EPSC Abstracts
Vol. 12, EPSC2018-132, 2018
European Planetary Science Congress 2018

Gradual desiccation of rocky protoplanets from ^{26}Al-heating

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Abstract

The formation and distribution of Earth-like planets remains poorly constrained. However, stochasticity during accretion and the variety of exoplanet compositions favor rocky worlds covered in thick volatile ice layers as the dominant family of terrestrial analogues [1], deviating from the water-poor inner-Solar system planets. Here, we demonstrate the power of ^{26}Al, a short-lived radioisotope abundant in the early Solar system, to control the water content of terrestrial exoplanets. Using numerical models of planet formation, evolution, and interior structure [2], we generate synthetic planet populations that are subject to a varying degree of ^{26}Al-heating during accretion [3]. We show that planet bulk water fraction and radius are anti-correlated with the host system's ^{26}Al levels (Fig. 1). This yields a system-wide correlation [4] of bulk abundances, and is consistent with the location-independent scarcity of water within the TRAPPIST-1 planets [5]. The generic sensitivity of exoplanet observables on primordial ^{26}Al inferred from our models suggests two distinct classes of rocky exoplanets: high-^{26}Al systems form small, water-depleted planets, those devoid of ^{26}Al form ocean worlds, with the mean planet radii deviating by up to $\sim$10%.

References

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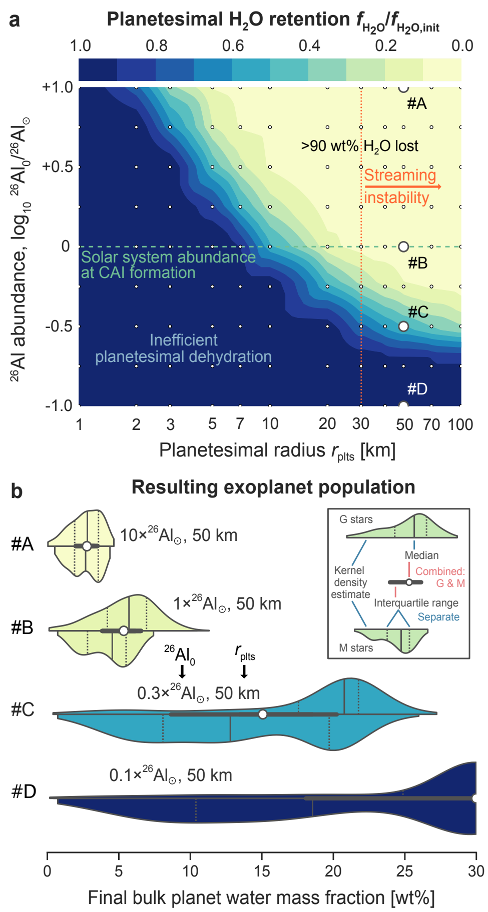

Figure 1: (a) Water retention in planetesimals subject to a varying degree of ^{26}Al heating. (b) Bulk planet water abundances $f_{\mathrm{H_2O}}$ in exoplanet populations with M_{planet} = 0.1–10 M_{Earth} and $f_{\mathrm{H_2O}} > 0$, formed with fixed $^{26}\mathrm{Al}_0$ and planetesimal radius r_{plts}.