Pre-biotic organic matter from comets and asteroids

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Anders (1989) suggested interplanetary dust particles (IDPs), ~5 to 50 μm in size, delivered a layer of organic-rich material from asteroids and comets to the surface of the early Earth and proposed this organic matter may have been important for the origin of life. Recent modeling by Nesvorny and Jenniskens (2010) suggests >85% of the interplanetary dust results from fragmentation of Jupiter-family comets like 81P/Wild 2, sampled by NASA's Stardust spacecraft, and 26P/Grigg-Skjellerup, the target of a short stratospheric dust collection coinciding with the Earth's crossing of the dust steam from a recent outburst on that comet. Analyses of organic matter in Wild 2 samples was further complicated by organic contamination in the aerogel. Nonetheless, volatile aliphatic hydrocarbon, co-located with the particle tracks, but distributed out to several track diameters, was seen in some Wild 2 tracks by infrared spectral mapping. In addition, using carbon x-ray absorption near-edge structure spectroscopy, we detected several spectrally distinct C=C and C=O bearing organic phases spatially associated with surviving Wild 2 particles. We also analyzed particles from the Grigg-Skjellerup timed collection. These were collected from the stratosphere after relatively gentle deceleration, better preserving indigenous organic matter than for the Wild 2 particles. We found a diversity of mineralogies and elemental compositions and abundant organic matter, identified by detection of the aliphatic $C\text{-}H_2$ and $C\text{-}H_3$ functional groups, in particles from the Grigg-Skjellerup timed collection. The organic/silicate ratio in both the Wild 2 impactors and the particles from the Grigg-Skjellerup timed collection is significantly larger than in carbonaceous chondrite meteorites, which have reflection spectra very similar to C-type asteroids, the most common type of asteroid in the outer-half of the main-belt. This indicates both direct delivery by cometary impacts (Chyba *et al*., 1990) and accretion of cometary IDPs (Anders, 1989) contributed significant quantities of organic matter, including aliphatic hydrocarbons ($C\text{-}H_2$ and $C\text{-}H_3$), C=C (most likely C-rings), and C=O, to the surface of the early Earth. Further analysis should determine the abundance and speciation of N in this organic matter.

Fe isotopes and the contrasting petrogenesis of A-, I and S-type granite

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Our study of closed to oxygen differentiation of a tholeiitic dolerite sill [1], from mafic dolerite parent through to highly differentiated felsic granophyre, shows strong fractionation of the isotopic composition of iron with a strong positive correlation of δFe^{57} with $Fe^{3+}/\Sigma Fe$. Both initially rise during fractionation controlled by ferrous iron bearing phases (pyroxenes) and then fall abruptly after magnetite saturation is reached. This is consistent with the model of Dauphas *et al* [2] that assumes $\Delta^{57}_{Fe3+\text{ - }Fe2+}$ =0.45‰.

Our new data from a range S-, I- and A-type (ferroan) granites from the Cambrian Delamerian orogen in South Australia [3] yields similar results to Dauphas and Freydier [4] and shows that the A-types have very heavy δFe^{57} values (0.3-0.45) whereas the I- and S-types tend to be less fractionated and lighter. These results suggest the ferroan A-types result from protracted closed magma chamber fractionation with delayed magnetite saturation. This is also consistent with their depletion in compatible elements (Mg, Ni and Cr) and enrichment in incompatibles (REE, U, Th). S- and I-types are generated at least in part by crustal partial melting, where the persistent buffering by restitic residual minerals and early magnetite or Fe^{3+}-rich biotite saturation prevents iron isotope fractionation.

[1] Sossi, Foden & Halverson, (2011) *EPSL* (in press).
[2] Dauphas *et al*. (2009) *EPSL* **288**, 255-267. [3] Foden *et al*., (2002) *J.Geol Soc*, **159**, 601-621. Dauphas and Freydier Chem. Geol. **222** 132–147.