From the East China Sea to Global Continental Margins: Their Role in the Global Biogeochemical Cycle in the Past, Present and Future

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Continental margins are an important yet poorly understood component in the Earth's biogeochemical system. However, we do know that they serve as efficient CO_2 sequestration machinery in the ocean, known as the continental shelf pump. The estimated net CO_2 uptake by continental margins could be as much as 0.3 Pg C/yr, representing ca 20% of the net CO_2 uptake (1.6 PgC/yr) in the global ocean. They also account for more than 3/4 of oceanic denitrification (including anoxic ammonium oxidation) and probably nitrogen fixation, too. It is remarkable that many continental margins that receive high loads of carbon discharged by rivers can still take up atmospheric CO_2. In fact, they could be a net source of CO_2 in pre-industrial era, but how they have evolved to become a net sink at present and how they will change in the future are critical issues we need to grapple with. The future change will likely have a significant impact on the global carbon cycle, while the past evolution may be the key to future prediction.

The biogeochemical system of the East China Sea (ECS), which first inspired Professor Tsunogai to coin the term, continental shelf pump, may serve as a model system for us to examine the critical biogeochemical processes in continental margins. It is intriguing that the ECS can be so efficient in absorbing atmospheric CO_2 in spite of a huge riverine load of organic and inorganic carbon discharged from some of the largest rivers in the world. There have to be very effective processes in transporting the received carbon to the deep ocean. In recent years, it has been recognized that a suite of physical processes, including some rarely known ones, e.g., dense water cascading, fluid mud flow, tide-induced solitons, etc., facilitate the cross-shelf exchange. The fates of the carbon input follow three pathways of comparable importance, namely, burial in shelf sediments, export as organic carbon and export as dissolved inorganic carbon. Most of the buried carbon is probably the more refractory terrigenous organic carbon and carbonates. The export of organic carbon from the shelf may be facilitated by sediments, which serve as the carrier and protector. Dissolved organic carbon is another important form for export. Traditionally, heterotrophy (respiration exceeding photosynthesis) in continental shelves was equated to outgasing of CO_2. However, recent studies show that the stratified water column in continental margins, resulting mainly from freshwater runoff, often serves as an insulator to prevent escaping of CO_2 from respired organic carbon and allows export of the produced CO_2 to the deep ocean.

As we have gained better knowledge of how the biogeochemical system operates currently in continental margins, we are still far from understanding the changes of air-sea CO_2 fluxes since the industrial revolution, let alone predicting the future. Nevertheless, emerging new findings shed light on these crucial issues. A recent assessment indicates that the riverine loading of nutrients have increased significantly by human activities. The extra nutrient loads may have contributed to the sequestration of atmospheric CO_2. On the other hand, negative impacts of human activities on riverine loads of Si may reduce the abundance of diatoms, an efficient CO_2 fixer, in the river plume. It is highly desirable to develop coupled physical-biogeochemical models to examine how the natural and human-induced changes in physical-chemical conditions that have driven and will continue to drive the biogeochemical changes in continental margins in the Anthropocene.