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Developments in the chronology of aqueous alteration in the era of sample return missions

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JAXA's Hayabusa2 mission returned 5.4 g of aqueously altered CI-like material from asteroid Ryugu [1-4]. Sample analysis teams developed detailed sample handling and coordinated analysis workflows to maximize scientific gain while limiting sample consumption and terrestrial contamination, especially for sensitive organic or hydrated materials [e.g., 2,5].

Ryugu samples contain few unaltered primary minerals suitable for dating high temperature solar nebular processes [1-4]. Rather, abundant secondary carbonate minerals enable investigations of the timing of parent-body aqueous alteration using in-situ ^{53}Mn-^{53}Cr measurements by secondary ion mass spectrometry (SIMS). The desire to establish a precise and accurate chronology of aqueous alteration has driven significant improvements in SIMS methodology.

Precise (sub ~Myr) measurements of carbonate formation ages in astromaterials can be performed at high spatial resolution (<5 µm spot size) following the introduction of the Hyperion II RF oxygen plasma source to SIMS analyses ahead of sample arrival [6]. Some sample analysis teams used this source design to perform precise Mn-Cr analyses on a broader size range of carbonates relative to the conventional duoplasmatron oxygen ion source [4,7].

The accuracy of Mn-Cr dating has also benefited from a push to establish better-matched reference materials for measurements of carbonate, particularly for dolomite, the most common carbonate mineral found in Ryugu samples [2-4,7-9]. Measurements using recently-developed Cr-doped dolomite standards to determine the Mn/Cr ratio during SIMS analyses yield significantly older carbonate formation ages than measurements performed with non-matrix-matched carbonate standards (e.g., calcite), suggesting earlier accretion and alteration of CI-like materials than previously considered [7].

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