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Nb-Zr systematics of U-Pb dated achondrites

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The short-lived radionuclide 92Nb decays to 92Zr 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 abundabce of 92Nb (or 92Nb/93Nb) and its homogeneity in the solar system to be unambiguosly defined. Yet previously reported initial 92Nb/93Nb values range from ~10^-5 to >10^-3 [2-6], and remain to be further constrained. All but one of the previous studies estimated the initial 92Nb/93Nb 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 92Nb/93Nb and Zr isotopic compositions [2-5]. To evaluate the homogeneity of the initial 92Nb 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 92Nb/93Nb of the solar system.

To establish the solar system intial 92Nb/93Nb 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 92Zr 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 92Nb/93Nb is in the order of ~10^-5, consistent with the results of previous work using the internal isochron approach [6].

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