PETROGRAPHIC AND HIGH PRECISION Al-Mg ISOTOPE SYSTEMATICS OF A TYPE B CAI FROM VIGARANO: R. K. Mishra[1], M. Chaussidon[1], and Tu-Han Luu[1], Centre de Recherches Pétrographiques et Géochimiques, CRPG - Nancy Université - CNRS, UPR 2300, 15 rue Notre Dame des Pauvres, BP 20, 54501Vandoeuvre les Nancy, France (ritesh@crpg.cnrs-nancy.fr).

Introduction: Calcium-, Aluminium-rich inclusions (CAIs) are the earliest formed objects in the solar system: they have absolute ages in between 4568.2±0.3 Ma [1] and 4567.2±0.5 Ma [2]. These data indicate that the duration of CAIs formation lasted at maximum a few (~2 Myr) million years. Short- lived, now extinct, nuclides (SLNs) studies, particularly with half life less than nine million years, have long been used to infer the events and their duration during the earliest history of the solar system [3]. Recent development of analytical techniques now allow high-precision Mg isotopic measurements below the per mil level, either in-situ using secondary ion mass spectrometers [4] or in bulk (or semi-bulk) using MC-ICPMS. A major outcome of these recent high-precision measurements has been the discovery that condensation and crystallization of CAIs occurred in less than a few 10 kyr. This comes from the fact that the $^{26}Al/^{27}Al$ ratios determined either from a bulk CAIs isochron ($5.23\pm0.13\times10^{-5}$ [5]) or from a mineral isochron within a CAI ($5.27\pm0.17\times10^{-5}$ [6]) are identical within errors. Such a small range of $\approx \pm0.2\times10^{-5}$ for $^{26}Al/^{27}Al$ would correspond to a duration of ≈ ± 40 kyr in the hypothesis of an homogeneous distribution of ^{26}Al in the inner accretion disk as suggested by chondrules Mg isotopic compositions [3]. Thus, these high precision measurements offer the opportunity to delineate events occurring on the time scales of few ten to hundred thousand years. However, the existing high-precision data are still much too scarce for a general scenario to be firmly established : (i) variations apparently greater than the reported error bars do exist for absolute U/Pb ages between different CAIs (this might be due to variations in the U isotopic ratio), (ii) bulk ^{26}Al isochrons are restricted to CV CAIs, (iii) only very few high precision ^{26}Al mineral isochrons have been determined, (iv) the distribution of radiogenic ^{26}Mg excesses in CAIs is quite complex indicative of i.e. either of older ages (supracanonic $^{26}Al/^{27}Al$) ratios or of secondary perturbations due to reheating/remelting events. High precision measurements on different types of CAIs from different meteorites are necessary to delineate the complex history of CAIs. Such high-precision measurement necessitate the identification of unaltered minerals in pristine CAIs and an appropriate consideration of other analytical factors that could significantly affect the inference of initial $^{26}Al/^{27}Al$. Here we present the first results (for a Vigarano CAI) of an ongoing work aimed at better constraining the Al-Mg systematics of CAIs to decipher their duration of formation and their complex history.

Petrographic studies: Petrographic studies of thin sections of two of the least altered CV meteorites, Vigarano (3.1-3.4) and Efremovka (3.1-3.4) were carried out to identify refractory objects in them. About eight CAIs and four Amoeboid olivine Aggregates (AOAs) in Vigarano and nine CAIs and eight AOAs in Efremovka have been identified and some of these refractory objects have been quantitatively analysed for identification of mineral phases present in them. The CAIs found in these sections are representative of the typical types found in such CV chondrites and consist of both the fine and coarse grained as well as non- igneous to igneous types. Scanning electron microscope (SEM JEOL 6510) and Electron probe microanalyser (Cameca SX 100) were utilised for obtaining the backscattered secondary electron images, X-ray elemental distribution profile and characterisation of various mineral phases. Back scattered image of the Vigarano CAI analysed for Al-Mg isotope analysis reported here is shown in Fig.1. The inset in Fig. 1 shows the combined mosaic of Al-,Mg, and Ca elemental profile of a region within it. The CAI has typical Wark-Lovering rims and rather homogenous in distribution of Al, Mg, and Ca in it, except for in the rims. The CAI is consisting primarily of melilite with spinel dispersed in it. The spinels show a marginal trend of increase in size towards the core of CAIs.

