^{53}Mn-^{53}Cr SYSTEMATICS OF THE BRACHINITE NWA 4882.

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Introduction: High-resolution timescales of planetary accretion and differentiation can be interrogated through the application of the ^{53}Mn-^{53}Cr relative chronometer. Manganese-53 has a short half-life ($t_{1/2}$ = 3.7 Ma) and decays to ^{53}Cr making it ideally suited to resolve time differences between objects forming within the first ~20 Ma of Solar Sytem history. The ^{53}Mn-^{53}Cr chronometer has been successfully applied by many studies in recent years (e.g., [1-5]). Additionally, the mass independent anomalies in ^{54}Cr can serve as a powerful genetic tracer of meteorite parent bodies (e.g., [6-8] and references therein).

In this study, we have made high precision analyses of the Mn-Cr isotope systematics in the brachinite Northwest Africa (NWA) 4882 as part of our broader investigations of the high resolution chronologies of primitive and ungrouped achondrites. The NWA 4882 brachinite is a coarse-grained dunite with a protogranular texture composed dominantly of olivine (Fa_{35}) with minor clinopyroxene ($Fs_{9.3}$ $Wo_{47.1}$), K-poor plagioclase ($An_{35.-37.2}$ $Or_{0.3-0.5}$), chromite, iron sulfide, and kamacite [9].

Methods: All sample handling, mineral separation and ion exchange chromatography procedures were performed under clean laboratory conditions in the Isotope Cosmochemistry and Geochronology Lab (ICGL) at Arizona State University (ASU). An interior fragment, free of any fusion crust was ultrasonicated in methanol and ultra pure H_2O before any further processing. A small chip (~51 mg) was broken off and digested using HNO_3:HF treatment, followed by dissolution of residual chromites in a Parr bomb, to obtain a dissolved whole rock (WR) sample. Another larger chip (~106 mg) was broken off the main mass and processed through a differential dissolution protocol that results in an olivine-rich fraction (Ol), a pyroxene- and plagioclase-rich silicate fraction (Sil) and a chromite fraction (Chr). A ~10% aliquot of each fraction was reserved for Mn/Cr ratios, while aliquots of the remaining fractions (each containing 5-30 μg of Cr) were processed for Cr purification. The Mn/Cr ratios were measured using a Thermo iCAP-Q ICPMS in the Keck Laboratory at ASU. The chemical separation procedures and mass spectrometrtic methods for Cr isotope analyses have been described previously [10,11]. Chromium isotope compositions have thus far been measured for the NWA 4882 WR, Chr and Ol fractions in high-resolution mode using ICGL's Thermo Finnigan *Neptune* multicollector ICPMS. The Cr isotopic data are reported relative to the NBS 979 standard after internal normalization to ^{50}Cr/^{52}Cr (=0.051859; [12]). Our external reproducibility is ±0.05 and ±0.10 (2SD) for ε^{53}Cr and ε^{54}Cr, respectively, based on repeat measurements (where each measurement utilized ~1 μg of Cr) of the NBS 979 Cr standard and terrestrial rock standards made over the course of this study.

Results and Discussion: The slope of the ^{53}Mn-^{53}Cr internal isochron for NWA 4882 corresponds to a ^{53}Mn/^{55}Mn ratio of $(2.75 \pm 0.37) \times 10^{-7}$ with the initial $\varepsilon^{53}Cr_i$ of 0.23 ± 0.04 (where $\varepsilon^{53}Cr = [(^{53}Cr/^{52}Cr_{sample}/^{53}Cr/^{52}Cr_{standard}) - 1] \times 10^4$) (MSWD = 3.4). Relative to the D'Orbigny angrite age anchor [2,13,14], a ^{53}Mn-^{53}Cr age of 4550.2 ± 0.8 Ma is calculated for NWA 4882. This age is significantly younger than the high precision Mn-Cr age we recently reported for the brachinite type meteorite, Brachina [11]. Furthermore, the initial $\varepsilon^{53}Cr_i$ for NWA 4882 is also resolvably higher than for Brachina [11]. Combined with its coarse-grained protogranular texture, this indicates that NWA 4882 is likely to have undergone re-heating and re-equilibration at 14.6 ± 0.8 Ma after the formation of Brachina. This suggests a protracted thermal history (most likely from impact heating) on the brachinite parent body that extended to well beyond the lifetime of ^{26}Al ($t_{1/2}$ = 0.705 Ma) in the early Solar System. Finally, the ε^{54}Cr value based on analyses of the WR (n=4) fraction is -0.45 ± 0.18 (2SE) ε units. This value is similar to that of other brachinites [8], suggestive of a common parent body for these primitive achondrites.

References: [1] Lugmair G. W. and Shukolyukov A. 1998. *Geochimica Cosmochimica Acta* 62:2863–2886. [2] Glavin D. P. et al. 2004. *Meteoritics & Planetary Science* 39:693-700. [3] Shukolyukov A. and Lugmair G. W. 2006. *Earth & Planetary Science Letters* 250:200-213. [4] Moynier F. et al. 2007. *The Astrophysical Journal* 671: L000–L000. [5] Trinquier A. et al. 2008. *Geochimica Cosmochimica Acta* 72:5146-5163. [6] Trinquier A. et al. 2007. *The Astrophysical Journal* 655:1179-1185. [7] Suguira N. and Fujiya W. 2014. *Meteoritics & Planetary Science* 49:772–787. [8] Sanborn M. et al. 2015. Abstract #2241. 46th Lunar & Planetary Science Conference. [9] Keil K. 2014. *Chemie der Erde* 74:311-329. [10] Mercer C. M. et al. 2015. Abstract #2920. 46th Lunar & Planetary Science Conference. [11] Dunlap D. R. et al. 2016. Absract #3055. 47th Lunar & Planetary Sciences Conference. [12] Shields W. R. et al. 1966. *Journal of Research NBS* 70A:193-197. [13] Amelin Y. 2008. *Geochimica Cosmochiimica Acta* 72:221-232. [14] Brennecka G. A. and Wadhwa M. 2012. *Proceedings of the National Academy of Sciences* 106:9299-9303.