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An inverse model of the coupled carbon cycle and seawater chemistry for the Cenozoic

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Many studies have related paleo-seawater chemistry to changes in tectonic processes (e.g., mountain building, ocean crust accretion rate) and climatic conditions but few have rigorously evaluated the uncertainties in the interpretations of such models. Such uncertainties come from multiple sources: (i) the way the model is constructed; (ii) the parameter values used in the model; (iii) the range of possible drivers forcing the system that are considered; and (iv) the uncertainties in paleo-records. Without considering all such uncertainties any model that can recreate a given proxy record is at best likely to be just one of a spectrum of such models. Building on a previous developed model of the Li, Mg, Ca, and Sr cycles in seawater (Coogan and Dosso, 2022) we have developed a coupled model of the C, Li, Mg, Ca, and Sr cycles in the surficial environment. Element fluxes within the ocean associated with: (i) high- and low-temperature seawater-basalt reaction, (ii) chemical sediment formation, and (iii) diagenesis, are all parameterized to depend on the composition of seawater as well as other things (e.g., climate). The solid Earth C degassing rate is an unknown model parameter rather than being fixed as in most C cycle models. The carbon system in seawater is constrained by the major ion composition of seawater and temperature, as well as records of the carbonate compensation depth and estimated paleo-pCO_2 levels. The thermodynamics of the carbon system in seawater, and how these change with ocean chemistry and temperature, are included. Realistic uncertainties are estimated for all model parameters (e.g., mineral-fluid partition coefficients and isotopic fractionation factors). Inverting for the model allows the range of possible driving forces (e.g. changes in weatherability, spreading rate, degassing rate, etc), and the climatic dependence of element and isotope fluxes, that are consistent with the record of the evolution of Cenozoic seawater chemistry to be determined – these will be presented and the mechanisms controlling the climate buffering fluxes discussed.

Coogan and Dosso (2022) Controls on the evolution of Cenozoic seawater chemistry, GCA 329, p 22-37.