

What is the mineral-fluid interface?

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For decades, we have described the extent and rates of interactions between minerals and aqueous solutions using thermodynamics and kinetics but these provide only macroscopic averages of behaviour over entire systems. Averages mask the individual processes that go on at the molecular scale. In the laboratory, thermodynamics and kinetics can reasonably describe the relationships we observe but in nature, there are often major discrepancies between predicted and measured parameters.

Nature is complex so it is possible that our models miss one or many reactions that play a key role. A common explanation for the discrepancy is that slow rates of reaction prevent systems from reaching equilibrium. Nanotechniques and molecular modelling have moved us a long way toward understanding what really happens at fluid-solid interfaces, providing the data we need to deconvolute effects from multiple processes. However, there are still many observations that cannot be explained with current knowledge.

There is mounting evidence, gathered over the past two decades using high resolution techniques, that all mineral surfaces have a strong affinity for organic compounds. These adsorbed carbon containing molecules can dramatically alter the mineral surface properties and in many cases, the modifications are permanent. Wettability, the surface response to the fluid, and the ability of the adsorbed material to attract other organic compounds make the properties of the surface different than they would be on a pure termination of the bulk crystal. Our studies have shown that all mineral surfaces in our world have at least a few molecular layers of adventitious carbon compounds. It is likely that this previously unrecognised material plays at least some role in the discrepancies between predictions and observations. Developing parameters to describe it is likely to significantly improve our predictive models for natural geochemical systems.