Analytical procedure: Melilite and spinels, the predominant minerals constituting the CAI were analysed. A ~20nA, primary O^- beam accelerated at 13kV from SIMS (Cameca 1280 HR2) was utilised to obtain a spot size of ~35x25 µm to generate secondary ions of Al and isotopes of Mg. The multi-collection mode utilising faraday cup at L'2, C, H'1, and H'2 were used for obtaining a high precision data in the analysis. Terrestrial standards (olivine, spinel, Morb, pyroxene) in a given session give $^{26}Mg^*$ within ±0.04‰ (1σ error, n=20)

Result and discussion: Melilite present in the various regions of this CAI were analysed and data are shown in Fig 2. $^{27}Al/^{24}Mg$ show a range from 2 to 25. The data do not define a single ^{26}Al isochron for the CAI. A regression through data from melilites primarily from the core give a $^{26}Al/^{27}Al$ slope of 7.5 (±2.5) $\times10^{-5}$ (Fig. 2) much higher than the canonical value $(5.23\pm0.13)\times10^{-5}$ of bulk CAIs. The melilites present in the boundary show much lower ^{26}Mg excesses and large scatter. Spinels present primarily in the core were also analysed (Fig. 2) and are consistent with an initial $^{26}Al/^{27}Al$ of 5.3 (±0.4) $\times10^{-5}$. A clear disturbance of Al-Mg systematics is thus present in melilites of this CAI while spinels in the core seem to have retained the pristine isotopic records. The perturbation seen in melilite could be due to post-crystallisation disturbance (Al-Mg diffusive exchange, post^{26}Al decay?). High resolution mapping of Mg, Al in melilites surrounding spinels will be done to look for evidence of diffusive exchange. Other CAIs from Vigarano and Efremovka will be analysed for Al-Mg systematics.

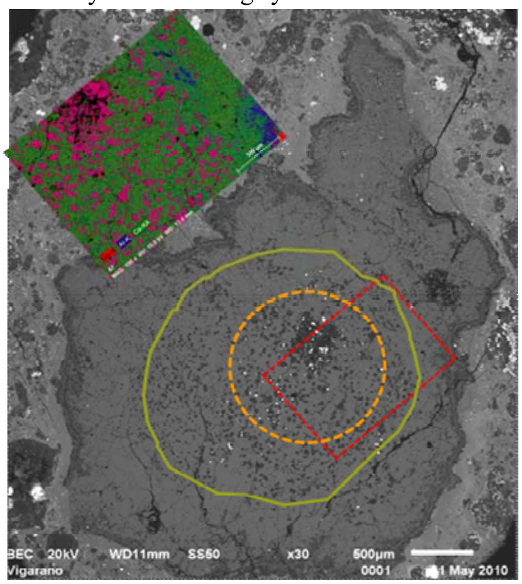

Fig. 1. BSE image of type B Vigarano CAI #1; A combined elemental mosaic of the inset rectangle Al (blue)-Mg(Red)-Ca(green) is shown in the upper left corner. The dashed circle represents the area that has been considered as the core which is rich in spinels, while the minerals present in the region outside the solid line (devoid of spinels) have been considered as minerals present in the boundary of CAI.

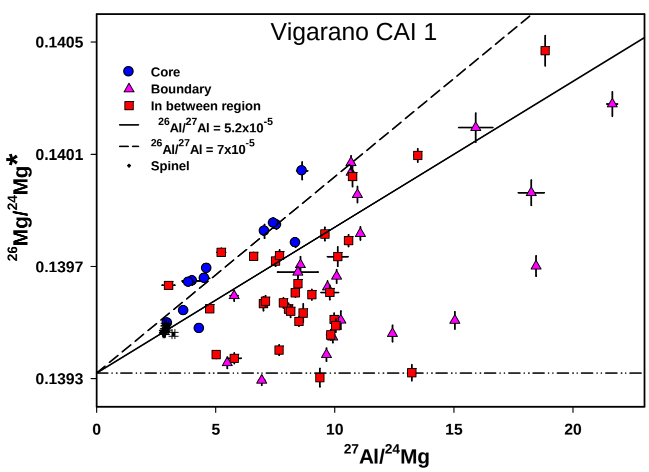

Fig. 2. Al-Mg isochron type diagram for Vigarano CAI: Melilites present in various regions are identified by different symbols. The error bars shown are 1σ. Spinels are from the core.

References:

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