Stochasticity, Stability, and Hysteresis in Biogeochemical Cycling of Carbon and Silicon

Photo: Yi Hou

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The cycling of elements between surface environments and the rock reservoir sets the chemistry of the atmosphere, natural waters, and soils. Carbon (C) and Silicon (Si) are particularly interesting as they are important in controlling our planet's climate and habitability. However, the rates at which relevant biogeochemical processes drive and respond to environmental change remain poorly constrained. Uncertainties further arise from *stochasticity* (i.e., randomness) and *hysteresis* (i.e. state-dependence) inherent in the Earth system. With these thoughts in mind, this presentation will focus on two key geochemical processes, 1) the burial and preservation of organic carbon (OC), and 2) the chemical weathering of silicates, and how they co-evolve with other Earth-surface processes.

OC burial is affected by sedimentation dynamics. Due to the internal dynamics in sedimentary systems, sedimentation rates at a discrete location appear virtually random. To investigate the previously unknown effect of this stochasticity on OC preservation, reactive-transport modeling was coupled with statistical methods. The results show that this stochasticity alone can profoundly alter OC burial efficiencies and create autogenic signals independent of climatic or environmental forcings, which are likely prevalent in observed chemostratigraphic records.

How silicate weathering responds to glaciation remains debated. A novel multi-proxy model was developed leveraging modern field observations. Changes of weathering flux over the past 10 ka were reconstructed in two Icelandic watersheds with different glacial histories. The results show a synchronous increase in weathering fluxes with the expansion of glaciers. Our findings suggest that portions of the land surface do not necessarily follow global predictions for a negative climate weathering feedback, which represents a plausible mechanism of generating multiple steady-states in the carbon cycle.

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