Tracking the long-term carbon cycle in Earth history: Himalayan anecdotes

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The long-term carbon cycle controls atmospheric CO_2 on $>10^6$ year time scales. Therefore, tracking temporal variability in the magnitude of CO_2 input from volcanic-metamorphic outgassing and the efficiency of the silicate weathering CO_2 sink through geologic time is critical to understand the mechanisms that drove changes in Earth's baseline climate. Here we will discuss the utility of proxies that aim to track both processes associated with the volcanic CO_2 flux and paleo-weathering rates. The detrital zircon U-Pb record tracks regional silicic magmatism, mostly derived from magmatic arcs. Our large zircon data compilation demonstrates a consistent first-order relationship between the variable distribution of continental arcs and major icehouse-greenhouse transitions, suggesting that volcanic CO_2 outgassing exerted the dominant control on baseline climate for the last ~720 Myr. We then use integrative structural, geo-/thermochronometric, and geochemical data from Himalayan bedrock and foreland basin deposits to examine the influence of Himalaya exhumation on the Sr and Os paleo-weathering proxies. Importantly, our data show that shifts in exhumation of compositionally and isotopically distinct thrust sheets directly corresponds with respective changes in seawater $^{87}Sr/^{86}Sr$ and $^{187}Os/^{188}Os$. Our age constraints for unroofing combined with mass-balance modeling indicates that the Neogene seawater $^{87}Sr/^{86}Sr$ and $^{187}Os/^{188}Os$ records were primarily driven by compositional changes in the source rock being weathering, rather than changes in global weathering rates. The influence of substrate compositions on these records hinders their utility to track silicate or shale weathering processes related to the carbon cycle during the Cenozoic, as well as throughout deep geologic time.