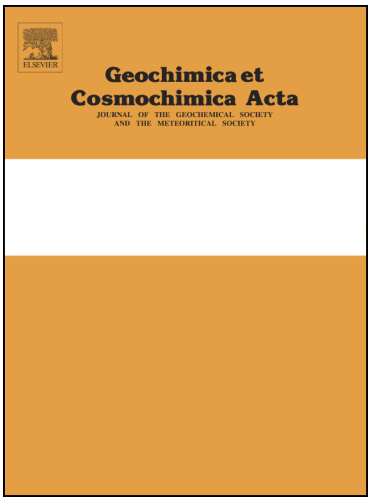

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Iron and nickel isotope compositions of presolar silicon carbide grains from supernovae

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ABSTRACT

We report the carbon, silicon, iron, and nickel isotope compositions of twenty-five presolar SiC grains of mostly supernova (SN) origin. The iron and nickel isotope compositions were measured with the new Chicago Instrument for Laser Ionization, CHILI, which allows the analysis of all iron and nickel isotopes without the isobaric interferences that plagued previous measurements with the NanoSIMS. Despite terrestrial iron and nickel contamination, significant isotopic anomalies in $^{54}Fe/^{56}Fe$, $^{57}Fe/^{56}Fe$, $^{60}Ni/^{58}Ni$, $^{61}Ni/^{58}Ni$, $^{62}Ni/^{58}Ni$, and $^{64}Ni/^{58}Ni$ were detected in nine SN grains (of type X). Combined multi-isotope data of three grains with the largest nickel isotope anomalies (>100 ‰ or <−100 ‰ in at least one isotope ratio, when expressed as deviation from the solar value) are compared with the predictions of two SN models, one with and one without hydrogen ingestion in the He shell prior to SN explosion. One grain's carbon-silicon-iron-nickel isotope composition is consistent with the prediction of the model without hydrogen ingestion, whereas the other two grains' isotope anomalies could not be reproduced using either SN models. The discrepancies between the measured isotope compositions and model predictions may indicate element fractionation in the SN ejecta prior to or during grain condensation, and reiterate the need for three-dimensional SN models.

1. INTRODUCTION

Silicon carbide (SiC) is the most thoroughly studied presolar phase (e.g., Zinner, 2014). The isotope composition of major elements carbon and silicon, and the minor element nitrogen are used to distinguish between different origins of presolar SiC grains. SiC grains belonging to the "Mainstream" (MS), Y, and Z groups formed in the winds of low-mass (1.5–3 $M_{\odot}$) asymptotic giant branch (AGB) stars of different metallicities (e.g., Lugaro et al., 2003; Zinner et al., 2006), whereas the sources of most grains of types A and B are probably J-type carbon stars and post-AGB stars (Hoppe et al., 1994; Amari et al., 2001a). Based on their silicon isotope compositions and on the evidence for the initial presence of ^{44}Ti in many of them, presolar SiC grains of types X and C are thought to have condensed in the ejecta of type II core collapse supernovae (SNe; Amari et al., 1992; Hoppe et al., 2000; Croat et al., 2010).