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How does surface life affect interior geological processes?

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We propose that biologically-mediated processes operating on the surface of the Earth need to be incorporated into our understanding of the geological evolution of the Earth. We argue that biotic effects may penetrate the lithosphere and be responsible for altering the dynamics of mantle convection. Geological processes have played a fundamental role in the emergence and evolution of life on Earth. For example, the out-gassing of volatile compounds affects the composition of the atmosphere and thereby the climatic conditions for life while tectonic processes deliver and sequester material to and from the biosphere and thereby acts as a source and sink within the biogeochemical recycling system. This supports a perspective in which internal processes drive surface processes. An alternative perspective is that causation is more complex. For example, tectonic processes may in part control interior processes [1] and that the evolution of oxygenic photosynthesis had a profound impact on the rate of formation of continental crust [2].

We extend this perspective by providing first order estimates for the amount of work that is performed by life and atmospheric processes on the surface of the Earth and compare this with the amount of work done by geological processes within the interior of Earth. We show that surface life performs a magnitude more work that interior geological processes. We propose mechanisms whereby a fraction of the work performed by life can be used to alter interior processes. These effects arise from the ability of life to alter the boundary conditions for thermodynamic processes. We formulate a series of geological processes in terms of non-equilibrium thermodynamics. We calculate rates of power, energy dissipation and entropy production in order to quantify the nature of the interactions between surface and interior processes. These illustrate how biologically-mediated surface processes such as weathering and erosion can affect geological processes such as mantle convection.

References
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[2] Rosing M. T. et al (2006) The rise of continents..., Palaeogeography, Palaeoclimatology, Palaeoecology 232 99:113