Two distinct chondrule generations in Acfer 094 based on ^{26}Al-ages and oxygen isotope ratios

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Models of chondrule formation in the protoplanetary disk suggest a short formation interval for chondrules within a single chondrite group [1,2]. Indistinguishable $(^{26}Al/^{27}Al)_0$ values were found among most type-I (FeO-poor) chondrules in Acfer 094 (ungrouped C3.00) [3], corresponding to ^{26}Al-ages of ~2.3 Ma after CAI (hereafter: initial $^{26}Al/^{27}Al$ of 5.2×10^{-5}, [4]). However, one chondrule is significantly older (1.8 ±0.2 Ma). There is no obvious correlation between ages and oxygen isotope ratios ($\Delta^{17}O = \delta^{17}O–0.52\times\delta^{18}O$) [3].

We obtained ^{26}Al-^{26}Mg measurements of 7 type-II (FeO-rich) chondrules in Acfer 094 using a Cameca IMS 1280 that is equipped with a RF Plasma ion source [5,6]. We used O_2^- primary ions and analyzed plagioclase (4-5 µm spot size, 50 pA) and olivine/pyroxene (~7 µm, 1 nA) by using multi-collection electron multipliers [5] and Faraday cups [3], respectively. Six type-II chondrules have indistinguishable ^{26}Al-ages ranging from 2.3 +0.2/–0.2 to 2.7 +0.3/–0.2 Ma after CAI that also overlap with 9 out of 10 type-I chondrule data from [3]. This narrow age range agrees with our current understanding of chondrule formation and material mixing in the disk [1,2]. One type-II chondrule (G85) is older (1.8 ±0.2 Ma) than other type-II chondrules, but the age is similar to that of the oldest type-I chondrule fragment (G39) in Acfer 094 by [3]. Both have $\Delta^{17}O$ values of ~0‰ and show $\delta^{18}O$ and $\delta^{17}O$ values comparable to those of chondrules in ordinary chondrites. This suggests either (i) both chondrules formed in different disk regions with distinct oxygen isotope signatures followed by chondrule migration; or (ii) assuming no migration of chondrules, the oxygen isotope reservoir of the chondrule-forming region was variable with time.

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