A net-loss of Earth's volatile elements as the result of a chondritic late-veneer

SAMI MIKHAIL[1,2] AND DUNCAN H FORGAN [2,3]

[1] School of Earth and Environmental Sciences, The University of St. Andrews, UK (sm342@st-andrews.ac.uk)
[2] St Andrews Centre for Exoplanet Science, The University of St. Andrews, UK
[3] SUPA, The School of Physics and Astronomy, The University of St. Andrews, UK

Stochastic events including primary accretion, the Moon-forming impact, late veneer, and late heavy-bombardment were fundamental to the origin and evolution of Earth's atmosphere, and hydrosphere [1-2]. Therefore, these events must be quantitatively understood to discern how Earth became habitable, and by extension, to provide a rigid framework within which to categorize current and future exoplanet discoveries as potentially habitable exoworlds. To this end, the late veneer is the focus of a long-standing quandary; did secondary accretion provide Earth's volatile elements? [3] Here we contribute to this line of inquiry using astronomical modelling to explain primordial noble gas abundance datasets. These data show that Venus, which is slightly smaller that Earth, has a more volatile-rich and massive atmosphere [4]. We explain this observation using the results of a series of N-body simulations to show that Earth should have received significantly more impacts relative to Venus and Mars, respectively. These data rule out secondary accretion providing more volatiles to Venus, and thus imply that a chondritic (asteroidal) late-veneer resulted in a net-loss of Earth's Hadean atmosphere. Importantly this model prohibits a chondritic late veneer from being the primary source of Earth's volatile elements. We will show how this finding has important consequences for the search for life on telluric planets elsewhere in the Milky Way and beyond, because stochastic processes likely drove the post-accretion development of habitable (clement) environmental conditions on Earth.

1. *Morbidelli et al. 2000. Meteoritics and Planetary Sciences, 35, 1309-1320*
2. *Genda & Abe. 2005. Nature, 433, 842-844*
3. *Marty 2012. Earth and Planetary Science Letters, 314, 56-66*
4. *Porcelli & Pepin. 2003. Treatise on Geochemistry, 319-347*