

IN SEARCH OF ^{26}Mg EXCESS IN ACHONDRITES: FORENSICS OF THE HEAT SOURCE FOR THE PRIMORDIAL IGNEOUS DIFFERENTIATION. G. Huhlet¹, V. Debaille¹, J. Wimpenny², Q-Z. Yin², ¹Département des Sciences de la Terre et de l'Environnement, Université Libre de Bruxelles, CP 160/02, 50, Av. F.D. Roosevelt, 1050 Brussels, Belgium (ghuhlet@ulb.ac.be), ²Department of Geology, University of California, Davis, CA 95616, USA

Introduction: Short-lived radioactive isotopic systems such as ^{26}Al - ^{26}Mg are highly useful in studies of chronology due to their high timeframe resolution during the lifetime of their parent elements. As such, they can be considered as the most efficient chronometers for the first few million years (Ma) of the solar system history. The now extinct radionuclide ^{26}Al , decayed to ^{26}Mg with a half-life of $\sim 0.73 \times 10^6$ years [1]. This chronometer can thus date only the objects that formed during a period of ~ 5 Ma after the solar system formation. The major weakness of the short-lived radiochronometers is the fact that absolute chronology is no longer possible. The short-lived relative age must be anchored with long-lived absolute age in order to be used and compared. CAI's (calcium-aluminium inclusions) have been shown to represent the oldest objects in the solar system [2] and have been commonly used as age anchor. Other meteorites, that are younger than CAI's, such as angrites [3], have also been used to anchor the short-lived radiochronometers but do not always compare well with CAI age anchors [4].

In order to provide new anchor values and potentially reconcile different short-lived radiochronometers, we have investigated the usefulness of other younger objects as an anchor, such as iron meteorites and eucrites that may have been formed when ^{26}Al was still extant [2].

Iron meteorites are divided in two groups: magmatic and non-magmatic iron meteorites. The former are considered to be sampling metal cores of planetesimals formed by metal-silicate segregation followed by fractional crystallization of the metal melt [5, 6] and ejected from their parent body by impact. In contrast, non-magmatic (NM) iron meteorites have silicate inclusions formed by incomplete metal-silicate segregation induced by local impact melting on a chondritic parent body. We chose the second group because of the presence of silicate inclusions, and also because some of them are expected to be sufficiently old to have contained ^{26}Al .

Eucrite's and diogenite's are igneous rock belonging to a magmatic meteorite series: Howardite-Eucrite-Diogenite (HED), widely believed to have come from the asteroid 4-Vesta. Eucrite's are basaltic achondrites and are among the oldest known volcanic rocks in the solar system [7]. They resulted from early magmatic activity on 4-Vesta [7, 8]. Recent studies have demonstrated an excess in ^{26}Mg in some eucrites [9-11] and

suggested the presence of ^{26}Al at the time of their formation. On the other hand, diogenites are orthopyroxenites formed as a cumulate before the fractional crystallization of magma that probably formed eucrites [12]. However, a previous study [13] has shown that the parental magma of the diogenites could have been intruded and contaminated by eucrite crust. The diogenite crystallization age is not well defined but may be either contemporaneous or alternatively younger than eucrites [13].

In this study, Al-Mg systematics have been investigated in different achondrites: two eucrites (Millbillillie - Camel Donga), three diogenites (Johnstown - Bilanga - Tatahouine) and one NM iron meteorites (Mont Dieu IIE). The results will be discussed in order to determine which achondrite could represent a lower limit of the ^{26}Al - ^{26}Mg isotopic system chronology in order to propose the lowest anchor point using Pb-Pb dating.

Analytical technique: All the preparation and chemical procedure were realized in clean laboratory at ULB. $\sim 50\text{mg}$ of each sample was crushed in an agate mortar. We proceeded with mineral separation only for the Camel Donga eucrite. The pyroxene and plagioclase separates were obtained from density separation followed by magnetic separation using a Frantz magnetic separator. All samples and minerals fractions (pyroxene fraction, px; and plagioclase fraction, pl) were dissolved with an HNO_3/HF mixture (2: 2) following by two steps in concentrated HNO_3 . Mg was separated using cation-exchange resin (Bio Rad AG[®]50W-X12, 200 – 400 mesh). The elution and sample collect were performed with 1N HNO_3 . The column chemistry was repeated three times in order to ensure for unsure a perfect separation of Mg and limited interferences with matrix.

Mg isotopes were measured on ULB MC-ICP-MS Nu-plasma. Samples were introduced in 0.05N HNO_3 using a DSM-100 desolvating nebulizer. Measurements were performed in medium resolution in order to avoid the possible isobaric interferences ($^{12}\text{C}^{14}\text{N}$) [1]. We performed three sessions of measurement. Each sample was measured two times during each session. Terrestrial standard BCR-2 was measured between each sample with a $\delta^{26}\text{Mg}^*$ value of 0.012 ± 0.013 .

