

エコンドライトのニオブ-ジルコニウム同位体学 Nb-Zr systematics of U-Pb dated achondrites

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The short-lived radionuclide ^{92}Nb decays to ^{92}Zr with a half-life of 36 Ma [1]. Nb and Zr are both refractory lithophile elements and can fractionate from each other during partial melting of the mantle. Thus, Nb-Zr isotope systematics can potentially place chronological constraints on early planetary silicate differentiation. This application requires the initial abundance of ^{92}Nb (or $^{92}\text{Nb}/^{93}\text{Nb}$) and its homogeneity in the solar system to be unambiguously defined. Yet previously reported initial $^{92}\text{Nb}/^{93}\text{Nb}$ values range from $\sim 10^{-5}$ to $>10^{-3}$ [2-6], and remain to be further constrained. All but one of the previous studies estimated the initial $^{92}\text{Nb}/^{93}\text{Nb}$ using Zr isotope data for single phases with fractionated Nb/Zr in meteorites such as zircons and CAIs, under the assumption that their source materials and bulk chondrites had had identical initial $^{92}\text{Nb}/^{93}\text{Nb}$ and Zr isotopic compositions [2-5]. To evaluate the homogeneity of the initial ^{92}Nb abundance, however, it is desirable to define internal mineral isochrons for meteorites with known absolute ages. Although Schonbachler et al. [6] defined Nb-Zr internal isochrons for two meteorites (Estacado and Vaca Muerta), their absolute crystallization (or possibly recrystallization) ages are not precisely constrained, leading to uncertainties in the resultant estimate for the initial $^{92}\text{Nb}/^{93}\text{Nb}$ of the solar system.

To establish the solar system initial $^{92}\text{Nb}/^{93}\text{Nb}$ and its homogeneity, we are studying the Nb-Zr systematics of minerals from achondrites whose absolute crystallization ages were precisely determined with the U-Pb chronometer. Abundances of trace elements including Nb and Zr were determined by LA-ICPMS for pyroxene, plagioclase, pyrite, spinel and/or opaque minerals from 3 eucrites (Agoult, Ibitira and A-881394), 5 angrites (SAH99555, D'Orbigny, NWA2999, NWA4590 and NWA4801) and Acapulco. The results reveal that Agoult, Ibitira and NWA4590 contain phases with reasonably high Zr contents and a good spread in Nb/Zr (<0.01 for pyroxene and ~ 3 for opaque minerals and spinel) to define precise internal isochrons. These minerals and whole rock samples were further processed for Zr separation and analyzed for Zr isotopes by MC-ICPMS. We found that the spinel and opaque mineral fractions have restricted positive ^{92}Zr anomalies up to 30 ppm relative to the terrestrial standard samples. We are still in the process of determining their Nb/Zr isotopic ratios, but preliminary results of Zr isotope analyses, combined with the approximate Nb/Zr of minerals estimated by LA-ICPMS, suggest that the initial $^{92}\text{Nb}/^{93}\text{Nb}$ is in the order of $\sim 10^{-5}$, consistent with the results of previous work using the internal isochron approach [6].

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