

Emergence of a habitable planet

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We address the first several hundred million years of Earth's history [1]. The Moon-forming impact left Earth enveloped in a hot silicate atmosphere that cooled and condensed over ~1000 yrs. As it cooled the Earth degassed its volatiles into the atmosphere. It took another ~2 Myrs for the magma ocean to freeze at the surface. The cooling rate was determined by atmospheric thermal blanketing. Tidal heating by the new Moon was a major energy source to the magma ocean. After the mantle solidified geothermal heat became climatologically insignificant, which allowed the steam atmosphere to condense, and left behind a ~100 bar, ~500 K CO₂ atmosphere. Thereafter cooling of the surface was governed by how quickly CO₂ was removed from the atmosphere. If carbonate subduction were efficient, this could have taken as little as 10 million years. In this case the faint young Sun suggests that a lifeless Earth should have been cold and its oceans white with ice. But if carbonate subduction were inefficient the CO₂ would have mostly stayed in the atmosphere, which would have kept the surface near ~500 K for many tens of millions of years. Hydrous minerals are harder to subduct than carbonates and there is a good chance that the Hadean mantle was dry. Hadean heat flow was locally high enough to ensure that any ice cover would have been thin (<5 m) in places. Moreover hundreds or thousands of asteroid impacts would have been big enough to melt the ice triggering brief impact summers. We suggest that plate tectonics as it works now was inadequate to handle typical Hadean heat flows of 0.2-0.5 W/m². In its place we hypothesize a convecting mantle capped by a ~100 km deep basaltic mush that was relatively permeable to heat flow. Recycling and distillation of hydrous basalts produced granitic rocks very early, which is consistent with preserved >4 Ga detrital zircons. If carbonates in oceanic crust subducted as quickly as they formed, Earth could have been habitable as early as 10-20 Myrs after the Moon-forming impact.

[1] Zahnle, Arndt, Cockell, Halliday, Nisbet, Selsis & Sleep (2007) *Space Sci. Rev.* **129**, 35-78.

Trace metal pollution in the sediments of an urban river: An impact of anthropogenic activities

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The banks of Old Nakagawa River in Tokyo, Japan is a location where a significant amount of different types of industrial units were available at the time of second world war (USAMS, 1945-46) and the people of that area informed that in some locations a huge amount of industrial metal contained waste was deposited about 30 years ago. The landscape of the area favour deposition of trace metals in sediments, and still it receives significant amount of various waste from different types of industries and residential areas. The association of Cd (76-98 %) and Zn (48-67 %) were found highest with AEC (adsorbed/ exchangeable/ carbonate) phase; Cu (45-60 %) and Pb (44-73 %) with amorphous Fe oxyhydroxide phase, and the maximum fractionation of Cr was in both crystalline Fe oxide (12-60 %) and amorphous Fe oxyhydroxide phase (15-60 %). For retention by amorphous Fe oxyhydroxide minerals, the observed stoichiometric gradient was: 1.52 for Cu, 1.23 for Pb, 2.25 for Cr and 3.09 for Zn. Corresponding values for association with crystalline oxides, and sulfides and organics were an order of magnitude greater than those for amorphous oxyhydroxide, indicating a greater affinity of trace metals for these phases. The total concentration ranges of Cd, Cr, Cu, Pb and Zn in Old Nakagawa River sediments were 2.86-16.95, 551.7-3953.1, 340.6-1565.3, 136.9-385.9 and 931.4-3650.1 µg g⁻¹, respectively. The observed order of potential trace metal mobility in the aquatic system was: Cd > Zn > Pb > Cu > Cr. Organic carbon contents in sediment samples were comparatively high (mean 5.48 %), and the X-ray diffraction (XRD) study detected the presence of several clay minerals, those are likely to be major host of trace metals in sediments. According to the enrichment factors (EF_c), most of the sites have several times higher values of trace metals than the standard.

[1] USAMS (US Army Map Service) 1945-46. US Army map service city plans for the Tokyo area. Sheet 9- Honjo. Reproduced from compilation manuscript by overprints. UT Library online.