Silicate weathering vs. organic carbon burial: Who wins?

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The primary sinks for CO_2 released to the atmosphere and ocean are: (1) direct reaction with silicate rocks (whether exposed at the land surface or within oceanic crust) followed by burial in the form of calcium (/magnesium) carbonate, and (2) uptake and incorporation into biogenic molecules followed by burial as organic carbon. Either, or both jointly, could be responsible for the long-term (>100 kyr) regulation of atmospheric CO_2 and climate, and equally, either or both could play key roles in driving the recovery of the Earth system from faster (<100 kyr) transient and particularly carbon release driven perturbations. As such, studies and models generally pick one or the other (and less commonly both, but often as independent sinks), depending on the question and preconceptions about the 'answer'. However, weathering at the land surface, in addition to removing CO_2, also leads to the supply of dissolved phosphate to the ocean, fueling biological productivity and hence carbon burial. Not only are both sinks hence inherently coupled, but should exhibit very different relationships under fully oxygenated vs. reducing conditions, as the latter condition would be expected to be characterized by greatly increased phosphate recycling and carbon burial efficiency.

Here, using an Earth system model – (GENIE-) 'muffin' – that includes both terrestrial weathering and carbon-phosphorous cycling sedimentary components, we explore the relationship between the two primary sinks of CO_2 and how this relationship changes as a function of the oxidation state of the Earth surface.