Rock Metamorphism, the Global Carbon Cycle, and Planetary Habitability

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Planet Earth has supported life for billions of years. Despite profound changes in the surface environment and the deep Earth, our climate has remained relatively stable — and critically, habitable — over this time period. This stability is a result of the geologic Global Carbon Cycle, which acts to exchange carbon between the solid Earth, oceans, and atmosphere on timescales of ~1 million years or longer. A detailed understanding of this exchange provides an essential framework for consideration of the origin and evolution of life, the structure and composition of the deep mantle, and myriad Earth surface processes.

Although the lithosphere represents a small proportion of the solid Earth, it is the location of several key processes, linking carbon transfer in the ocean-atmosphere system to the deep mantle carbon cycle. While the literature has historically focused on volcanic-magmatic processes in the crust, my advances in the observation and modeling of metamorphic reactions demonstrate that rock metamorphism plays an equally important role in carbon mobility.

I will review the results of two studies: first, a field-based project in the Acadian metamorphic belt of New England reveals that mountain-building has the potential to release significant CO₂ and drive climate change over millions of years. Second, a comprehensive study of an ancient subduction zone in the Cycladic Islands of Greece shows that metamorphism alone may release about half of all carbon from a subducting slab, driving progressive carbon depletion of the mantle over Earth history.