# GENETIC RELATIONSHIPS AND THE NUCLEOSYNTHETIC HERITAGE OF THE ASTEROID BENNU

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**Introduction:** The OSIRIS-REx sample return mission visited the B-type asteroid Bennu and delivered 121.6 gof pristine material to Earth in September 2023. Genetic links between this pristine material and different meteorite groups can be determined using nucleosynthetic isotope variations. These variations reflect the heterogeneous distribution of isotopically distinct dust from different stellar environments within the protoplanetary disk. They can therefore be used to constrain different formation locations of parent asteroids [e.g., 1]. In addition, isotope variations are powerful tracers to establish the nucleosynthetic heritage of returned samples [e.g., 2] and to evaluate mixing and reservoir formation within the disk [1,3]. Here we present nucleosynthetic Ti and Fe isotope data for samples from Bennu and several carbonaceous chondrites. We also report the Ti isotope composition of hand-picked matrix fractions from CR and CV meteorites.

**Methods:** A 20.66 mg aliquot of aggregate material (OREX-803015-0) was dissolved at Washington University in St. Louis to determine major and minor trace element abundances [4]. From this dissolution, two aliquots of ~5 mg were sent to the Swiss Federal Institute of Technology (ETH) Zurich and Lawrence Livermore National Laboratory (LLNL) for analysis. The results are presented here and in a companion abstract [5].

At ETH Zurich, one of these 5 mg aliquots was processed through a succession of anion- and cation-exchange columns to separate Ti, Fe, Cr, and Ni from the sample matrix for isotopic analysis with a Thermo Scientific Neptune Plus MC-ICP-MS.

**Results & Discussion:** Our new Ti and Fe isotope data for Bennu overlap with those of CI chondrites and Ryugu [1,6,7]. The Bennu and Ryugu data were each obtained from just ~20 mg samples consisting of aggregate material. Nevertheless, the data are indistinguishable from those of CI chondrites, and the results demonstrate the close genetic relationship of Bennu samples to those of Ryugu [6,7] and CI meteorites [e.g., 1,6]. Thus, the composition of Bennu closely resembles our best estimate of the initial composition for the solar system. This confirms the mission hypothesis that Bennu formed in the carbonaceous reservoir, which consists of material that originated beyond the snowline [8].

Although CV and CR chondrites have distinct bulk-rock Ti isotope compositions from each other [e.g., 1], their hand-picked matrix fractions display a homogenous composition. The matrix data fall at the lower end of the Ti isotope trend within the carbonaceous reservoir. This suggests an isotopically uniform, primitive matrix component for bodies within the carbonaceous reservoir. Titanium isotope variations between and within different carbonaceous chondrite groups can be explained by the addition of different amounts of calcium-aluminium–rich inclusions (CAI) and/or amoeboid olivine aggregates (AOA), both of which are enriched in supernovae-derived Ti isotopes, to this uniform matrix [e.g., 9-11]. The Ti isotope data of Bennu, as well as Ryugu and CI meteorites, fall above those of the CR and CV matrix, and this suggests that they are composed of a uniform matrix together with ~0.1–0.7% CAI/AOA material.

**Conclusions:** The Ti and Fe isotope composition of Bennu sample OREX-803015-0 shows an affinity to the CI meteorite group and Ryugu. Titanium isotope data on carbonaceous meteorite matrix indicates that Bennu, Ryugu, and CI meteorites contain between 0.1 and 0.7% refractory inclusions.

**References:** [1] Rüfenacht M. et al. (2023) *Geochimica et Cosmochimica Acta* 355:110. [2] Yokoyama T. et al. (2022) *Science* 379:eabn7850. [3] Mezger K. et al. (2020) *Space Science Reviews* 216:27. [4] Koefoed P. et al. (2024) *Lunar and Planetary Science Conference,* Abstract #2264. [5] Render J. et al. (2024) this conference. [6] Hopp T. et al. (2022) *Science Advances* 8:46. [7] Yokoyama T. et al. (2022) *Science Advances* [vol#]:eadi7048. [8] Lauretta D. S. et al. (2023) arXiv:2308.11794. [9] Trinquier A. et al. (2009) *Science* 324:374-376. [10] Torrano Z. A. et al. (2024) *Earth and Planetary Science Letters* 627:11855. [11] Jansen C. A. et al. (2024) *Earth and Planetary Science Letters* 627:118567.