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The distribution of radiogenic heat-producing elements in super-Earths

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The abundance and distribution of radiogenic heat-producing elements (HPEs) such as potassium (K), thorium (Th), and uranium (U) are key factors in shaping the internal dynamics and habitability of rocky exoplanets. Conventional models, developed with Earth in mind, commonly assume that these elements remain highly lithophile [1], residing predominantly in planetary mantles. Here, we present ab initio molecular dynamics simulations that reveal a markedly different scenario under the extreme pressure-temperature conditions relevant to super-Earths. Our results show that K, Th, and U all become increasingly siderophile as pressure and temperature rise, leading to substantial incorporation of these elements into metallic cores [2]. This partitioning behavior has profound geochemical consequences for super-Earths. By shifting a significant fraction of radiogenic heating from the mantle to the core, it elevates core temperatures and augments the heat flux across the core-mantle boundary. Such a redistribution of heat sources can prolong volcanism in the mantle and promote vigorous dynamo action, giving rise to long-lived magnetic fields. These findings challenge traditional assumptions about HPEs partitioning and underscore the need to revisit thermal evolution and interior structure models of large exoplanets.

[1] Chidester et al. *Geochem. Geophys. Geosyst.* 2022, 23, e2021GC009986.

[2] Luo et al. *Sci. Adv.* 2024, 10, eado7603.