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Precipitation and dissolution of calcium carbonate: key processes bridging the bio- and geosciences (Vladimir Ivanovich Vernadsky Medal Lecture)

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In this Vladimir Ivanovich Vernadsky medal lecture, I will focus on the biogeochemical cycle of calcium carbonate ($CaCO_3$) which is arguably one of the best example of a set processes that bridge the bio- and geosciences. The main reactions involved are calcification and dissolution that, respectively, manufacture and destroy calcium carbonate. Biology is intimately involved in these two processes which are key controls of the Earth's climate and leave remains that are of great use to human societies (as building materials) and geoscientists. I will illustrate the bridge between the bio- and geosciences by providing brief examples for each of the following four issues.
(1) The marine cycle of $CaCO_3$ and its relationship with climate. The release of CO_2 by the precipitation of calcium carbonate and the uptake of CO_2 by its dissolution are important controls of atmospheric CO_2 and climate. The vertical distribution of Ψ, the ratio of CO_2 released/used per $CaCO_3$ precipitated/dissolved in the ocean will be shown to be consistent with the Högbom-Urey reactions.
(2) The use of $CaCO_3$ in paleooceanography. The remains of calcium carbonate shells and skeletons are wonderful archives of past environmental changes. Their isotopic composition and the concen-tration of trace elements are invaluable in the reconstruction of past climate. I will address the challenge of calibrating one of the proxies used to reconstruct past ocean pH.
(3) The challenge of understanding calcification. Despite having been investigated for decades, many aspects of the physiological and molecular processes involved in calcification by marine organisms remain obscure. Recent breakthroughs, mostly on reef-building corals, will be briefly reviewed.
(4) The response of calcification and dissolution to environmental change. The critical importance of $CaCO_3$ precipitation and dissolution as climate controls makes it vital to understand their response to global environmental changes such as ocean warming and acidification. A few examples of knowns and unknowns will be presented.