Global Carbon Cycling on a Heterogeneous Seafloor

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Diverse biological communities mediate the transformation, transport, and storage of elements fundamental to life on Earth, including carbon, nitrogen, and oxygen. However, global biogeochemical model outcomes can vary by orders of magnitude, compromising capacity to project realistic ecosystem responses to planetary changes, including ocean productivity and climate. Here, we compare global carbon turnover rates estimated using models grounded in biological versus geochemical theory and argue that the turnover estimates based on each perspective yield divergent outcomes. Importantly, empirical studies that include sedimentary biological activity vary less than those that ignore it. Improving the relevance of model projections and reducing uncertainty associated with the anticipated consequences of global change requires reconciliation of these perspectives, enabling better societal decisions on mitigation and adaptation.

Where Has All the Carbon Gone?

Rapid and well-documented environmental change over the past century has accelerated interest in quantifying the critical role of the ocean in global carbon and nutrient cycling [1]. As human pressures [e.g., climate change and biodiversity (see Glossary)] alter physical and biological processes, we must improve our capacity to predict the consequences of these alterations and their links to global cycles [2]. Divergent thinking in evaluating global cycles [3,4] and the role of biodiversity [5] has led most marine studies to compartmentalize biogeochemical versus biological approaches, with little effort to integrate alternative perspectives [6]. The functioning of most of the global seafloor depends largely upon the addition of oxygen and organic matter to the sediment–water interface [7] (Figure 1). Biogeochemical and ecological approaches both have value in assessing these processes, but remain poorly reconciled [8], an issue also noted in geological [9] and paleobiological [10] studies. Previous authors have highlighted the need for all types of model to improve how they represent sedimentary processes [8,11,12]. Here, we illustrate how different biases and/or perspectives associated with different world views (Figure 1) can lead to both different model projections and differential abilities to interrogate model outcomes to understand better the cumulative effects of drivers of change. The nature of the questions a model is expected to inform should influence the complexity of the model. However, the application of models to broad-global scale projections often requires simplification and averaging [13], which can lose key complexity or heterogeneity [14] essential in detecting all but the coarsest change. Biogeochemical modelers focus on the physical and chemical processes [15] that affect microbial activity in a way highly suited to developing global models [16], whereas ecologists focus on developing overarching themes governing ecosystems by studying different groups of organisms and how their activities vary.

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References

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