Rethinking Long-Term Controls on Planetary Climate

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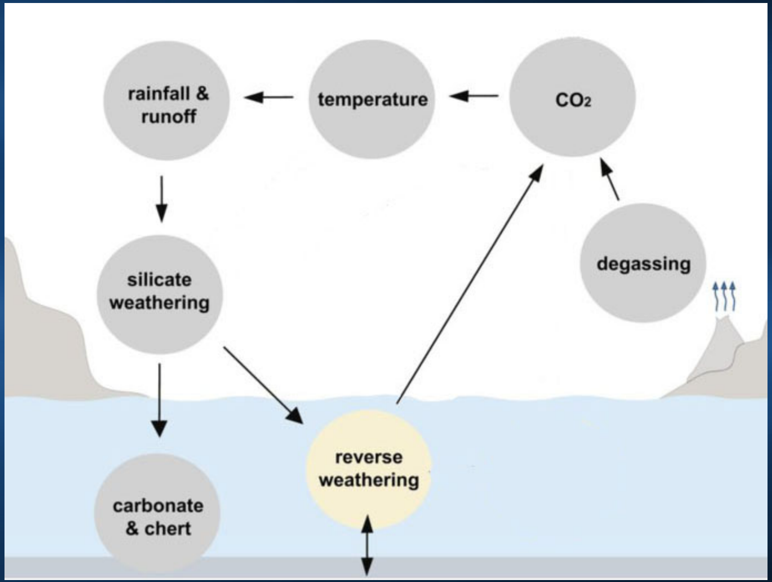
A CO_2 production process known as reverse weathering could explain how the early Earth stayed warm despite a fainter sun—and speaks to the potential habitability of rocky exoplanets that are otherwise too far from their host stars to sustain liquid water.



CONCEPTUAL MODEL FOR REVERSE WEATHERING. The return rate of CO_2 to the atmosphere was greater when silica content of the oceans was higher, as during the first four billion years of Earth's history.

INNOVATION | Over geologic time, chemical weathering of silicate rocks on Earth removes CO_2 from the atmosphere. This study suggests that the reverse of this process, when dissolved products of weathering react in the ocean to form clay minerals and return CO_2 to the atmosphere (left), would have been more active on Earth prior to about 500 million years ago.

DISCOVERY | Before the evolution of silica-secreting eukaryotic life, early oceans were more silica rich. Higher silica fueled more rapid rates of clay formation and CO_2 production during reverse weathering. This process would have also enhanced climate stability by mitigating large pCO_2 swings—a critical component of Earth's natural thermostat that dominated the planet's first four billion years. The rise of siliceous organisms and resulting decline in silica-rich conditions lowered baseline *p*CO2 levels and established a more volatile climate system, including rapid icehouse-greenhouse transitions.

RELEVANCE | Understanding how our planet regulates climate in the modern era and in the distant past is critical for explaining the long-term maintenance of planetary habitability on early Earth and Earth-like worlds beyond our solar system.

ALTERNATIVE EARTHS