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A water budget dichotomy of rocky protoplanets from ^{26}Al-heating

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In contrast to the water-poor inner solar system planets, stochasticity during planetary formation and order of magnitude deviations in exoplanet volatile contents suggest that rocky worlds engulfed in thick volatile ice layers are the dominant family of terrestrial analogues among the extrasolar planet population. However, the distribution of compositionally Earth-like planets remains insufficiently constrained, and it is not clear whether the solar system is a statistical outlier or can be explained by more general planetary formation processes. Here we employ numerical models of planet formation, evolution, and interior structure, to show that a planet's bulk water fraction and radius are anti-correlated with initial ^{26}Al levels in the planetesimal-based accretion framework. The heat generated by this short-lived radionuclide rapidly dehydrates planetesimals prior to accretion onto larger protoplanets and yields a system-wide correlation of planet bulk abundances, which, for instance, can explain the lack of a clear orbital trend in the water budgets of the TRAPPIST-1 planets. Qualitatively, our models suggest two main scenarios of planetary systems' formation: high-^{26}Al systems, like our solar system, form small, water-depleted planets, whereas those devoid of ^{26}Al predominantly form ocean worlds, where the mean planet radii between both scenarios deviate by up to $\approx$ 10 %.