Silicate weathering: Where have we come in the last 50 years?

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In the context of the Geochemical Society's fiftieth anniversary I shall review how ideas on chemical weathering have evolved and where I think the field is going. The field received a large boost in the 1980s and early 1990s in conjunction with public concern over acid deposition. The objective here was to develop quantitative predictions of how acid neutralization by mineral weathering would respond to different levels of acid deposition from the atmosphere. It led to integrated quantitative models of how various ecosystem processes affect surface water chemistry. There was also extensive laboratory work on mineral dissolution kinetics. We learned a great deal about mineral dissolution mechanisms in laboratory systems but we have been remarkably unsuccessful to date in using laboratory results to model quantitatively weathering processes in the field. In the near future we should see new insights into mineral dissolution mechanisms from atomic-scale imaging and various spectroscopies.

In the past decade, the emphasis has been on role of weathering in the global carbon cycle, particularly as a long-term control on the CO_2 concentration and hence temperature of the atmosphere. This brings in the role of tectonic uplift, physical erosion, and various ecosystem processes, including human intervention, in CO_2 consumption by chemical weathering. New insights are coming from the innovative use of various isotopic systems.

Understanding of the role of chemical weathering in environmental processes cannot come from study of weathering processes in isolation. Weathering rates are strongly affected by ecosystem processes, by physical processes, particularly erosion, and by hydrologic processes. We need an integrative approach in order to understand how our planet functions.

Does life leave a topographic signature on Earth?

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If we only had high-resolution topographic data of the Earth's surface, and all signs of human activity were eliminated, could we tell from morphology alone that there is life of Earth? All landscapes on Earth today have evolved since the emergence of terrestrial life. Biotic processes influence nearly all erosion and transport processes, yet very little quantitative theory or observation about the role of biology exists. Consequently, few landscape evolution models explicitly account for biotic effects, hence the results of modeled linkages among climate, topography and tectonics are of uncertain value.

One approach to this problem is to ask how different would processes and landforms be in the absence of life. This analysis concludes that biotic processes strongly affect erosion and evolution of landscapes, but apparently does not lead to a unique topographic signature, i.e. a landform that could only be due to the presence of life. The removal of all life from present day Earth would cause landscapes to be more rocky and steep. Smooth convex hilltops, however, are possible in an abiotic world. Meandering rivers, while certainly less frequent in the absence of life, would still occur. The absence of vegetation would change the spatial pattern of precipitation, which would, in turn, change the height, width and symmetry of mountain belts. This inference argues that life matters, then, to mountain scale topography, although not in a way that leaves a distinctive morphology. If life had never arisen, the Earth might have similar features to today, but one outcome might have been a loss of all liquid water to space, and, as a consequence, an absence of plate tectonics.