Returned sample from carbonaceous asteroid Ryugu and its astrochemical implications

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The Hayabusa2-returned C-type asteroid Ryugu samples [1] are the chemically most pristine material in the Solar System as they have not been exposed to terrestrial conditions [e.g., 2-9]. The Ryugu samples have the bulk elemental compositions similar to those of the Sun and CI chondrites, which are the chemically most primitive meteorites [1], suggesting that Ryugu formed from the Solar System's original elemental ingredients without experiencing elemental fractionation except for highly volatile elements such as H, C, N, and noble gases.

The carbon abundance of the bulk Ryugu samples ranges from 3.2 to 6.8 wt % [2, 5, 8, 9], which is similar to that in CI chondrites and among the highest in the meteorite samples. About 2/3 of this carbon is in organic matter [1]. The organic matter in Ryugu records the molecular evolution from the Sun's parent molecular cloud chemistry to the asteroidal aqueous alteration [e.g. 7-9]. The Ryugu samples contain organic matter having hydrogen and/or nitrogen isotopic compositions highly enriched/depleted in D and ^{15}N [7]. These distinct isotope compositions of macromolecular organics may have been inherited from the chemistry in the Sun's parent molecular cloud or the cold outer Solar System.

The N/C ratio of the Ryugu's macromolecular organic matter ranges from 0.01 to 0.035 [5]. Thosee N/C ratios of the Ryugu's macromolecular organic matter are within the range of thoseN/C ratios found inof insoluble organic matter (IOM) in carbonaceous chondrites and those inof organic particles from comet 67P/Churyumov-Gerasimenko [e.g., 10]. It is thus suggested that the macromolecular organics with the N/C ratio lower than the solar N/C ratio was present with those having the high N/C ratios in the Sun's protoplanetary disk, and the organics with the lower N/C ratio was incorporated into the Ryugu's parent body and comet 67P/Churyumov-Gerasimenko [10].

We review the results of Ryugu sample analysis and discuss the evolution of organic matter in the early Solar System by comparing with the recent radio and infrared observations of protostars and protoplanetary disks.

References

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