THE ISOTOPIC COMPOSITION OF COSMIC-RAY CALCIUM

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The isotopic composition of galactic cosmic-ray calcium has been measured over the energy range $\sim$ 150–400 MeV/nucleon using the Cosmic Ray Isotope Spectrometer (CRIS) on the Advanced Composition Explorer (ACE) mission. The five calcium isotopes with mass numbers 41, 42, 43, 44, and 46 have large secondary contributions from fragmentation of ^{56}Fe and sub-Fe secondaries during propagation. The two doubly-magic isotopes ^{40}Ca and ^{48}Ca, however, have neutron-to-proton ratios significantly different from that of ^{56}Fe and therefore are not copiously produced as cosmic-ray secondaries. Using the measured abundances of the A=41–46 secondaries as constraints, in combination with measured cross sections for the production of calcium isotopes by fragmentation of ^{56}Fe on hydrogen, we have derived source abundances of ^{40}Ca and ^{48}Ca. We find that these isotopes are both present in cosmic-ray source material with abundances relative to ^{56}Fe which are close to the solar-system values. This similarity has important implications for the origin of cosmic rays since very different stellar sites are required to account for the production of the observed abundances of these two isotopes. Model calculations (e.g., Woosley and Weaver 1995) indicate that ^{40}Ca is produced mainly by oxygen burning in massive stars which lead to type II supernovae. These stars do not produce sufficient ^{48}Ca to account for the observed abundance, and it has been suggested that this isotope may originate in a special variety of type Ia supernovae. For such different sources to yield the same abundances in cosmic rays as in solar system material suggests that both populations are sampling similar, well-mixed pools of seed material originating from many stellar sources. We will present the cosmic-ray observations, describe the derivation of source abundances, and discuss the comparison with supernova models and the implications for the origin of cosmic rays.

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