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Biomolecules in the Interiors of Distant Worlds

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Understanding the delicate interplay of geological, hydrological, and chemical cycles on terrestrial worlds is key to uncovering how planets come to create and nurture living systems. In this dawn of exoplanet discovery and characterization, effective geochemical models are perhaps the best way to deduce information about a distant planet's interior composition by leveraging the limited data available. Observations of exoplanets by current missions such as the James Webb Space Telescope (JWST) collect data on orbital parameters and atmospheric composition, scratching only the surface of the vast depths of complexity which remain to be explored for each planet [1]. The upcoming Habitable Worlds Observatory will specifically target planets such as our own, answering fundamental questions about Earth's place in the cosmos. This mission will be able to collect even more information about the distribution and diversity of terrestrial worlds, but a telescope capable of measuring the interior compositions of distant planets is unlikely to launch within this century. At this point in time, some of the most commonly detected exoplanets around sun-like stars fall in the category of super-Earths and sub-Neptunes, worlds between 1 and 4 earth radii [2,3]. It seems entirely likely that many of these worlds, often carrying water, would host a suite of hydrothermal systems in their interiors. However, our understanding of the internal processes and compositions of terrestrial worlds remains incomplete without advanced modeling. To bridge the gap imposed by current technological limitations, this work optimizes aqueous geochemical models [4,5] to describe the interior fluid composition of any terrestrial world in question. Here, we model terrestrial worlds of 1, 2, and 4 earth radii (see figure), with a focus on biomolecule formation and distribution.

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[2] Howard et al. (2012), *The Astrophysical Journal Supplement Series* 201 (2), 15.

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[4] Huang & Sverjensky (2019), *Geochimica et Cosmochimica Acta* 254, 192- 230.

[5] Wolery (1992), *Lawrence Livermore National Lab*.