^{3}He/^{4}He in Stardust samples

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The presence of excess ^{3}He, which cannot result from air contamination, is strong evidence that indigenous noble gases exist in Stardust samples. The ^{3}He/^{4}He ratio can in principle point to when comets acquired their noble gases, and from what volatile reservoir —the early protosolar nebula, near the evolving sun during or just after the deuterium burning that elevated the level of protosolar ^{3}He, or by later implantation of solar-wind-like radiation. Jupiter's ^{3}He/^{4}He ratio of 1.66×10^{-4} (Mahaffy *et al*., 1998) likely reflects the protosolar value. ^{3}He/^{4}He is $\sim 3.6 \times 10^{-4}$ in the sun after deuterium burning (Geiss *et al*., 2004), and 4.82×10^{-4} in the solar wind (Heber *et al*., 2007). Our preliminary measured ratio of $\sim 2.7 \pm 0.3 \times 10^{-4}$ falls between the protosolar and solar D-burning values.

Production of the excess ^{3}He by galactic cosmic ray (GCR) spallation reactions is unlikely. While measured ^{3}He contents are small (< 600,000 atoms), abundances/gram are not; the minimum grain concentration is estimated to be $\sim 6 \times 10^{-5}$ cm^{3}STP/g. GCR production rates in a fosterite/enstatite particle, on the Wild-2 surface or buried under 1 m of ice, are $\sim 7\text{-}5 \times 10^{-9}$ cm^{3}STP/g per Ma, requiring GCR exposures of ~1000 Ma, in either location, to generate only 10% of the ^{3}He concentration. Estimated mass loss from Wild-2 just since its 1974 appearance is ~1 m (Brownlee *et al*., 2004), and was probably significantly more in the Wild-2 jet sources if they were active on previous apparitions. The collected particles were therefore likely buried until very recently at depths where GCR production is essentially nil. While ancient surfaces may be preserved on Wild-2 (Brownlee *et al*., 2004), only ~50% of the observed ^{3}He could be produced in them by GCR spallation over the 4500 Ma age of the solar system.

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The dynamic Archean Earth

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Archean cratons stand distinct from younger orogens as a result of their refractory lithospheric keels and relatively abundant komatiite and tonalite-trondhjemite-granodiorite (TTG) rock types. Yet detailed petrogenetic and structural studies within well constrained geochronological frameworks point to the operation of plate-tectonic-like processes as far back as 3.8 Ga. Modern geodynamic settings provide a template for interpretation of igneous rock sequences based on the assumption that melt compositions are governed by mantle mineral assemblages, dependent on depth and temperature, mediated by fluid fluxes. Application of the modern template to the Phanerozoic and Precambrian record has been validated through consideration of multiple characteristics including depositional setting, and timing and duration of magmatic and structural events. The Superior Province of North America records the formation of several independent protocontinental fragments between 3.8 and 2.8 Ga. Continental margin rift sequences suggest plume-driven magmatism, which was followed by production of plateau-type juvenile basaltic crust in the early Neoarchean. Consumption of oceanic domains of undetermined extent is recorded in <2750 Ma oceanic and continental arcs with subduction signatures including pre-orogenic boninite, calc-alkaline basalt and adakite, and syn-to post-orogenic shoshonite and sanukitoids. Five discrete collision events between 2720 and 2680 Ma united the oceanic and diverse protocontinental terranes. Evidence from the western Pilbara craton supports the operation of subduction by 3.12 Ga, whereas the 3.51-3.24 Ga sequences of the eastern Pilbara appear to have evolved in a plume setting (Smithies *et al*. 2005). However, evidence for even earlier sea-floor spreading within a plate-tectonic framework derives from the 3.8 Ga Isua belt (Furnes *et al*. 2007). It is likely that plumes were a common heat-release phenomenon early in Earth history, and once may have been dominant, but evidence for Neoarchean plume-arc interaction (Dostal and Mueller 1997) suggests that as in the modern Earth, plumes were not incompatible with organized convection. Evidence from the Hadean record is scant and views of Earth's very early evolution are guided by thermal models and insights from planetary geology.

Many features of Archean terranes appear to be directly (komatiites, charnockites) or indirectly related to higher mantle temperatures. The highly depleted compositions of lithosphere keels may result from fluxed melting of depleted mantle in high-temperature suprasubduction-zone wedges.

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