Geochemistry of Carbon Cycles on Rocky Exoplanets

A Lithology-based Silicate Weathering Framework

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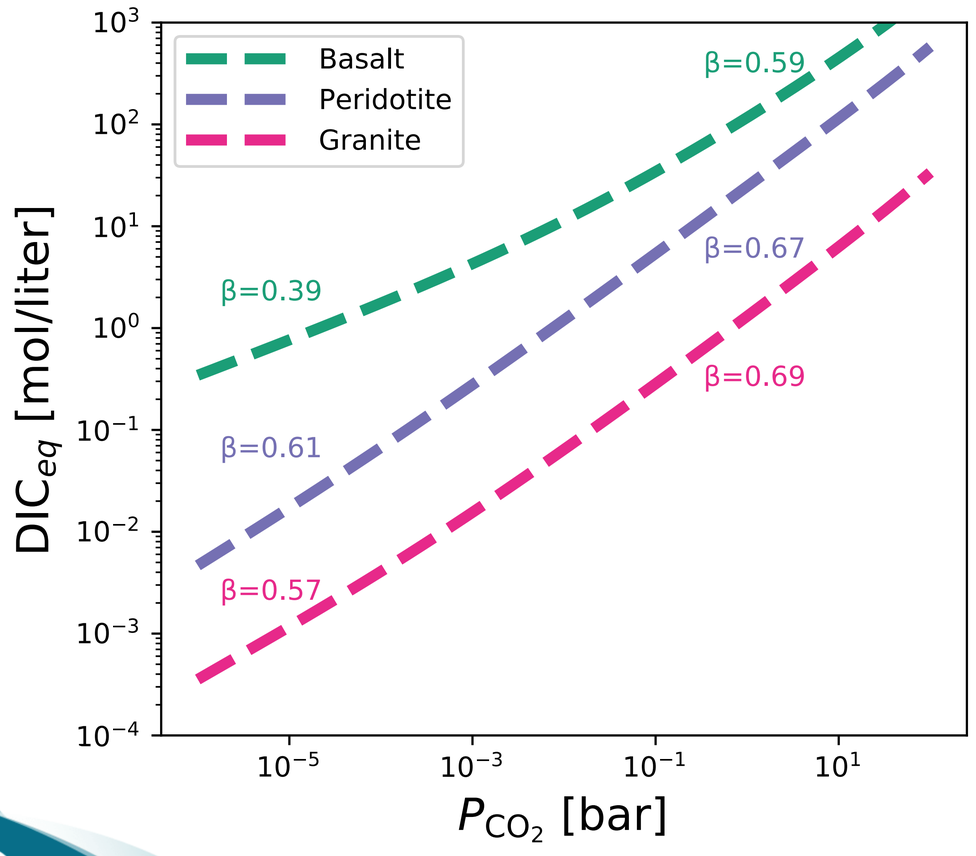
WHY?

- The long-term carbon cycle (carbonate-silicate cycle) provides the essential negative feedback in maintaining temperate climates on Earth [1]*
- Silicate rocks on exoplanets are likely to be diverse than present-day continents
- Previous studies model the sensitivity of weathering rates on the partial pressure of carbon dioxide P_{CO_2} using reaction rate coefficients based on chemical kinetics

  Weathering rate $\propto P_{CO_2}^{\beta}$ [1]
- Example weathering reaction:

  $CaSiO_{3(s)} + 2\ CO_{2(aq)} + H_2O \leftrightarrow Ca^{2+} + 2\ HCO_3^- + SiO_{2(aq)}$
- Equilibrium chemistry also allows determining β [2]

WHAT?



KEY FEATURES

- Estimates of weathering from first principles of chemistry
- Applicable to both seafloor and continental silicate weathering

HOW?

