SOLAR SYSTEM ISOTOPIC HETEROGENEITY FROM ^{53}Mn-^{53}Cr. S. J. McKibbin[1], T. R. Ireland[1] and Y. Amelin[1]. [1]Research School of Earth Sciences and Planetary Science Institute, Bldg 61 Mills Road Acton ACT 0200 Australia. Seann.McKibbin@anu.edu.au; Trevor.Ireland@anu.edu.au; Yuri.Amelin@anu.edu.au

Introduction: One of the requirements for the application of the short-lived nuclide chronometer ^{53}Mn (half-life of 3.7 My, anchored to angrite LEW86010) and short lived nuclides in general is that samples are derived from a common reservoir with a homogeneous distribution of the parent nuclide. Ideally, this should reflect the solar system abundances as a whole, but it requires that the solar nebula was well mixed after collapse of the molecular cloud. A more likely scenario is that the solar system is heterogeneous for many isotopes, but particular subsections (such as a specific parent body) will be homogeneous and suitable for short-lived nuclide chronometric studies. Short-lived radionuclide chronometry has been successfully applied and has produced useful information, but many assumptions about initial ratios and ages are involved because insufficient samples have had two or more chronometric systems applied to them. A few samples have been found to have isotope systematics that make them discordant in different systems, showing that a completely uniform distribution of short-lived nuclides in the solar system is not the case [1, 2].

Mn and Cr isotopic heterogeneity: A widespread and systematic chromium isotopic heterogeneity in the inner solar system was recognised by Lugmair and Shukolyukov [1] who found an apparent linear relationship between heliocentric distance and initial ^{53}Cr/^{52}Cr expressed in samples from Earth, Mars and those inferred to originate in the Asteroid Belt. With a few exceptions, meteorites from the Main-Belt have a common ^{53}Cr/^{52}Cr, which suggests that ^{53}Mn/^{55}Mn is homogeneous within the Asteroid Belt and the chronometric interpretation of ^{53}Mn/^{55}Mn for samples from this region is justified. An anomalous case is that of the enstatite chondrites: Shukolyukov and Lugmair [3] showed that they have Mn/Cr ratios that are chondritic, coupled with ^{53}Cr/^{52}Cr ratios that are lower than those of all other meteorites believed to come from the Asteroid Belt. Chondritic Mn/Cr shows that elemental fractionation has not suppressed the evolution of ^{53}Cr/^{52}Cr in enstatite chondrites, so either ^{53}Mn/^{55}Mn or ^{53}Cr/^{52}Cr must be heterogeneous in the solar nebula.

Simple explanations of the radial trend could involve a stellar-derived nucleosynthetic heterogeneity in ^{53}Cr/^{52}Cr, or heterogeneity in ^{53}Mn/^{55}Mn, with either ^{53}Cr or ^{53}Mn increasing with heliocentric distance. Shukolyukov and Lugmair [4] noted that ^{54}Cr anomalies were not observed in meteorites other than carbonaceous chondrites, so anomalies of ^{53}Cr were probably absent as well. Recent ^{54}Cr data does show heterogeneity in the solar system for this isotope [5], but it is not correlated with radial heliocentric distance. Elemental volatility leading to a depletion in Mn (and hence ^{53}Mn) must also be considered. Mn and Cr are approximately in the middle of the volatility range, with Cr being referred to as a *common element* (50% T_C 1296 K) and Mn a *moderately volatile element* (50% T_C 1158 K) [6]. Difference in volatilities is not a favoured explanation because the bulk compositions of the planets are not well known and few constraints can be put on such models.

Comparison with ^{26}Al and Pb-Pb timescales: Though CAIs are used as the reference point for ^{26}Al/^{27}Al, the ^{53}Mn/^{55}Mn ratios obtained from CAIs are inconsistent with the rest of the ^{53}Mn timescale [e.g. 7, 8] (Figure 1) and their generally anomalous isotopic composition suggests that they should not be used as anchors for short-lived nuclide chronometric systems. CAIs have average initial ^{53}Mn/^{55}Mn of 4.4×10^{-5} [9] although values as high as 14.8×10^{-5} have been reported [10]. As CAIs are known to have been isotopically disturbed, these values may represent a lower limit. Using the average ^{53}Mn/^{55}Mn value, this equates to a CAI age that is ~19 Ma older than LEW86010, implying a solar system timescale that is irreconcilably long. The Pb-Pb dates for Efremovka CAIs and LEW86010 [11, 12] give a much smaller age difference of 9.4 ±1.1 Ma, which is consistent with the ^{26}Al timescale, as well as theoretical models and astronomical observations of stellar system formation. The high initial ^{53}Mn/^{55}Mn may reflect an extreme early heterogeneity in the early solar system [1], which had been largely smoothed over by the time of chondrule formation.

Discrepancies between ^{26}Al and ^{53}Mn ages of some samples (D'Orbigny, Asuka 881394 and others; see [2] and Figure 1) are possibly expressions of solar system heterogeneity for these isotopes, or resolved differences in closure temperature. Placement of samples in the absolute timescale is also problematic, as Pb-Pb dates often have poor precision and different phases commonly return different ages. The most recent efforts at Pb-Pb dating of phases from D'Orbigny [13, 14] have yielded precise ages that are older than previously found, and make this meteorite discordant with the ^{26}Al-timescale. As such, a unique reconciliation of Pb-Pb, Al-Mg, and Mn-Cr isotope systematics is not possible with the data presently available.

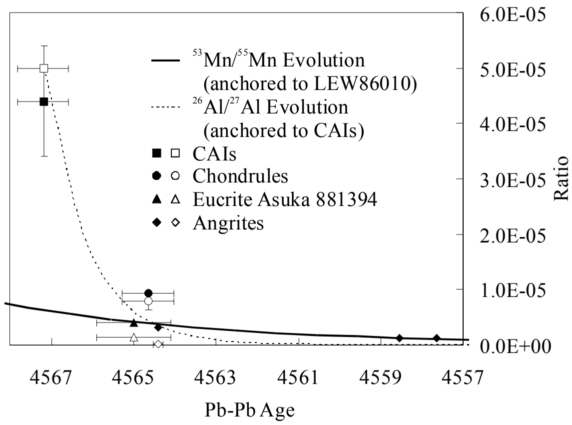

Figure 1. $^{53}Mn/^{55}Mn$ and $^{26}Al/^{27}Al$ in selected solar system objects. Filled symbols represent $^{53}Mn/^{55}Mn$, open symbols represent $^{26}Al/^{27}Al$. The evolution lines are calibrated to angrite LEW86010 and CAIs respectively. Data from [1, 9, 11, 14, 15, 16, 17, 18, 19, and 20].

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