

MODELING GLOBAL GEOCHEMICAL CYCLING OF PHOSPHORUS AND SULFUR ON TERRESTRIAL PLANETS. M. Jusino¹ and H. J. Cleaves II², ¹Planetary Habitability Laboratory (marcos.jusino1@upr.edu), ²Earth-Life Science Institute (hcleaves@elsi.jp).

Introduction: Phosphorus and sulfur, in their oxidation states as components of various chemical species, play many important roles in biology and planetary habitability, including the origin and evolution of life, cell metabolism, and structuring of molecules important to life. However, the behavior of these species in abiotic environments, how distinct reservoirs interact with each other, and how the distribution of these chemical species changes through time are not completely understood.

Phosphorus (e.g. phosphates) is suggested to be the main limiting factor for a considerable amount of aquatic organisms, and are key components for modern metabolism [1, 2]. Sulfur minerals (e.g. pyrite) in deep ocean floors have been proven to store precursor molecules to amino acids, and possibly help with their assembly [3]. Previous studies have also suggested that early greenhouse effects on Mars may have been augmented by atmospheric sulfur chemical species [5], which directly implicates an active role on the habitable conditions of a planet.

Based on a previous study by Laneuville *et al.* [4] regarding the abiotic cycling of nitrogen, and using their implemented programming tools, we are developing a planet-scale abiotic cycling model of the major chemical species for phosphorus and sulfur.

Reservoirs and Fluxes: Major reservoirs for P include the core, the mantle, the continental crust, the oceans, and the oceanic crust (see Table 1). Although not a major reservoir, due to very short P residence times on Earth, the atmospheric P composition is also considered. Core-mantle interactions and their effect on P distributions are not entirely understood, but can be seen affecting the surface reservoirs.

The previously mentioned reservoirs are also considered for S (see Table 2). Atmospheric S content is much higher in comparison to the P content. In modern Earth, S residence time in the atmosphere is also higher, and more chemically reactive as well.

Reservoir	P Bulk Content (kg)
Core	1.4×10^{22}
Mantle	8.02×10^{20}
Continental Crust	1.1×10^{17}
Oceans	$\sim 9.92 \times 10^{13}$
Oceanic Crust	8.7×10^{18}

Table 1. P bulk content for major reservoirs. Values suggested by multiple authors.

Reservoir	S Bulk Content (kg)
Core	1.02×10^{23}
Mantle	6.70×10^{19}
Continental Crust	–
Oceans	$3.06 - 5.70 \times 10^{20}$
Oceanic Crust	$3.10 - 6.24 \times 10^{21}$
Atmosphere	–

Table 2. S bulk content for major reservoirs. Values suggested by multiple authors.

Flux rates have changed many times throughout history (see scheme on Figure 1). Some rates, such as the continental crust-mantle flux, have remained relatively stable throughout time [6]. However, rates can drastically change when we consider more fluctuating reservoirs, such as the oceans and the atmosphere.

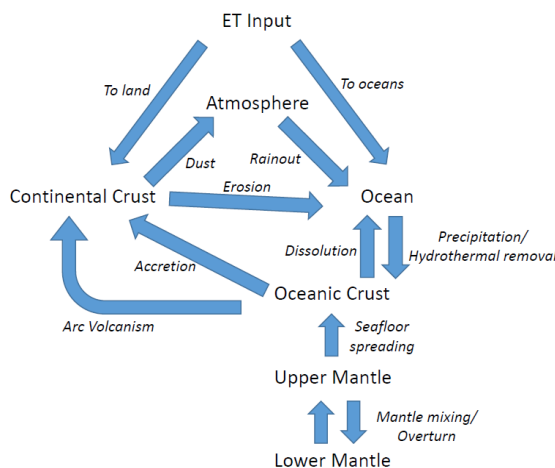


Figure 1. Flux scheme for an Earth-like planet with continents and oceans.

Conclusion: This is an ongoing project, and it is expected to shine light on questions such as how these elements were integrated into life, how they influenced the development of complex life, and give insights into their behavior in other planetary bodies.

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