MN – CR CHRONOLOGY OF EUCRITE CMS 04049 AND ANGRITE NWA 2999. A. Shukolyukov and G.W. Lugmair, Scripps Institution of Oceanography, University of California, San Diego, La Jolla CA 92093-0212, USA

This work is a continuation of our effort to improve our understanding of the earliest evolutionary period of the solar system. It extends the investigation of the ^{53}Mn-^{53}Cr systematics to two newly classified igneous meteorites: the eucrite CMS 04049 and the angrite NWA 2999.

CMS 04049. This is a recently classified meteorite and was described as "a beautiful unbrecciated eucrite" [1]. The thin section shows an unbrecciated intergrowth of coarse (up to 1 mm) pyroxene and plagioclase grains with a gabbroic texture. Pyroxene is exsolved to orthopyroxene ($Fs_{50}Wo_5$) and augite ($Fs_{28}Wo_{41}$) (Fe/Mn ~30) and plagioclase [1]. Our earlier studies of eucrites have shown that the ^{53}Mn-^{53}Cr isotope system is a useful tool for dating processes within the HED parent body such as timing of mantle fractionation and basaltic volcanism [2]. The unbrecciated eucrites may provide an opportunity to apply several short- and long-lived isotope systems to the same object in order to explore the feasibility of cross-calibration of the short-lived ^{53}Mn-^{53}Cr and ^{26}Al-^{26}Mg systems with U-Pb and, thus, refine the use of these systems as high-resolution chronometers. An example of such work was our collaborative study (with M. Wadhwa and Yu. Amelin) of the unbrecciated eucrite Asuka 881394 [3]. The results show that this meteorite is old (4564-4565 Ma) and indicate concordance of the ^{53}Mn-^{53}Cr and ^{26}Al-^{26}Mg systems but a slightly older U-Pb age, probably due to different closure temperatures. CMS 04049 may be a good candidate for investigations similar to those carried out on Asuka 881394. Here we present results on its ^{53}Mn-^{53}Cr system.

To obtain phases with different Mn/Cr ratios we applied our usual differential dissolution procedure that allows separating chromites from silicates. We have measured ^{53}Cr/^{52}Cr ratios and Mn and Cr abundances in chromite (Chr), silicates (Sil), and total rock (TR). As in the past, in order to achieve higher precision, we also have applied the second order fractionation correction to the ^{53}Cr/^{52}Cr data based on the ^{54}Cr/^{52}Cr ratios [2]. This procedure assumes no excesses or deficits of ^{54}Cr. However, it was shown recently [4], that bulk samples of some meteorite classes, including eucrites, posess relative deficits of ^{54}Cr. Our data for CMS 04049 also show a deficit of ~60 ppm. Here we present both the second order corrected data and the 'raw' data (no second order fractionation correction applied). The results are presented in Figure 1. From the slope of the isochron (second order corrected data) we calculate a ^{53}Mn/^{55}Mn ratio of (1.40±0.14) x 10^{-6} at the time of isotope closure. Using the angrite LEW 86010 as an absolute time marker [2] we obtain an absolute age of 4558.4±0.6 Ma. Thus, the age of the eucrite CMS 04049 is indistinguishable within uncertainties from that of LEW 86010 (4557.8±0.5 Ma, [5]) and of the eucrite Ibitira (~4557 Ma, [2]) and is clearly much younger than the ages of the eucrites Juvinas, Chervony Kut, and Asuka 881394 (4563-4565 Ma, [2,3]). Less precise "raw" data are presented in Figure 1 for comparison. The calculated ^{53}Mn/^{55}Mn ratios agree, however, the uncertainty in the "raw" data results is considerably larger. This demonstrates that the application of the second order fractionation correction is a useful tool for obtaining well-resolved ages even for samples with anomalous ^{54}Cr. Obviously, initial ^{53}Cr/^{52}Cr ratios can only be determined with "raw" data. However, the age calculations are based merely on the isochron slopes.

