The origins of the short-lived radionuclides in the solar system

S.J. DESCH

School of Earth and Space Exploration, Arizona State University, PO Box 871404, Tempe AZ, 85287-1404

In my keynote address, I will review the astrophysical origins of the short-lived radionuclides (SLRs) inferred from meteorites to have existed in the early Solar System. These include ^{41}Ca, ^{36}Cl, ^{26}Al, ^{60}Fe, ^{10}Be, ^{53}Mn, ^{107}Pd, ^{182}Hf, and ^{129}I, ranging in half-life from 0.1 to 16 Myr. In broad brush, the three possible sources can be termed inheritance, irradiation, and injection. Inheritance is possible if the molecular gas from which the Solar System formed happened to contain high abundances of an SLR. This requires the SLR be relatively long-lived (tens of Myr) to avoid decay, and inheritance of ^{60}Fe seems ruled out. A unique exception is ^{10}Be; a high fraction of Galactic cosmic rays are themselves ^{10}Be nuclei and can become trapped in the molecular cloud during collapse. Irradiation refers to production of SLRs within the Solar System by energetic ions accelerated in solar flares. Production and incorporation of SLRs into meteoritic components, in the observed proportions, is a modelling challenge, and is not possible for ^{60}Fe. Injection of SLRs by a stellar nucleosynthetic source is required to explain the presence of ^{60}Fe in the early Solar System. The only source naturally associated with forming solar systems is a core-collapse supernova; but over 50% of Sun-like stars do form in association with a supernova. A supernova is capable of injecting all of the known SLRs (except the unique ^{10}Be), in very nearly their observed proportions. I will review a variety of models pertaining to the inheritance, irradiation and injection scenarios.

Exploring for photosynthesis in deep time and space

D.J. DES MARAIS

NASA Ames Research Ctr., Moffett Field, CA 94035, USA

The rise of photosynthesis led ultimately to an energy source substantially exceeding the geochemical source from redox reactions associated with weathering and hydrothermal activity. Today, hydrothermal sources deliver (0.1-1) x 10^{12} mol yr^{-1} globally of reduced S, Fe^{2+}, Mn^{2+}, H_2 and CH_4; estimated to sustain about (0.2-2.0) x 10^{12} mol C yr^{-1} of organic C production by chemotrophs. Photosynthetic global productivity is about 9,000 x 10^{12} mol C yr^{-1}. Because oxygenic photosynthesis provides abundant reductant by splitting H_2O, it frees the biosphere from depending solely upon geochemical sources of reductants, e.g., hydrothermal and weathering processes.

Photosynthetic microbes created robust fossil records in part because they populated stable continental platforms and margins and thereby contributed to sediments having high potential for preservation. Proterozoic cyanobacterial fossils and organic biomarkers are well documented. Sedimentary steranes extend evidence of oxygenated environments into the Archean. Low $^{13}C/^{12}C$ values of some 2.8 Ga kerogens have been attributed to methanotrophic bacteria, which require O_2 and CH_4. Perhaps reduced C and sulfides in extensive platform and margin deposits are the most enduring legacies of photosynthesis.

There are hints of even earlier origins. The 3.43 Ga Strelley Pool cherts, W. Australia, show that diverse stromatolites populated a partially restricted, low-energy shallow hypersaline basin. Molecular studies of extant bacteria hint that the earliest chlorophyll-using photosynthesizers needed geochemical sources of reductants. Did these anoxygenic phototrophs once sustain an extensive, highly productive biosphere? Perhaps the substantial decline in geothermal activity during the Archean created a driver for the development of oxygenic photosynthesis. Can we further document the Archean biosphere? Will Mars exploration extend our understanding of emerging biospheres to even earlier times?