IN-SITU ^{26}Al-^{26}Mg DATING OF SINGLE CHONDRULES BY SECONDARY ION MASS SPECTROMETRY.

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Introduction: In-situ Mg isotope measurements of olivine, pyroxene and mesostasis in chondrules from unequilibrated chondrites allow to determine higly-precise crystallization ages of individual chondrules that provide, based on the decay of the short-lived ^{26}Al ($t_{1/2}$ = 0.717 Ma) to ^{26}Mg, important information on the time and duration of chondrule formation. Published ^{26}Al-^{26}Mg data point to peaks in chondrule formation between c. 1.5 and 3.0 My after CAIs [e.g. 1, 2], whereas absolute U-corrected Pb-Pb ages suggest chondrule formation already starting contemponaeously with CAI and lasting for c. 3 My [e.g. 3]. The comparison of ^{26}Al-^{26}Mg datasets derived from different laboratories within the last decades is not straightforward due to varying analytical setups and individual data correction procedures to account for instrumental and intrinsic mass fractionation. This study aims to extend the already existing ^{26}Al-^{26}Mg data set of chondrule ages by high-precision Mg isotope measurements for a comprehensive suite of chondrules from carbonaceous and ordinary chondrites. Some key questions of chondrule formation that are controversly discussed in the community and that will be addressed are e.g.: Are all chondrules in one meteorite class identical or do they show a spread in ages? Do systematic age differences exist among different chondrule types?

Samples: The study comprises a set of some of the least metamorphosed carbonaceous as well as ordinary chondrites (NWA 779 (CV3), NWA 8276 (L3.00), NWA 5206 (LL3.05)) some of which were kindly provided by NASA from their collection of Antarctic Meteorites for this project (MET 00452 (L(LL)3.05), MET 96503 (L3.10), QUE 97008 (L3.05), MET 00526 (L(LL)3.05), DOM 08006 (CO3)).

Method: Samples are measured using the Cameca IMS 1280-HR large radius secondary ion microprobe at the SwissSIMS laboratory, University of Lausanne. Primary minerals yielding high Al/Mg ratios (e.g. plagioclase) are relatively rare and tiny in chondrules whereas suitably sized glassy mesostasis is more commonly found but tends to have lower Al/Mg ratios. Thus we set up a routine for multicollection Mg isotope measurements in olivine, pyroxene and mesostasis following in parts previously published analytical protocols [4, 5] in order to derive age information from a high number of chondrules applying the identical analytical procedure and thus minimizing methodological bias on the results. To ensure high precision on the measured isotopic ratios even for the mesostasis, the samples are sputtered with a primary beam intensity (13 kV, O^-) of about 28 nA, resulting in >1.3 x 10^9 cps for ^{24}Mg in olivine (Mg#90) with a typical beam diameter <40 µm, resulting in internal counting statistic errors on δ^{25}Mg of 0.02 to 0.06‰ (2 s.e.).

Discussion: Especially for low Al/Mg material improper correction for instrumental mass fractionation (IMF) of Mg isotopes during SIMS analysis can impact on the accuracy and precision of resulting isochrons. Additionally, some chondrules might entail natural mass fractionation at relevant levels. However, separate correction for instrumental and natural mass fractionation at high precision is only possible, if the effect of instrumental mass fractionation $(\alpha^{25/24})_{inst}$ can be quantified using intrinsic parameters of the measurement itself (e.g. count rates on the isotopes, primary beam intensity, etc.), a task that might be possible for olivine Fo#>70 but challenging for e.g. glass. Here we report the procedure we apply to correct for IMF using instrumental mass fractionation laws determined during each session by measuring a set of terrestrial reference materials (olivine and pyroxene of different composition, synthetic and natural glass standards), and discuss the aspect of natural mass fractionation correction.

After correction for mass fractionation eight different terrestrial standards measured during one analytical session show, consistent with their terrestrial origin, no deficit or excess ^{26}Mg with an average δ^{26}Mg* (i.e. radiogenic ^{26}Mg) of -0.001 (±0.008, (2 s.e.), n=30)‰. Measurements of minerals and mesostastis in individual chondrules from ordinary chondrites reveal resolvable radiogenic ^{26}Mg for most of the samples and well defined isochrons.

References:

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