The deep Earth redox engine

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Over geologic time, exchange of volatiles such as CO_2 and H_2O between the Earth's deep interior and surface have set the composition of our habitable atmosphere, facilitated plate tectonics, and driven the dynamo in Earth's core. At depth within the Earth, volatiles encounter not only a gradient of increasing pressure and temperature, but also chemical stratification with decreasing availability of oxygen. These differences in conditions stabilize different mineralogy and forms for storing volatiles. I will discuss experiments on the chemistry and physical properties of minerals in Earth's mantle containing important redox-sensitive elements iron and carbon. As the major element with most complex redox behavior, iron is a key indicator of Earth's redox conditions, and the seismic properties of iron-bearing minerals could reveal heterogeneous redox conditions in inaccessible depths of Earth's mantle. Carbon is challenging to trace using geophysical methods, but deep carbon cycling provides us with the deepest-originated samples of the Earth: diamond inclusions. For these problems, developing experimental approaches to control of redox conditions and measurement of chemistry for miniaturized samples is essential. The results of these experiments allow us to understand deep Earth volatile cycles based on geochemistry and geophysics.