

# Spatial constraints for ureilite precursors from $\epsilon^{54}\text{Cr}$ , $\epsilon^{50}\text{Ti}$ , and O isotopes

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Mass-independent isotopic heterogeneities (e.g., O, Cr, Ti) in meteorites and their constituents have often been used to identify and to evaluate mixing between chemically and isotopically distinct reservoirs in the early Solar System. Ureilites – mantle restites of an early formed planetary body – are of particular interest because they exhibit isotopic heterogeneities of nucleosynthetic origin of varying magnitude. This contrasts with the isotopic homogeneity observed among other differentiated achondrites. The reason for the isotopic heterogeneities in ureilites is not well understood, but may be related to the inheritance of chemically and isotopically distinct precursor materials. To better constrain the possible sources of ureilites, we measured Cr and Ti isotopes on main group (MG) ureilites and combined these data with published O-isotope signatures [1]. The high precision Cr and Ti isotope analyses of ureilites were measured at the University of Bern by Thermal Ionization Mass Spectrometry (TIMS) and Multicollector Inductively-Coupled Plasma Mass Spectrometry (MC-ICPMS) and show a variation in the neutron-rich isotopes  $^{54}\text{Cr}$  of  $> 30$  ppm and  $^{50}\text{Ti}$  of  $> 50$  ppm. The O isotopic compositions of MG ureilites ranges in  $\Delta^{17}\text{O}$  from  $-2.45$  to  $-0.23$  ‰ [1].

The  $^{54}\text{Cr}$  and  $^{50}\text{Ti}$  abundances of MG ureilites are the lowest recorded in any known meteorite group and suggest formation from an isotopic end-member in the non-carbonaceous chondrite (NC) reservoir. While NC bodies like Earth, Mars and Vesta lie on a well-defined correlation line in  $\epsilon^{50}\text{Ti}$ - $\epsilon^{54}\text{Cr}$  space with Cl-like  $\epsilon^{50}\text{Ti}/\epsilon^{54}\text{Cr}$ , MG ureilites deviate from this line to different extent. The isotopic and chemical variability of MG ureilites indicates that the ureilite parent body formed by mixing of at least two isotopically and chemically distinct precursor components. The O isotopic compositions of ureilites plot on or close to the carbonaceous chondrite anhydrous mineral (CCAM) line, suggesting similarities to aqueously altered carbonaceous chondrite-like material. The combined  $\epsilon^{54}\text{Cr}$ ,  $\epsilon^{50}\text{Ti}$  and O isotope data of MG ureilites suggest that ureilite precursors are derived from the extreme part of the NC reservoir, probably beyond the ice line.

[1] Clayton and Mayeda (1996), *GCA* 60, 1999-2017.