

The global CO₂ degassing flux estimated from the O-isotopic evolution of seawater

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On long timescales the global carbon cycle involves degassing of CO₂ from the solid earth, reaction of this CO₂ with silicate minerals, and the subsequent formation of secondary silicate and carbonate minerals (the Urey reactions). This cycle regulates Earth's climate. However, there are currently substantial uncertainties in the long term flux of CO₂ from the solid Earth hindering attempts to quantify this process and to understand the evolution of ocean chemistry.

As well as removing CO₂ from the atmosphere, the Urey reactions transform minerals formed at high-temperatures (e.g., igneous feldspars) into mineral stable at low-temperatures (e.g., carbonates and clays). These low-temperature minerals are enriched in ¹⁸O relative to their precursors providing a link between the evolution of the C-cycle and the O-isotopic composition of the hydrosphere [e.g. Coogan et al., 2018]. Recent work [e.g. Henkes et al., 2018] strongly suggests that the O-isotopic composition of seawater has not changed substantially over the Phanerozoic. This means that the sources of isotopically heavy O to seawater (principally high-temperature hydrothermal circulation at mid-ocean ridges) must be balanced by the sinks related to C-draw-down (weathering and carbonate precipitation). Quantifying these links allows the average Phanerozoic CO₂ degassing flux to be directly calculated from the O-isotope fractionations associated with the Urey reactions. Using this approach the average Phanerozoic CO₂ degassing flux was 5±1.2 Tmol per yr.

The largest uncertainty in the approach to determining CO₂ degassing rates used here comes from the relative masses of silicate and carbonate minerals formed during weathering. The larger the relative mass of silicates formed the smaller the global CO₂ degassing flux needed to balance the O-isotope budget of seawater. This has important implications for the maximum role reverse weathering can have played in the C-cycle during the Phanerozoic because this acts to form low temperature (¹⁸O-enriched) silicates without forming carbonates.

Refs: Coogan et al., 2019, EPSL, 508, p 41-50; Henkes, et al., 2018. EPSL, 490, p 40-50.