Cr Isotope Variation in the Components of Unequilibrated Chondrite QUE 97008 (L3.05) and Implications for ^{53}Mn-^{53}Cr Dating of Unequilibrated Chondrites.

Y. Kadlag[1] and H. Becker[1], [1]Institut für Geologische Wissenschaften, FU Berlin, Malteserstr.74-100, 12249 Berlin, Germany
yogita@zedat.fu-berlin.de

Unequilibrated ordinary chondrites exhibit moderate excesses in ε^{53}Cr (0.21 ± 0.05) and deficits in ε^{54}Cr (-0.37 ± 0.05) compared to terrestrial rocks and Cr standards [1,2]. The decoupling of ε^{53}Cr and ε^{54}Cr in bulk rocks of unequilibrated ordinary chondrites indicates the presence of different carrier phases of ^{53}Cr and ^{54}Cr in precursors of ordinary chondrites. Systematic study of Cr isotope composition in components of unequilibrated chondrites may be useful to understand the origin of these differences and the processing history of the precursor dust in the early solar system. In the present study, we report Cr isotope data on physically separated components of the unequilibrated ordinary chondrite QUE 97008 (L3.05). Mn/Cr of components of QUE 97008 were determined from diluted digestion solutions on an Element XR^{TM} ICP-MS using the standard addition method. Chromium was separated from matrix elements by two-stage (anion exchange on the first column and cation exchange on the second column) chromatography. Total Cr yield was nearly 100% on the first column and greater than 96% on the second column. Chromium isotopic compositions were measured on a Triton TIMS at FUB relative to the NIST 3112a Cr standard. External reproducibilities of ε^{53}Cr and ε^{54}Cr determined on the NIST 3112a Cr standard are 6 ppm and 8 ppm, respectively (2s).

Mn/Cr in components shows a large variation (Mn/Cr = 0.54-1.57) compared to the bulk rock data of QUE 97008 (Mn/Cr = 0.73 ± 0.01 from calculated bulk rock values of this study and literature data [2]). Of all components, the fine grained metal-rich (magnetic) fraction shows the lowest Mn/Cr and a slightly magnetic matrix-rich fraction shows the highest Mn/Cr. Components analyzed for Cr isotopes so far show ε^{53}Cr ranging from -0.47± 0.04 to 0.41± 0.07 and ε^{54}Cr is ranging from -0.9 ± 0.2 to 0.6 ± 0.1. Except for the coarse-grained slightly magnetic fraction (> 250µm), all components show a deficit in ^{54}Cr compared to the NIST 3112a Cr standard. This fraction also shows a higher Cr concentration (Cr % = 0.539 ± 0.003) compared to other components. The slightly magnetic matrix-rich component with the highest Mn/Cr shows lowest ε^{53}Cr and ε^{54}Cr values.

No systematic variation is observed between ε^{53}Cr, ε^{54}Cr and Mn/Cr or the metal (Fe-Ni) content in the components. Decoupling of ε^{53}Cr, ε^{54}Cr from Fe-Ni metal content indicates that the Cr isotope variations in the components likely have been produced by processes that occurred before the last metal-silicate partitioning event (i.e. chondrule formation). The decoupling of isotope systematics from Mn/Cr ratios indicates accretion of heterogeneous precursors with different carrier phases of ^{53}Cr and ^{54}Cr in the chondrite components. An important observation is that the slightly magnetic matrix-rich fraction (which also is characterized by the highest Mn/Cr) shows the lowest ε^{54}Cr (and ε^{53}Cr). Several explanations may account for this. The observed mixture of ^{54}Cr-depleted and -enriched carriers may have been present in the accretion region of ordinary chondrites to begin with [3]. Alternatively, minor quantities of ^{54}Cr rich carriers (which are more typical of other chondrite classes) were added later in variable proportion to the initial ordinary chondrite-like ^{54}Cr-depleted composition. Another possibility is variable late thermal processing of material containing ^{54}Cr rich carriers, but that would be at odds with the high Mn/Cr of this component. Silicate-rich material mostly derived from chondrules in QUE 97008 is less depleted in ^{54}Cr, whereas the component with the lowest Mn/Cr (and highest Cr concentration) is characterized by the highest ^{54}Cr. A preliminary interpretation of the ^{54}Cr-^{53}Cr variation involves binary mixing of ^{54}Cr-^{53}Cr depleted and enriched carriers, overprinted by in situ decay of ^{53}Mn in some of the components. The heteoregenous presence of ^{54}Cr depleted phases in components indicate the highly unequilibrated nature of this meteorite, because ^{54}Cr depleted carriers in ordinary chondrites are more easier to destroy during leaching experiments [3]. We conclude that, as in carbonaceous chondrites [4,5,6] and in ordinary chondrites [3] heterogeneous mixing of ^{53}Cr and ^{54}Cr enriched and depleted phases in chondrite precursors affected the Cr isotope systematics of unequilibrated bulk chondrites. This may prevent using the ^{53}Mn-^{53}Cr system as a reliable chronometer for ordinary chondrite formation processes.

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