BIOGEOCHEMISTRY

Oxygen lost and found

The canonical checks and balances of Earth's oxygen cycle — production through photosynthesis and consumption through cellular respiration — greatly influence the climate and redox chemistry of the planet. In addition to respiration, oxygen can also be lost through a lesser known process, microbial conversion to superoxide, a reactive oxygen species that plays many diverse roles in metabolism. Although superoxide has largely been overlooked when it comes to oxygen budgets, evidence has suggested that this process could be particularly pervasive across marine microbial systems.

Kevin Sutherland from the Woods Hole Oceanographic Institution, USA, and colleagues compiled light-independent, extracellular superoxide production rates obtained using a chemiluminescent probe on representative microbes that dominate key ocean regions. Superoxide production by cyanobacteria and unicellular eukaryotic phototrophs, such as diatoms and coccolithophores, was found to far exceed heterotrophic bacterial production. One exception was *Prochlorococcus*, the most abundant cyanobacterium in the ocean, which had the lowest

rate of production of the organisms tested. Scaled up to the global ocean, superoxide production rates were calculated to represent a loss of $\sim 4 \times 10^{15}$ moles of oxygen per year, an amount that equates to approximately 36% of the total oxygen produced by marine photosynthesis. Such a substantial proportion indicates the so-called cryptic oxygen cycle is an overlooked but critical facet of marine redox dynamics.

Although these estimates were ground-truthed with environmental measurements of superoxide, the analyses only considered production by select organisms grown under laboratory conditions that are not necessarily reflective of the environment. Culture conditions — known to accelerate metabolic processes — could therefore yield artificially high estimates. Moreover, a suite of additional superoxide production mechanisms, such as light-dependent pathways, were not taken into account by the experiments. Thus, the superoxide production estimates are conservative and can be assumed to be even greater in the natural environment.

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