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Inverse modelling of linked geochemical cycles and climate over the Cenozoic: what can we say about the drivers and feedbacks?

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Many models of the long-term carbon cycle and associated elemental and isotope fluxes have been developed and these have variously been used to support (or reject) different models of the long-term carbon cycle. Most commonly these models are tested against paleo-records of: (i) atmospheric pCO_2; (ii) climate; (iii) seawater chemistry; and (iv) the CCD. However, such models rarely consider the uncertainties in our understanding of the controls on all the relevant fluxes.

We will present results from an up-dated version of the model used in [1] that tracks the tectonically and climatically driven changes in surficial geochemical cycles. In this model the fluxes from continental weathering, marine diagenesis, and high- and low-temperature alteration of the oceanic crust are calculated as functions of time, varying with tectonic and climatic boundary conditions. Uncertainties in all input parameters are explicitly included, and the model is inverted to determine what range of model parameter sets are consistent with the observational constraints. Modelling shows that the Mg, Ca and Sr concentrations in seawater, and the Li, Mg and Sr isotopic compositions of seawater over the Cenozoic can all be fit while maintaining a balanced alkalinity cycle. Importantly these data can be fit equally well while from 65 Ma to present: (i) CO_2 degassing rates increase, are constant or decrease; (ii) seafloor accretion rates decrease or remain constant; and (iii) continental weatherability increases or remains constant; i.e., these data cannot currently differentiate between such models as the controls on Cenozoic cooling and ocean chemistry evolution.

We will also present results exploring how the lower dolomite/calcite ratio in modern carbonate sediments than in those weathering on the continents affects these results depending on whether this excess Mg flux is removed through exchange for Ca in hydrothermal systems or via reverse weathering [2]. Constraints from Mg isotopes will also be presented.

References:

[1] Coogan and Dosso (2022) GCA v329, p 22-37.

[2] Husson and Coogan (2023) Geochemical Perspective Letters, in revision.