SOURCES OF SHORT-LIVED RADIONUCLIDES IN THE EARLY SOLAR SYSTEM.
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Many short-lived radionuclides were present in the early solar system (e.g., ^{10}Be, ^{26}Al, ^{41}Ca, ^{53}Mn, ^{60}Fe). Short-lived radionuclides are produced in several ways, including by nucleosynthesis in stellar interiors [1], by explosive nucleosynthesis during nova or supernova explosions [2], by cosmic-ray interactions [3], and by interactions between high-speed stellar ejecta and ambient interstellar dust [4]. A major challenge facing cosmochemists is to determine which of these sources contributed significantly to the solar system inventory of short-lived radionuclides. Keys to resolving this issue are to identify radionuclides that are produced by only one process and to study co-production of different nuclides by a single mechanism.

^{10}Be is produced efficiently only by spallation, either by cosmic rays or through high-speed collisions between parcels of gas and dust. The discovery [5] that ^{10}Be was abundant in CAIs ((^{10}Be/^{9}Be)$_0$ ~ 1 x 10^{-3}) [5-7] raises the possibility that spallation could have produced most of the short-lived radionuclides. One calculation seems to indicate that ^{10}Be, ^{26}Al, ^{41}Ca, and ^{53}Mn could have been produced in the observed abundances by irradiation of core-mantle protoCAIs with low-energy ^{3}He-rich solar cosmic rays in the reconnection ring near the protosun [3]. However, conditions necessary for this to work, especially for ^{26}Al, are very specific and quite extreme [6]. Also ^{10}Be and ^{26}Al are decoupled in some CAIs [6, 7], making an irradiation source for both unlikely. ^{10}Be (and ^{41}Ca) can be produced efficiently by typical early solar system proton fluxes.

In contrast, ^{60}Fe is not produced at all efficiently by spallation, so an inferred solar-system abundance greater than the steady-state abundance in the galaxy would require a stellar input. Earlier this year, our group [8, 9] and the Mainz group [10] reported clear evidence of ^{60}Fe in primitive ordinary chondrites at abundances that require a stellar source. The type of stellar source can perhaps be determined from the solar-system initial ^{60}Fe/^{56}Fe, estimated to have been between ~3x10^{-7} and ~1x10^{-6} [8-10, also see 11], and from the relative abundances of various radionuclides. An AGB source can only produce the inferred ^{60}Fe/^{56}Fe ratios under extremely neutron-rich condition occurring in higher-mass stars [1]. However, AGB stars of >~3 solar masses have internal structures that inhibit the cool bottom processing necessary for high abundances of ^{26}Al [12]. A supernova efficiently produces ^{26}Al and ^{60}Fe and could generate their observed abundances. Both ^{26}Al and ^{60}Fe are produced primarily in the O/Ne zone of the pre-SN star, so they should remain correlated in SN ejecta, regardless of the details of mixing, shredding, or the nature of injection into the solar nebula [2].

Although the nature of the stellar source is still uncertain, it is now clear that both spallation and stellar nucleosynthesis contributed short-lived radionuclides to the early solar system.

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