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Plate tectonic driven changes in weatherability as the long-term control on Earth's climate state

Nicholas Swanson-Hysell (1), Francis A. Macdonald (2), Yuem Park (3), Yves Godderis (4), Lorraine E. Lisiecki (5), and Oliver Jagoutz (6)

(1) Department of Earth and Planetary Science University of California, Berkeley, (2) University of California, Santa Barbara , (3) University of California, Berkeley, (4) Géoscience Environnement Toulouse Observatoire Midi-Pyrénées, (5) University of California, Santa Barbara, (6) Massachusetts Institute of Technology

Through time, Earth's climate state has transitioned between non-glacial, glacial, and pan-glacial (Snowball Earth) regimes. A major unsolved question is: what sets Earth's climate state on these million-year timescales? While shifts between prolonged non-glacial and glacial intervals are widely considered to result from plate tectonic processes, the primary driver remains unclear. On geological time-scales, CO_2 is emitted primarily by volcanism and consumed primarily by the chemical weathering of silicate rocks. Prolonged imbalances between sources and sinks would catastrophically manifest in either the onset of a Snowball Earth or a runaway greenhouse. The relative clemency of Phanerozoic climate requires that CO_2 sinks scale with sources, which can be explained through the silicate weathering feedback where elevated CO_2 leads to higher temperatures and invigorated hydrological cycling that enhances chemical weathering and vice versa. Given that CO_2 sources must equal sinks on long timescales, what sets steady-state CO_2 levels on Earth at a given time? The concept of global weatherability, the product of variables such as lithology, tectonic uplift rates, and paleolatitude, which are set by evolving plate tectonic boundary conditions, is a useful framework to address these questions. On a more weatherable planet, the CO_2 concentration needed for the sink to equal the source is lower than on a less weatherable planet where CO_2 increases until high enough levels are reached for the chemical weathering flux to be sufficiently large. In this contribution, we evaluate long-term changes in paleogeography and mountain-building and their connections to Phanerozoic climate. We seek to test the hypothesis that ocean basin closure, arc-continent collision and ophiolite exhumation exert a major control on Earth's climate state by enhancing global weatherability. Using paleogeographic models, we reconstruct the past positions of ophiolite-bearing sutures from a newly-developed database. We find that when extensive arc-continent collisions have occurred in the tropics, the Earth has experienced a glacial climate, and otherwise the Earth has been in a non-glacial climate state. We interpret plate tectonic driven changes in rock type and topography in the tropics to be the most significant control on Earth's long-term climate state.