**Renewed Search for Evidence of $^{26}$Al as the Heat Source for Igneous Differentiation in Achondrites.** G. Hublet[1], V. Debaille[1], J. Wimpenny[2], Q-Z. Yin[2], [1]Département des Sciences de la Terre et de l'Environnement, Université Libre de Bruxelles, CP 160/02, 50, Av. F.D. Roosevelt, 1050 Brussels, Belgium (ghublet@ulb.ac.be), [2]Department of Geology, University of California, One Shields Avenue, Davis, CA 95616, USA

**Introduction:**

Short-lived radioactive isotopic systems such as $^{26}$Al-$^{26}$Mg are powerful to study the chronology of the early solar system 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 ~0.73 × $10^6$ 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 such as the $^{206}$Pb-$^{207}$Pb chronology in order to be used and compared. CAI's (calcium-aluminum 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 anchor, such as iron meteorites and eucrites that may have been formed when $^{26}$Al was still extant [2].

Eucrites and diogenites are igneous rocks belonging to a magmatic meteorite series: Howardite-Eucrite-Diogenite (HED) widely believed to result from early magmatic activity on 4-Vesta [5, 6]. Eucrites are basaltic achondrites and are among the oldest known volcanic rocks in the solar system [5]. Recent studies have demonstrated an excess in $^{26}$Mg in some eucrites [7-9] and suggested the presence of $^{26}$Al at the time of their formation. On the other hand, diogenites are orthopyroxenites formed as cumulates before the fractional crystallization of magma that probably formed eucrites [10] and could be contemporaneous than eucrites.

Ureilites are also differentiated achondrites. The lack of basaltic components suggest that ureilites are partial melting residues [11] or ultramafic igneous cumulates of chondritic precursors [12]. These precursors are probably carbonaceous chondrites because these ultramafic rocks share common characteristics with, such as their isotopic oxygen compositions, and high C-content (up to 5%) [13] Previous studies indicated an extremely early formation age, probably <5 Ma after the formation of the Solar system [14, 15].

Iron meteorites are divided in two groups: magmatic and non-magmatic iron meteorites. In the present study, only non-magmatic (NM) iron meteorites have been considered, because some of them are expected to be sufficiently old to have contained $^{26}$Al [16], but also because they have some silicate inclusions. These silicate inclusions are formed by incomplete metal-silicate segregation induced by local impact melting on a chondritic parent body.

In this study, Al-Mg systematics has been investigated in different achondrites: seven eucrites, three diogenites, five ureilites and two NM iron meteorites. 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 procedures were realized in clean laboratory at ULB. ~50mg of each sample were crushed in an agate mortar. Mineral separation was performed only for the Camel Donga eucrite. The pyroxene and plagioclase separates were obtained from density separation using heavy liquids followed by magnetic separation using a Frantz magnetic separator. All bulk rocks samples and minerals fractions (pyroxene fraction, px; and plagioclase fraction, pl) were dissolved with an $HNO_3$/HF mixture (1: 1) following by two steps in concentrated $HNO_3$ and one step in concentrated HCl. For ureilite samples, a step with $H_2O_2$/$HNO_3$ mixture (1: 4) has also been realized to remove organic compounds. 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 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 DSN-100 desolvating nebulizer. Measurements were performed in medium resolution in order to avoid the possible isobaric interferences ($^{12}C^{14}N$) [1]. We performed three sessions of measurement for the two eucrites (Camel Donga, Millbillillie), three diogenites (Bilanga, Tatahouine and Johnstown) and the Mont Dieu NM iron meteorite (IIE). Each sample was measured two times during each session. The instrumental mass bias was corrected by standard-bracketing with DSM-3 standard. Terrestrial standard BCR-2 was measured between each sample with a $\delta^{26}$Mg* value of 0.012±0.013 to control the accuracy of the measurements.

**Result and discussion:**

The preliminary results obtained for the first set of 2 eucrites, 3 diogenites and 1 NM iron meteorites are shown in Figure 1. Two achondrites indicate a small $^{26}$Mg* access: one whole rock (Millbillillie) and two mineral fractions of plagioclases and pyroxene from Camel Donga. Further repeated measurements will help to improve the precision.

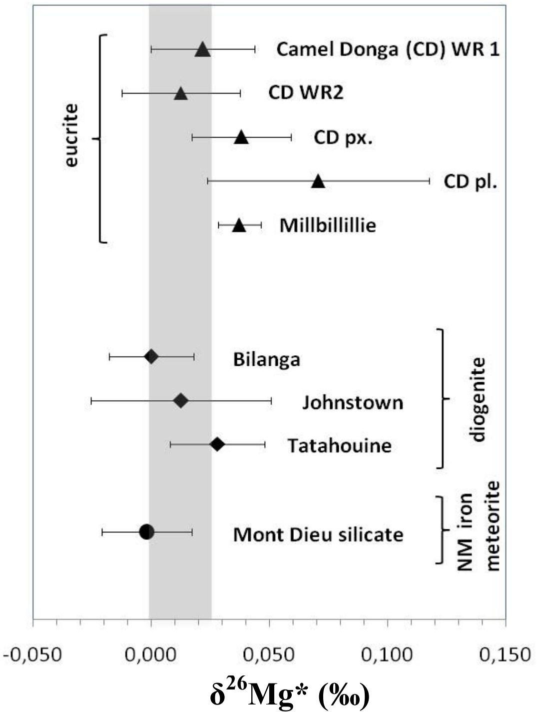

Figure 1: $\delta^{26}$Mg* measurement in the different meteorites analyze. Grey zone correspond of the terrestrial standard (BCR-2 range value). All samples value comprise in this range do not have any $\delta^{26}$Mg* excess. Errors show in this diagram corresponds to standard error ($s_e = s_d/\sqrt{n}$).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

For Camel Donga eucrite, the $^{26}$Mg* excess is only detectable in the mineral separation fraction (CD pl.: $\delta^{26}$Mg* = 0.071±0.047 ; CD px. : $\delta^{26}$Mg* = 0.038±0.021). Inversely, Millbillillie eucrite shows this excess on WR analyses (Mi WR: $\delta^{26}$Mg* 0.037±0.009). These results are consistent with previous studies proposing that the eucrites contain a $^{26}$Mg* excess and so must have formed during extant $^{26}$Al [9]. On the other hand, the marginal anomaly observed in Tatahouine (Ta WR: $\delta^{26}$Mg* 0.028~0.020) may indicate that some diogenites could have known some $^{26}$Al and so could be contemporaneous to eucrites [17]. However, this anomaly is very small and not resolved from the others observed in eucrites because of a large error, and thus needs to be confirmed with more future measurements. When considering the analytical errors, only Millbillillie shows a fully resolvable $^{26}$Mg* excess.

In the case of NM iron meteorite Mont Dieu, the results show no anomaly in $^{26}$Mg, indicating that impact melting related to those samples cannot be dated with $^{26}$Al-$^{26}$Mg chronometer.

The remaining eucrites and ureilites will be measured in the next future.

**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 $^{26}$Mg* excess is small, and improvement of analytical techniques and further analyses are required in order to validate our results.

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