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Calcium isotope investigation of silicate stardust

JAN LEITNER[1], PETER HOPPE[2] AND MARIO TRIELOFF[3]

[1]Heidelberg University

[2]Max Planck Institute for Chemistry

[3]Universität Heidelberg

Presenting Author: jan.leitner@mpic.de

Isotopically anomalous dust grains that formed in the outflows of evolved stars and in the ejecta of stellar explosions are a minor, but important component of the primordial building blocks from which our Solar System formed [1]. Silicates are the most abundant type of "presolar" dust available for single grain analyses [2]. Based on their O-isotopic compositions, most (>99%) presolar silicates and oxides are divided into four distinct groups [3,4]. Low-mass asymptotic giant branch (AGB) stars were identified as main stellar sources, followed by core-collapse supernovae (CCSNe). Additional contributions are evident for intermediate-mass (4–8 M_{sun}) AGB stars undergoing hot bottom burning (HBB) and novae [e.g., 1]. Recent Mg isotope studies of presolar silicates showed that a significant fraction (~25 %) of the Group 1 and 2 grains display large ^{25}Mg-excesses, as well as significant ^{25}Mg-depletions, and/or ^{26}Mg-excesses, indicating CCSNe and, in some cases, intermediate-mass AGB stars or Super-AGB-stars as stellar sources [e.g., 5]. The Mg isotopes of grains from low-mass AGB stars show a trend reflecting Galactic Chemical Evolution (GCE), similar to Si [5].

Here, we report on an ongoing NanoSIMS high-spatial resolution (<100 nm) isotope study of the rock-forming element calcium in presolar silicates, to investigate the stellar origins of Ca and potential GCE trends, as well as the timing and astrophysical settings of grain formation in stellar environments. Two AGB silicates show deviation from the previously predicted GCE trend [4], while two out of five ^{25}Mg-rich CCSN grains have significant ^{44}Ca-enrichments, indicative of in situ ^{44}Ti-decay, which is exclusively produced in SNe. Inferred ^{44}Ti/^{48}Ti ratios agree well with model predictions for a CCSN with H-ingestion [6].

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