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Geoastronomy: Galactic chemical evolution expressed in rocky exoplanet geodynamics

STEPHEN JAMES MOJZSIS[1], FABRICE GAILLARD[2] AND KEVIN HENG[3]

[1]Research Centre for Astronomy and Earth Sciences (CSFK)
[2]Institut des Sciences de la Terre d'Orléans
[3]Ludwig-Maximilians-Universität München

Presenting Author: stephen.mojzsis@csfk.org

Mass and composition modulate a planet's bulk physical characteristics [1]. Viscosity (η) and heat production (A) control terrestrial-type ('rocky') planet interior dynamics. Yet, viscosity can differ by orders of magnitude between different common mantle silicate minerals (e.g. olivine, pyroxene), so that even small proportional changes yield large differences to η. A key parameter is (Mg:Si:Fe); Bulk Silicate Earth's (Mg:Si:Fe) is close to solar values [2-3], and we assume that exoplanets also follow the devolatilized compositions of their host stars [4]. Transition between mechanically weak (olivine-dominated at $(Mg/Si)\leq 1$, low η) vs. strong (pyroxene-dominated at $(Mg/Si)>1$), high η mantle convective regimes occurs over a narrow transitional range of (Mg/Si) values because small volume fractions of a weak phase can form an interconnected network that modulates rheology [e.g. 5]. System age determines how heat loss is accommodated by interior dynamics and expressed via outgassing to secondary atmospheres. Combining nuclear cosmochemistry with experimental petrology and astrophysical observations yields new insights into rocky exoplanets: Younger (≤2 Gyr) stars tend to have low $(Mg/Si)\leq 1$ [6]. If 'young' silicate exo-mantles [7] mirror such low (Mg/Si), their pyroxene-rich mantles ought to tend towards both high η and A, with episodic sluggish/rapid convection and slow cooling under low oxygen fugacities degassing H_2 and CH_4 at near-surface partial melting conditions. Earth-like, older (>4 Gyr) olivine-rich (high Mg/Si) oxidized exo-mantles should have low η and A, and effectively cool to degas N_2, CO_2, $H_2O \pm SO_2$. Forthcoming atmospheric retrieval data from next generation observatories (JWST) for ultra-short period planets around Sun-like stars can be evaluated using (hot) ionized atmospheres to explore (interior) geodynamics.

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