CA-ISOTOPE INVESTIGATION OF SILICATE STARDUST. J. Leitner and P. Hoppe, Max Planck Institute for Chemistry, Hahn-Meitner-Weg 1, 55128 Mainz, Germany (jan.leitner@mpic.de).

Introduction: Isotopically anomalous dust grains that formed in the outflows of evolved stars and in the ejecta of stellar explosions [1] are a minor, but important component of primitive solar system materials. Silicates are the most abundant type of "presolar" dust available for single grain analyses [2], with characteristic sizes of ~150 nm [3]. Based on their O-isotopic compositions, most (>99%) presolar silicates and oxides are divided into four distinct groups [4], with low-mass asymptotic giant branch (AGB) stars as main stellar sources, followed by core-collapse supernovae (CCSNe). Additional contributions are evident for intermediate-mass (4–8 M⊙) AGB stars undergoing hot bottom burning (HBB), post-AGB stars, and novae [e.g., 1,5]. Recent investigations of Mg isotopes in presolar silicates (Fig. 1) showed that a significant fraction of the Group 1 and 2 grains, previously assumed to have AGB star origins, display large ^{25}Mg-excesses, as well as significant ^{25}Mg-depletions, and/or ^{26}Mg-excesses (the latter *not* caused by ^{26}Al decay). These Mg-isotopic signatures are incompatible with a low-mass AGB star origin, indicating supernovae and, in some cases, intermediate-mass AGB stars or Super-AGB-stars as their stellar sources [6–10]. Here, we report Ca-isotopic data for seven Group 1 presolar silicate grains and one Group 2 silicate grain.

Samples & Experimental: The Ca-isotopic compositions (^{42}Ca/^{40}Ca and ^{44}Ca/^{40}Ca) of presolar silicates previously identified during standard O-isotopic mapping of the CR chondrites Meteorite Hills (MET) 00426, Elephant Moraine (EET) 92161, Northwest Africa (NWA) 6957, and the ordinary chondrite NWA 7540 (LL3.15) were conducted with the Hyperion RF plasma O ion source of the MPIC Cameca NanoSIMS 50. A focused O^- beam (<100 nm, ~0.5 pA) was rastered over 2×2 to 3×3 µm^2-sized areas around the presolar silicate grains, and secondary ion images of $^{24}Mg^+$, $^{40,42,44}Ca^+$, and $^{48}Ti^+$ were acquired simultaneously. A terrestrial perovskite standard was used for Ca isotope normalization. Measured ^{48}Ti/^{40}Ca ratios were corrected by using the relative sensitivity factor $\varepsilon(Ti^+)/\varepsilon(Ca^+) = 0.51$ from [13].

Results: One of the "normal" Group 1 (i.e., Mg isotopes plot along the Galactic chemical evolution – GCE – line, Fig. 1) silicate grains, NWA7540_2_12, shows no significant deviation from the terrestrial value (δ^{42}Ca = –106±117 ‰, δ^{44}Ca = 86±72 ‰), while the other, NWA7540_3A_3, is slightly enriched in ^{44}Ca (δ^{42}Ca = –21±18 ‰, δ^{44}Ca = 33±10 ‰). Two of the ^{25}Mg-rich Group 1 silicate grains

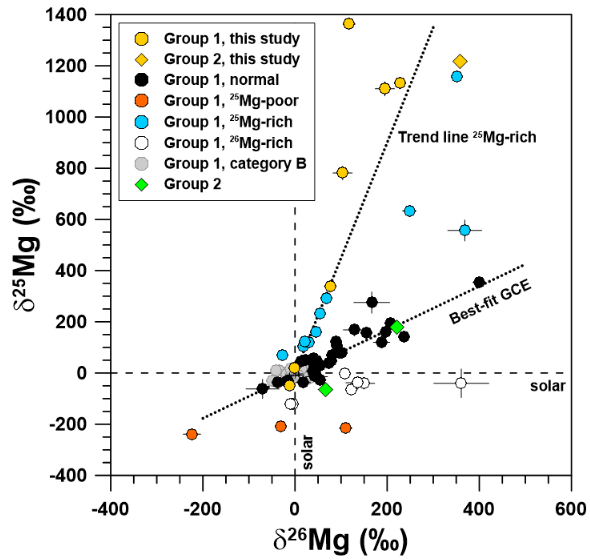

Figure 1. *Mg-isotopic compositions of five ^{25}Mg-rich and two normal Group 1 presolar silicate grains (yellow circles) and one ^{25}Mg-rich silicate (yellow diamond) analyzed for Ca isotopes in this study along with data of Group 1 and 2 grains from [6, 8]. Errors are 1σ.*

(NWA6957_C#6_50 and NWA6957_C#6_12) show ^{44}Ca-excesses (δ^{44}Ca = 137±44 ‰ and δ^{44}Ca = 88±30 ‰; Fig. 2) and have, within error limits, normal δ^{42}Ca-values. Grain EET_5B_5 has depletions (>2σ) in ^{42}Ca and ^{44}Ca (δ^{42}Ca = –290±108 ‰, δ^{44}Ca = –169±62 ‰; Fig. 2), and the last two ^{25}Mg-rich Group 1 grains, NWA6957_C#6_41_1 and NWA7540_2_21, as well as the ^{25}Mg-rich Group 2 silicate MET_01B_41, display no significant deviations from the solar value (Fig. 2). All isotopic data were corrected for dilution from surrounding Solar System material.

