Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17584

Exoplanet Ocean Chemistry in the Presence of Diverse Carbonates

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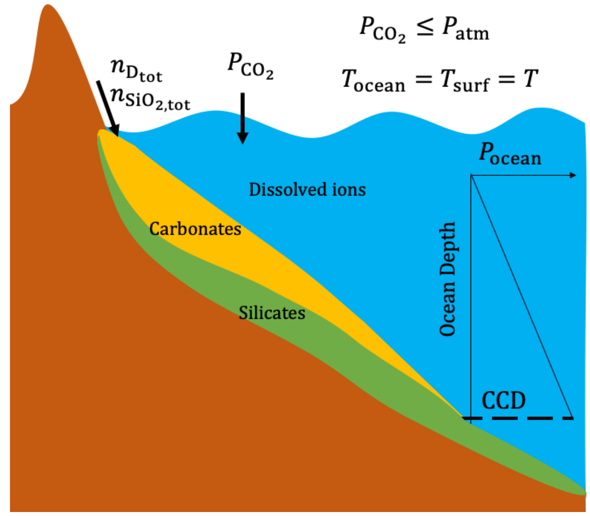

The carbonate-silicate cycle is thought to play a key role in planetary habitability. On Earth, continental silicate weathering and carbonate precipitation on the seafloor enable the storage of atmospheric CO2 in carbonates. Present-day carbonate precipitation on Earth's seafloor is mainly attributed to calcium carbonates. Geological evidence from the late Archean suggests that iron carbonates could have played a role. Observations of refractory element ratios in stellar photospheres and planet formation models suggest a larger diversity in exoplanet bulk composition than in the solar system and thereby their near-surface composition. In this work [1], we compute exoplanet ocean pH and carbonate compensation depth (CCD). We find that ocean pH exhibits a limited range of values as a function of ocean temperature and partial pressure of CO2, where the limits are given by the absence and presence of carbonates. The CCD increases with ocean temperature and partial pressure of CO2. If the CCD is above the seafloor, the carbonate-silicate cycle ceases to operate and therefore high ocean temperature and partial pressure of CO2 favor the carbonate-silicate cycle. With the help of pure carbonate systems of key divalent elements, we show that magnesium, calcium and iron carbonates produce an increasingly wider parameter space of deep CCDs, suggesting that chemical diversity promotes the carbonate-silicate cycle. This work motivates the inclusion of more chemically diverse targets than Earth twins in the search for life on exoplanets.

[1] Hakim K., Tian M., Bower D.J., Heng K., 2023, ApJL, 942, L20. doi:10.3847/2041-8213/aca90c