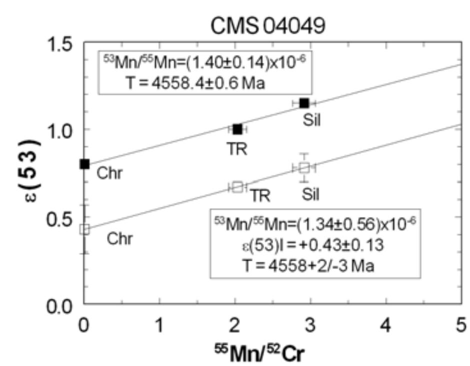

Fig.1 ^{53}Mn-^{53}Cr systematics in the eucrite CMS 04049. The filled symbols are second order corrected data, the open symbols are "raw" data (see text).

NWA 2999. The desert meteorite find NWA 2999 was recently classified as an angrite based on mineralogy, mineral chemistry and oxygen isotopes [6]. NWA 2999 has an overall plutonic, polygonal-granular texture (similar to Angra dos Reis and LEW 86010), but with distinctive large anorthite, spinel and recrystallized olivine porphyroclasts and discontinuous anorthite coronas around spinel grains, a mineral assemblage absent in other angrites [7].

The angrites are early equilibrated planetary differentiates that do not show signs of any later severe disturbance and, thus, are very suitable as time markers using various isotope systems. In the last year we reported [8] the $^{53}Mn/^{53}Cr$ systematics in bulk samples of four angrites, including NWA 2999. This work was an attempt to obtain constraints on the time of the angrite parent body differentiation. We found that the ^{53}Cr excesses are very well correlated with the respective $^{55}Mn/^{52}Cr$ ratios. The absence of a resolvable scatter of the data points from the isochron implies that the source reservoirs of all four meteorites were formed contemporaneously and that the Mn-Cr systems of the bulk samples of these meteorites remained closed since their formation. The last Mn/Cr fractionation and Cr isotope equilibration in the angrite parent body mantle occurred 4563.2±0.6 Ma ago. The first generation of angrites (D'Orbigny, Sahara 99555, Asuka 881371, and NWA 1670) has crystallized at the same time or shortly thereafter while the time of isotope closure in Angra dos Reis and LEW 86010 occurred ~5 Ma later.

Here we present the results of our investigation of the $^{53}Mn/^{53}Cr$ systematics in NWA2999. We have measured $^{53}Cr/^{52}Cr$ ratios and Mn and Cr abundances in chromite (Chr), silicates (Sil), and total rock (TR). Although the range in Mn/Cr is rather small the data points form a well-defined isochron (Figure 2). Its

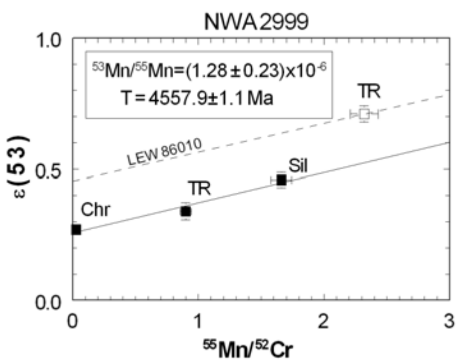

Fig. 2 ^{53}Mn-^{53}Cr systematics in the angrite NWA 2999. The isochron for LEW 86010 is given for comparison. The updated TR data point for LEW 86010 was obtained for the bulk angrite isochron [8]. The data are second order corrected (see text).

slope yields a $^{53}Mn/^{55}Mn$ ratio of $(1.28\pm0.23)\times10^{-6}$ at the time of isotope closure. A preliminary initial $^{53}Cr/^{52}Cr$ ratio obtained from the "raw" data is +4±10 ppm. Using the Pb-Pb age of the angrite LEW 86010 we calculate an age of 4557.9±1.1 Ma. Within uncertainties this age is indistinguishable from the ages of the texturally similar Angra dos Reis and LEW 86010 (4557.8±0.5 Ma). Thus, we observe two clusters in the angrite ages. The old cluster appears to be related to the primary activity on the angrite parent body while the "young" age cluster is likely to be the result of collisional disruption of the primary crust. Whether melting was induced by these later events or melt was still stored in the upper mantle is not clear. At any rate, most of the few young angrites studied so far appear to have maintained a closed system with the possible exception of NWA 2999, which has elevated Ni, Co, Ir, and Au contents that may imply the presence of an extraneous primitive meteoritic component [7].

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