Discussion: *Normal Group 1 grains.* Both data points plot above the GCE trend line (Fig. 2); however, the composition of NWA7540_2_12 does not deviate from the solar value within error limits. The second grain, NWA7540_3A_3 is a comparably large (890×420 nm) Ca-rich silicate. Its O-isotopic composition indicates an origin from a low-mass AGB star of sub-solar metallicity, thus, based on GCE trends, we would not expect any ^{44}Ca-enrichments. Interestingly, almost all Group 1 oxides [11,12] plot below the GCE trend. The data set of Ca isotopes for "normal" Group 1 silicates and oxides is still very limited (Fig. 1), thus, we cannot draw any definitive conclusions on potential trends. Nittler et al. [11] suggested inhomogeneous distribution of ^{44}Ca in the interstellar medium (ISM) as

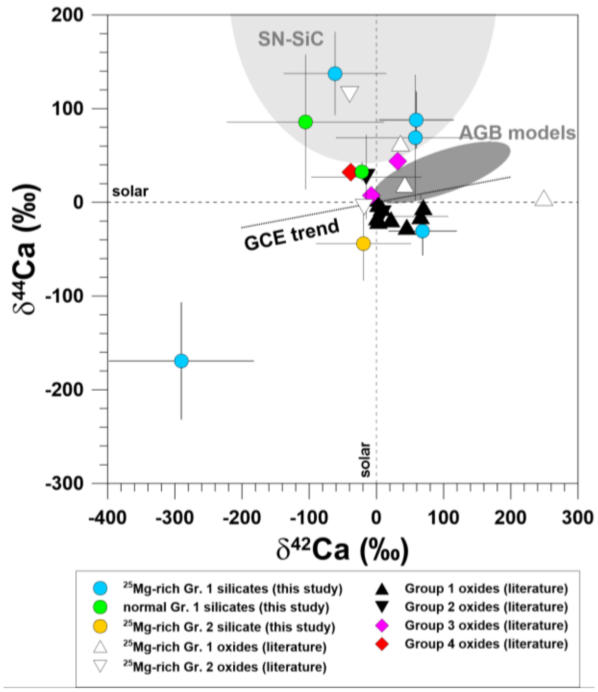

Figure 2. *Ca-isotopic compositions (δ^{42}Ca vs. δ^{44}Ca) for eight silicates and one spinel grain from this study, together with literature data for presolar oxide grains [11,12]. The light gray area marks the range observed for presolar SiC from CCSNe [13,14], together with a GCE trend line (dotted line, [11]), and the dark gray ellipse ("AGB models") shows the range of isotopic compositions predicted for AGB stars of 1.5–8 M⊙, with Z~0.5 Z⊙ to 2 Z⊙ [15,16]. Errors are 1σ.*

explanation for the lack of correlation between ^{42,43}Ca/^{40}Ca and ^{44}Ca/^{40}Ca.

^{25}Mg-rich Group 1 & 2 grains. These grains likely come from CCSNe with H-ingestion into the He shell prior to the collapse [6,8], while for some, intermediate-mass AGB stars with supersolar metallicities [8] or Super-AGB stars with M ≥ 8 M⊙ [9,10] could be alternative stellar sources. In such CCSNe, a so-called O/nova zone forms, where ^{25}Mg/^{24}Mg is strongly enhanced, while ^{26}Mg/^{24}Mg is much lower [17]; in addition, significant amounts of ^{44}Ti are produced here. Mixing with outer shell matter and pre-SN wind can account for Mg- and Si-isotopic compositions of the ^{25}Mg-rich Group 1 silicates [6, 8]. For the two ^{44}Ca-enriched grains NWA6957_C#6_50 and NWA6957_C#6_12, we calculate initial ^{44}Ti/^{48}Ti ratios of 0.42±0.14 and 0.17±0.06, respectively, following the approach of [13]. When we apply the mixing prescriptions for these grains from [6] to reproduce the ^{42}Ca/^{40}Ca and ^{44}Ca/^{40}Ca ratios, the model ^{44}Ti/^{48}Ti ratio is significantly lower (~0.002) than those observed in the grains. By taking a more detailed look at the 25T-H model [17], we find that ^{44}Ti/^{48}Ti ratios of up to 0.5 occur in the inner part of the O/Nova zone, with a sharp decrease towards the outer part. The modeled Ca-isotopic compositions can be matched with the grain data if we apply ^{44}Ti/^{48}Ti ratios of 0.3 to 0.5, in line with the estimates for our two silicates. This could indicate preferential trapping of ^{44}Ti-rich material from the inner O/nova zone into the growing silicate grains. The isotopic composition of NWA7540_2_21 could be matched similarly by assuming a smaller fraction of O/nova matter, but the large errors do not allow to unambiguously attribute a ^{44}Ti-contribution to this grain. The Ca-isotopic composition of grain EET_5B_5 cannot be explained as easily. In CCSNe, ^{44}Ti is mainly produced from ^{40}Ca via the reaction ^{40}Ca(α,γ)^{44}Ti. The ^{40}Ca-excess that we observe in EET_5B_5 might thus be due to material that "froze out" before the temperature was high enough for a significant production of ^{44}Ti (and thus destruction of ^{40}Ca). Super-AGB stars and high-Z intermediate-mass AGB stars are viable sources of some ^{25}Mg-rich grains. However, ^{44}Ca-enrichments in grains from these stars would be accompanied by even larger ^{42}Ca-excesses or significant ^{29}Si- and ^{30}Si-enrichments [e.g., 16], which we do not find for the ^{25}Mg-rich silicates discussed here. Instead, the observed ^{44}Ca-enrichments could well be the result of ^{44}Ti-decay, further supporting a CCSN origin of the grains studied here.

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