Result and discussion: The preliminary results obtained for the different meteorites are shown in Figure 1. Two achondrites indicate a small $^{26}\text{Mg}^*$ excess: one

whole rock (Millbillillie) and two mineral fractions of plagioclases and pyroxene from Camel Donga. The errors bars need to be reduced with further repeat measurements.

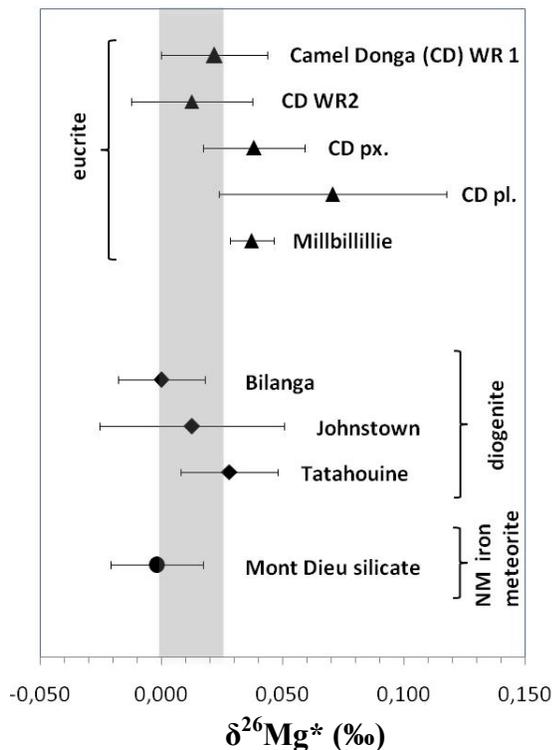


Figure 1: $\delta^{26}\text{Mg}^*$ measurement in the different meteorites analyze. Grey zone correspond of the terrestrial standard (BCR-2 range value). All samples value comprise in this range do not have any $\delta^{26}\text{Mg}^*$ excess. Errors show in this diagram corresponds to standard error ($s_e = s_d/\sqrt{n}$). The $\delta^{26}\text{Mg}^*$ is reported relative to the DSM-3 standard.

For Camel Donga eucrite, the $^{26}\text{Mg}^*$ excess is only detectable in the mineral separation fraction (CD pl.: $\delta^{26}\text{Mg}^* = 0.071 \pm 0.047$; CD px.: $\delta^{26}\text{Mg}^* = 0.038 \pm 0.021$). Inversely, Millbillillie eucrite shows this excess on WR analyses (Mi WR: $\delta^{26}\text{Mg}^* = 0.037 \pm 0.009$). These results are consistent with previous studies proposing that the eucrites contain a $^{26}\text{Mg}^*$ excess and so much have formed during extant ^{26}Al [11]. On the other hand, the marginal anomaly observed in Tatahouine (Ta WR: $\delta^{26}\text{Mg}^* = 0.028 \sim 0.020$) may indicate that some diogenites could have some ^{26}Al and so could be contemporaneous to eucrites [13]. However, this anomaly is very small and not resolved from the others observed in eucrites and associated with a large error, thus needs to be confirmed with more future measurements. When considering the analytical errors, only Millbillillie shows a fully resolvable $^{26}\text{Mg}^*$ excess.

In the case of NM iron meteorite Mont Dieu, the results show no anomaly in ^{26}Mg , indicating that im-

part melting related to those samples cannot be date with ^{26}Al - ^{26}Mg chronometer.

Conclusion: The preliminary results presented here indicate that eucrites could represent the very lower limit of ^{26}Al - ^{26}Mg isotopic system chronology. However, the resolvable $^{26}\text{Mg}^*$ excess is small, and improvement of analytical techniques and further analyses are required in order to validate our results.

References:[1] Jacobsen B., et al. (2008) *EPSL*, 272, 353-364. [2] Bouvier A., et al. (2010) *Nat Geosci*, 3, 637-641. [3] Wadhwa M., et al. (2009) *GCA*, 73, 5189-5201. [4] Scott R.D. (2007) *Annu. Rev. Earth Planetary Sci.*, 35, 577-620. [5] Mittlefehldt D.W. (2004) in *Treatise of Geochemistry*, voll, 291-324. [6] Markowski A., et al. (2006) *EPSL*, 242, 1-15. [7] Lugmair G.W., et al. (1998) *GCA*, 62, 2863-2886. [8] Wadhwa M., et al. (2004) *LPSC*, XXXV, #1843. [9] Srinivasan G., et al. (1999) *Science*, 284, 1348-1350. [10] Bizzarro M., et al. (2005) *Astrophys J*, 632, L41-L44. [11] Schiller M., et al. (2010) *GCA*, 74, 4844-4864. [12] Ruzicka A., et al. (1997) *MAPS*, 32, 825-840. [13] Barrat J.A., et al. (2010) *GCA*, 74, 6218-6231.