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The Origin of Ryugu in the Context of Modeling and Chronology Based CC Parent Body Accretion Timing

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Observations of C-type NEA and laboratory investigations of CC meteorites indicate a high porosity of C-type asteroids. The boulder microporosity derived for Ryugu is substantially higher than for water-rich CC and could indicate distinct parent body evolution paths. Application of thermo-chronometers to meteorites provides formation ages of various mineralogical components. The parent body chronology can be combined with planetesimal thermal evolution models to constrain the timescale of accretion and dynamical processes in the early solar system. While achondrite parent bodies are considered to have accreted early and in the NC reservoir of the protoplanetary disk, late accretion in the C reservoir produced mostly undifferentiated parent bodies, such as the parent body of CR chondrites that formed as late as 4 Ma after the formation of Ca-Al-rich inclusions (CAIs).[1] However, presence of more evolved CR-related meteorites suggests an earlier accretion timing.

We constrained the size and accretion time of Ryugu's parent body using a numerical model for the evolution of the temperature and porosity.[2] Our calculations indicate a size of only a few km in radius and an early accretion within â‰²2-3 Ma after CAIs. By contrast, calculated properties for CI and CM parent bodies obtained by fitting carbonate formation ages indicate radii of ≈20-25 km and accretion times of ≈3.75 Ma after CAIs. Furthermore, we fitted thermo-chronological data available for the C chondrite Flensburg and for CR-related meteorites (CR1-3, Tafassites[3], NWA011, and NWA 6704) that range from altered chondrites to basaltic achondrites to constrain accretion times of their respective parent bodies. Our results indicate a temporally distributed accretion of parent bodies in the C reservoir, ranging from <1 Ma to 4 Ma after CAIs. This implies that accretion in the C reservoir started as early as in the NC reservoir and produced differentiated bodies with carbonaceous compositions in addition to undifferentiated C chondrite parent bodies. We put our results for the origin of Ryugu in the general context established with these fits.

[1] Schrader D. L. et al. (2011), *GCA* 75, 308-325.

[2] Neumann W. et al. (2021), *Icarus* 358, 114166.

[3] Ma N. et al. (2021), Goldschmidt 2021, https://doi.org/10.7185/gold2021.3852.