Constraining the early history of Solar system events from ^{26}Al-^{26}Mg isotope systematics in CAIs

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Introduction: The earliest formed Solar system solids- **C**alcium, **A**luminum,-rich **I**nclusions (**CAIs**) with absolute age of ~4568 Myrs [1,2] are the most appropriate samples to study physico-chemical conditions, events, processes, and their evolution in temporal and spatial scale during the earliest stage of Solar system. The development of high precision analytical techniques now allow to discern difference at levels of sub permil and time durations of ≤100kyrs. These developments of high precision analytical techniques allows to investigate the veracity of hitherto assumptions and understand and provide stringent constraints of the conditions during the early Solar system [3-10]. To constrain the physico-chemical conditions and their evolution during the neonatal stage of Solar system a systematics high precision Al-Mg isotope systematics study in a suite of CAIs was carried with the following specific objectives. Obtain precise time of formation and initial $\delta^{26}Mg^*$ in various types of CAIs to address:

1)Spatial and temporal scale of homogeneous distribution of isotopes (at least Mg and Al isotopes and by inference others elements) in early Solar system,

2)Elucidate existence (or non existence) of a single epoch leading to formation of a particular (or all) type(s) of CAIs,

3)Existence of epochs or continuum of high temperature events (condensation, reheating, shock waves) leading to constraints on their casuals'.

Sample and Analytical procedure:

Different types of CAIs (A, B, igneous, fine grained; Fig. 2) present in some of the least altered meteorite sample Efremovka,Vigarano and Axtell were analysed using secondary ion mass spectrometer (SIMS) 1270 at CRPG, Nancy. A ~ 20nA O^- primary beam accelerated at 13kV was used to obtain secondary positively charged ions of ^{24}Mg, ^{25}Mg, ^{26}Mg, and ^{27}Al at a mass resolution of 2500 for isotopic analysis in a multi-collection mode using FCs' at L'2, C, H1 and H'2. The sample was kept at 10kV while an energy window of 50eV was used. The hydride contribution were suppressed by keeping vacuum > $3x10^{-9}$. Terrestrial standards of Burma spinel, MORB, San Carlos olivine, and synthetic glass standards (Bacati, Px, An) with composition similar to analogous minerals in CAIs were analyzed at regular intervals to ascertain instrumental mass fractionation during the analysis of meteoritic sample. The instrumental mass fractionation (1/β) varied between 0.511 -0.523 from one analytical session to another but was mostly in a narrow range during a given session (Fig. 1). The external reproducibility on $\delta^{26}Mg$ was ~0.018 ‰ ($\sigma/\sqrt{n}$; n~12).

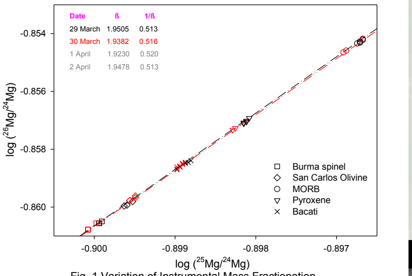

Fig. 1 Variation of Instrumental Mass Fractionation

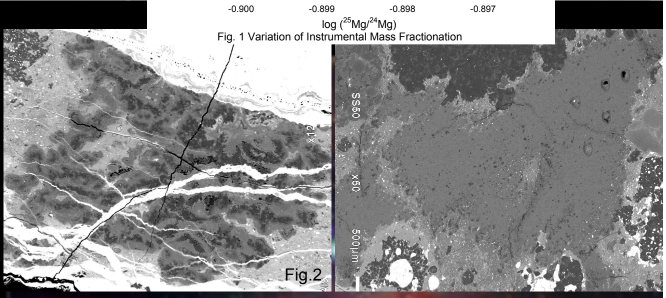

Fig.2

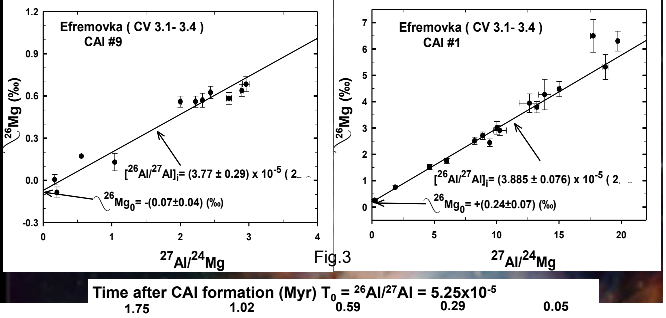

Fig.3

Results:

Initial $\delta^{26}Mg$ and $^{26}Al/^{27}Al$ obtained for 10 CAIs from Vigarano; 5 CAIs, 1 AOA, and a chondrule from Efremovka and another CAI from Axtell are shown in Fig.3 & 4. Data obtained suggest that the analysed CAIs formed or were last melted during different high temperature events during the initial time period ranging upto ~1.5Myr. This time period is considerably longer than class 0 and I stage. Considering homogeneous distribution of isotopes during the early solar system, 2 CAIs (#Efk9, Axt#1) show $\delta^{26}Mg^*$ indicating condensation ~0.4Myr later than fiducial t_0 when $^{26}Al/^{27}Al$ was $5.25x10^{-5}$. The data obtained can be also interpreted to suggest that a significant level of heterogeneity >10% existed during the earliest stage .

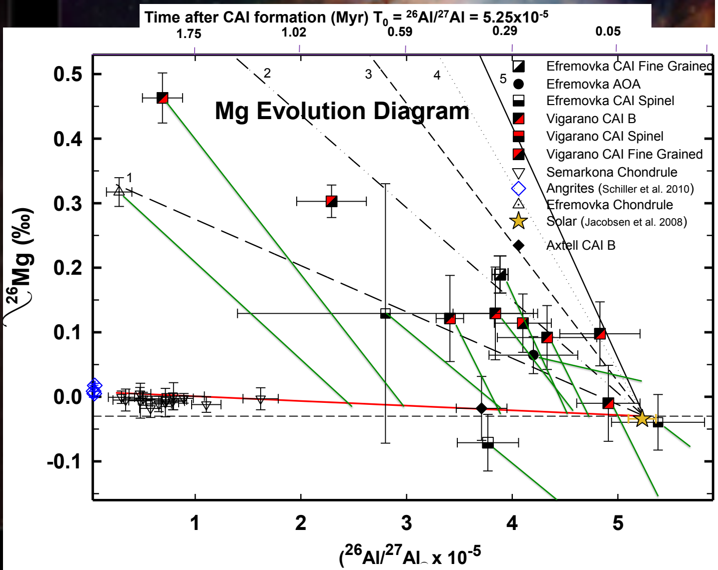

Fig.4

[1] Bouvier & Wadhwa (2010) *Nature geo.* **3**, 637-641. [2] Amelin et al. (2010) *EPSL* **300**, 343-350. [3]Villeneuve et al. (2009) *Science* **325**, 985-8. [4] Kita et al. (2010) *LPSC 41* 2154. [5] Davis et al. (2010) *LPSC 41* 2496. [6] MacPherson et al. (2010) *ApJ* **711**, L117-121. [7] Jacobsen et al. (2008) *EPSL* **272**, 353-364. [8] Bizzarro et al., (2011) *J. Anal. At. Spectrom.* **26**, 565-577. [9] Larsen K. K. et al. (2011) *Ap. J.* **735**, 37-41. [10] Schiller M. et al. (2011) GCA 74, 4844-64.