- We track the total dissolved inorganic carbon at chemical equilibrium (DIC_{eq})

$$DIC_{eq} = [CO_{2(aq)}] + [CO_3^{2-}] + [HCO_3^-]$$

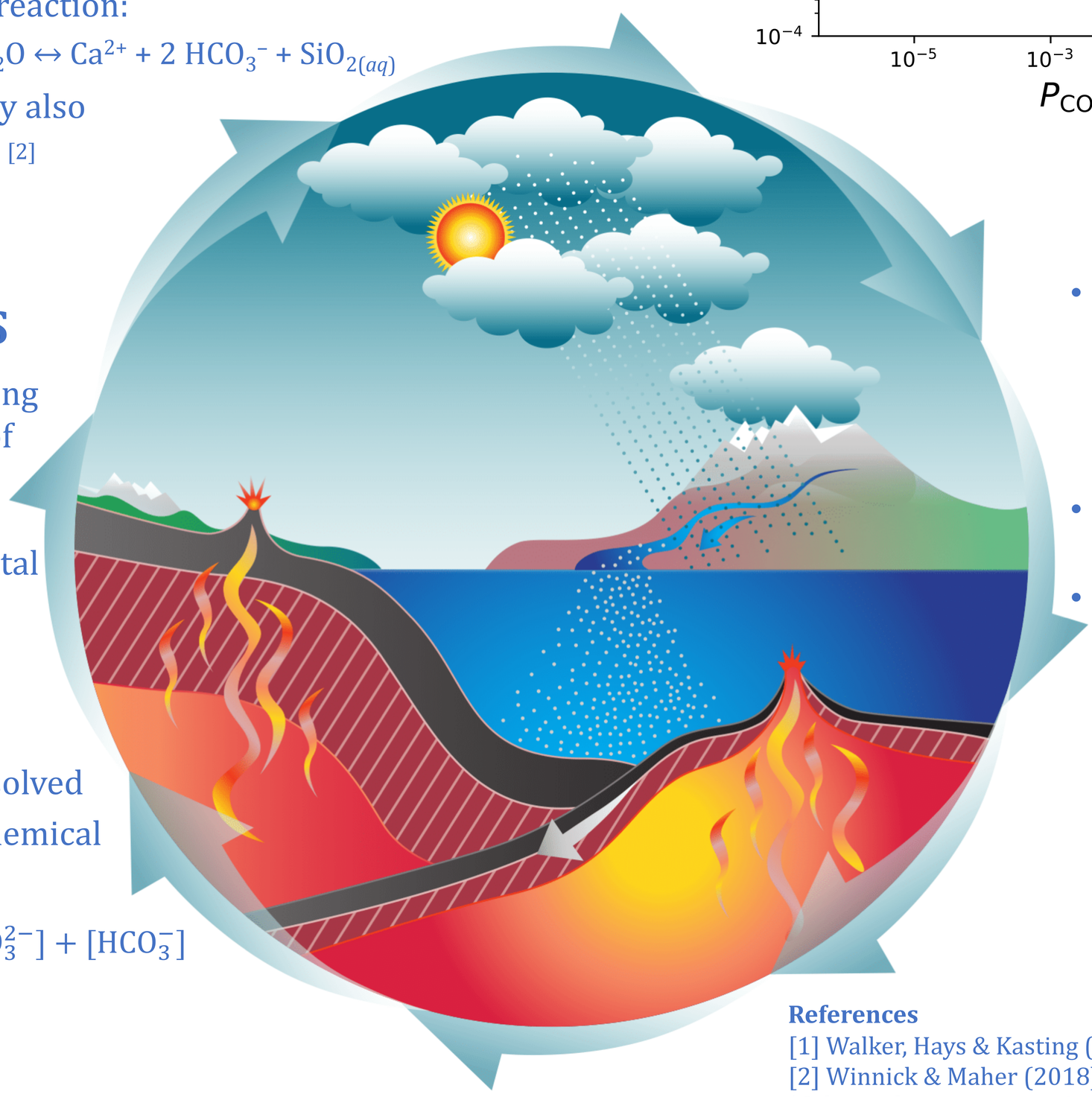


Illustration credit: Jenny Leibundgut

HIGHLIGHTS

- The sensitivity (β) of the weathering feedback to P_{CO_2} is not constant as assumed by previous studies
- It is a strong function of lithology and P_{CO_2}
- Our framework is based on geochemical reactions and extendable to non-silicate weathering and atmospheres denser or more dilute than that of Earth

References
[1] Walker, Hays & Kasting (1981), J. Geophys. Res., 86, 9776
[2] Winnick & Maher (2018) EPSL 485, 111-120
*Other references are omitted for clarity of this presentation

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