

The initial abundance and distribution of ^{92}Nb in the Solar System*Tsuayoshi Iizuka¹, Yi-Jen Lai², Waheed Akram², Yuri Amelin³, Maria Schönbachler²

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Niobium-92 is an extinct proton-rich nuclide, which decays to ^{92}Zr with a half-life of 37 Ma. Because Nb and Zr can fractionate from each other during partial melting of the mantle, mineral crystallization and metal-silicate separation, the Nb-Zr system can potentially be used to determine the timescales of silicate differentiation and core segregation for infant planets. In addition, the initial ^{92}Nb abundance in the Solar System provides constraints on the nucleosynthetic site(s) of p -nuclei (p - denotes proton-rich). These applications require the initial abundance and distribution of ^{92}Nb (expressed as $^{92}\text{Nb}/^{93}\text{Nb}$) in the Solar System to be defined. Yet previously reported initial $^{92}\text{Nb}/^{93}\text{Nb}$ values range from $\sim 10^{-5}$ to $>10^{-3}$ [1-6], 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, assuming that their source materials and bulk chondrites possessed identical initial $^{92}\text{Nb}/^{93}\text{Nb}$ and Zr isotopic compositions [1-5]. 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 Schönbachler et al. [6] applied the internal isochron approach to the chondrite Estacado and the mesosiderite Vaca Muerta, these meteorites include components of different origins and their formation ages are uncertain, which prohibits a precise determination of the solar initial ^{92}Nb abundance.

Here we present Nb-Zr data for mineral fractions from four unbrecciated meteorites, which originate from distinct parent bodies and whose U-Pb ages were precisely determined: the angrite NWA 4590, the eucrite Agoult and the ungrouped achondrites Ibitira. Our results show that the relative Nb-Zr isochron ages of the three meteorites are consistent with the time intervals obtained from the Pb-Pb chronometer for pyroxene and plagioclase, indicating that ^{92}Nb was homogeneously distributed among their source regions. The Nb-Zr and Pb-Pb data for NWA 4590 yield the most reliable and precise reference point for anchoring the Nb-Zr chronometer to the absolute timescale: an initial $^{92}\text{Nb}/^{93}\text{Nb}$ ratio of $(1.4 \pm 0.5) \times 10^{-5}$ at 4557.93 ± 0.36 Ma, which corresponds to a $^{92}\text{Nb}/^{93}\text{Nb}$ ratio of $(1.7 \pm 0.6) \times 10^{-5}$ at the time of the Solar System formation. On the basis of this new initial ratio, we demonstrate the capability of the Nb-Zr chronometer to date early Solar System objects including troilite and rutile, such as iron and stony-iron meteorites. Furthermore, we estimate a nucleosynthetic production ratio of ^{92}Nb to the p -nucleus ^{92}Mo between 0.0015 and 0.035. This production ratio, together with the solar abundances of other p -nuclei with similar masses, can be best explained if these light p -nuclei were primarily synthesized by photodisintegration reactions in Type Ia supernovae.

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Keywords: achondrite, early Solar System chronology, nucleosynthesis