

Temporal Scaling of Marine Respiration

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The extent to which respiration balances photosynthesis determines not only environmental concentrations of CO₂ but also O₂. An understanding of this balance is therefore crucial to understanding coevolving biogeochemical and evolutionary transitions.

Respiration occurs at all time (t) scales, but at progressively slower rates, decaying roughly like $1/t$ as organic matter falls from the sea surface to the sea floor, and as it proceeds through degradation in sediment [1]. Qualitatively, this slowdown can be at least partially attributed to the decreased accessibility of organic carbon to microbial degradation. In particular, the association of sedimentary organic carbon with clay mineral surface area is thought to preferentially protect some organic detritus from microbial degradation [2].

These observations motivate a theory for detrital decay. The key assumption is that the process is limited by the diffusion of hydrolyzed organic carbon from solid (i.e., mineral) surfaces to bacteria. The site-specific rate of decay is assumed to be proportional to diffusive fluxes associated with surface sites. Averaging over these microscopic rates one can then obtain the observed macroscopic $1/t$ decay. This correspondence appears valid for a reasonably wide range of porous microgeometries characterizing assemblages of minerals, microbes, and organic matter.

Biogeochemical interest lies not so much with the $1/t$ slowdown in *rates* but rather the decay of the *concentration* of organic carbon. Observations suggest that the latter decays like $t^{-\alpha}$, where α varies between about 0.1 and 1.0. Under certain general assumptions, however, the theory described above predicts a unique value of α . A better understanding of α 's natural variability is relevant to understanding changes in the carbon cycle at both short and long time scales. In particular, the latter may provide an important clue in attempts to understand the timing and mechanisms underlying the long-term production of atmospheric oxygen, especially insofar as they may be related to changes in the sedimentary deposition of clay minerals [3].

References

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