbelt, Maryland 20771, USA.)

Introdu ction: Carbon and nitrogen abundances and their isotopic compositions in extraterrestrial materials provide crucial information regarding origin and histories of the materials, and to stimulate scientific discussion on the origin of life. However, it is often difficult to precisely measure these chemical properties within small and limited quantities of samples, such as meteorites and the extraterrestrial materials obtained from sample-return missions. To measure the aforementioned chemical properties, we modified and optimized a commercial continuous-flow elemental analyzer/isotope-ratio mass spectrometer (EA/IRMS), and applied it to study various extraterrestrial samples. We overview the sensitivity-improved nano-EA/IRMS [1] and detail the results of its application to samples provided from the Hayabusa2 soluble organic matter (SOM) rehearsal analysis [2].

Determination of C and N Abundances and Isotopes in Meteorites: The EA/IRMS is an automated analytical technique, which simultaneously measures quantities and isotopic abundances of C and N in various materials. Using a high temperature flash combustion (up to 1800°C for a few seconds) mechanism for sample preparation, the EA/IRMS offers a wide range of analytical capabilities for the purpose of investigating the chemical properties of C and N. On the other hand, a known drawback of the EA/IRMS is its requirement for large quantities of sample (>50 µg as C or N) to facilitate precise measurements, which provides challenges when studying precious or less organic samples. Such samples include meteorites, which generally contain trace quantities of organic matter with less combustible forms, and therefore often exceed the oxidation capacity of the conventional EA/IRMS.

In an effort to capitalize on the advantages of the conventional EA/IRMS, while reducing its disadvantages, we developed a nano-EA/IRMS by modifying and optimizing an automated, conventional EA/IRMS (Thermo Flash EA1112-Conflo III-Delta Plus) to improve the sensitivity of the system for the purpose of enabling the precise determination of the quantities and stable isotopic compositions of C and N difficult samples [1]. The nano-EA/IRMS we developed, successfully reduced the quantity of required sample (i.e., ~100 ng) to obtain reliable data pertaining to the abundances and isotopic compositions of C and N within miniscule quantities (20 µg to 3 mg) of meteorites [3]. The nano-EA/IRMS has already been applied to selected meteorites and has consequently helped to stimulate deeper discussions [4,5]. When combined with the compound-isolation/purification benefits of high-performance liquid chromatography, the nano-EA/IRMS can be applied to study molecules spanning a wide range of polarities and molecular weights, as well as investigate bulk sample material. This is in strong contrast to the GC/IRMS (gas chromatography-combustion/IRMS), which is limited to relatively low polarity, low molecular weight (<600 Da) compounds (Figure1).

Nano-EA/IRMS Analysis of the Hayabusa2 SOM Rehearsal Samples: We will detail the results of the nano-EA/IRMS analysis of two CM carbonaceous chondrites (Murchison and Yamato 793321) as part of the Hayabusa2 SOM rehearsal analysis [2]. The abundances and isotopic compositions of C and N were obtained by analyzing the original (pre-treated) powders and the SOM extracted residues. We will also present preliminary results of bulk S quantification and isotopic determination for these samples. The analytical techniques used here are going to be applied to investigate sample material recovered from asteroid *Ryugu*, as part of the Hayabusa2 SOM analysis team objectives [2].

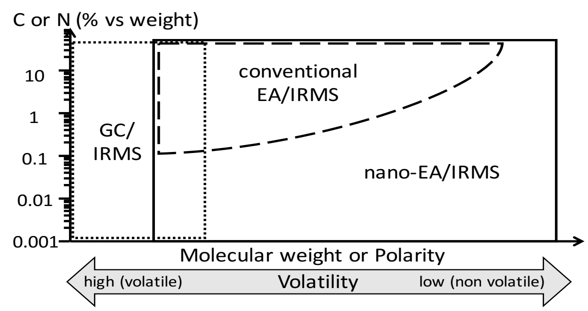

Figure 1 Schematic illustration of organic substances and the type of IRMS analysis. Together with powerful oxidation, EA/IRMS has broad analytical capability. The nano-EA/IRMS further extends the possibility with x100 higher sensitivity.

References: [1] Ogawa N. O. *et al.* (2010) in *Earth, Life, Isotopes, (eds N. Ohkouchi et al.) 339 (Kyoto Univ. Press)*. [2] Naraoka H. *et al.* (2019) *MetSoc2019*, Abstract #6314. [3] Ogawa N. O. *et al.* (2019) *MetSoc2019,* Abstract #6208. [4] Chan H. S. *et al.* (2016) *Earth, Planets Space, 68:7.* [5] Furukawa Y. *et al.* (2019) *PNAS,* 116: 24440.