Multiple hypotheses for change in the Cenozoic carbon cycle

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Global cooling over the past 60 Myrs is one of the remarkable features of the geologic record, yet conclusive understanding of this transition and its links to the global carbon cycle is elusive. The hypothesis of a tectonic driver of increased continental weathering and consequent drawdown of CO_2 from the atmosphere has received much attention but remains controversial. Meanwhile, debate has emerged over the extent of global-scale changes in solid Earth degassing and whether such decreases could explain changes in the global climate system. This contribution will present new modeling results showing that plausible changes in solid Earth degassing driven by changes in carbonate subduction could indeed contribute to, and even potentially explain, Cenozoic global cooling. We have tracked plate motion over time and followed the accumulation of carbonate as oceanic crust resides at varying depth and at varying latitudes prior to subduction. On this basis we infer a decrease in the amount of carbonate entering subduction zones that mirrors the global cooling of the past 60 Myr. When used to force a carbon cycle model, this decrease leads to significant magnitude of change in implied atmospheric pCO_2.

At the same time, the growing datasets from modern systems confirms that erosion stimulates CO_2 drawdown via silicate weathering but also releases carbon from the rock reservoir via coupled weathering of sulfides and carbonates. Changes in global sedimentation appear to be consistent with an increase in erosion over the past tens of millions of years. Thus either a “erosion-weathering” or a “degassing” explanation for Cenozoic cooling appear theoretically reasonable, and C cycle models are not on their own able to distinguish these possibilities.

The resulting question is whether existing geochemical evidence makes it possible to distinguish between these hypotheses. The isotopic records of Sr, Os, Be, and Li in seawater each provide some information, but each is also non-unique in its interpretation, obfuscating clear insight into the drivers of Cenozoic climate, and requiring renewed effort to tackle this problem by focusing on specific strategies for testing the multiple hypotheses.