Investigating Pre-Irradiation Effects in CAIs from Carbonaceous Chondrites

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Introduction: Calcium-aluminum-rich inclusions (CAIs) represent the earliest known solid materials to have formed in the Solar System, offering critical insights into the initial stages of the solar accretion disk's evolution. [1]. An important unresolved challenge in reconstructing material transport and flow processes in the evolving solar accretion disk is understanding how CAIs migrated and were stored during the period of up to 1 million years between their formation near the protosun and their incorporation into carbonaceous chondrites in the outer Solar System. The transport of CAIs to the outer Solar System may have either occurred through movement within the disk or via ballistic trajectories above the disk driven by X-winds. Their storage could have taken place within a pre-existing CAI parent body or in pressure bumps located in the distant regions of the solar accretion disk. In certain scenarios, CAIs were likely exposed to cosmic rays from the Sun or the galaxy. This project aims to investigate the cosmic ray-induced irradiation effects present in CAIs from carbonaceous chondrites.

Methods: Following our earlier study [2] demonstrating that X-ray scanning does not affect the noble gas budget, we performed X-ray scans of our samples to locate CAIs. The scans were conducted using a Bruker 2214 nano- and micro-CT scanner housed at the Institute of Anatomy, University of Bern. Based on the CT data, the samples were precisely sectioned at the Natural History Museum of Bern. The CAIs were subsequently analyzed for their chemical composition using SEM at the Institute of Geological Sciences, University of Bern. We extracted fine-grained and coarse-grained samples using microscopy, micro-drilling, and dental tools. Finally, the samples were analyzed for their isotopic compositions of He, Ne, Ar, and Kr using a sector field mass spectrometer at the University of Bern.

Results and Discussion:

The results so far indicate that the studied CAIs now show clear indications of pre-accretionary irradiation effects. Since the conclusion is solely based on CAIs from the CV3 chondrite Allende, we are currently extending the database to include CAIs from other carbonaceous chondrite types.

References: [1] Krot A. N. et al. (1995) Meteoritics 30, 530-531 [2] Ghaznavi P. et al. (2023) Meteoritics & Planetary Science, 58, Nr 6, 897–900