

A multi-component model for the partial melting in presence of CO₂ and H₂O in the mantle

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The link between volatiles and mantle melting has so far been illuminated by experiments revealing punctually, at a given P-T condition and under a specific chemical system, properties such as solubility laws, redox equilibria, and phase equilibria. The aim is to establish a multi-component model describing the Gibbs free energy of melt produced by mantle melting in presence of CO₂-H₂O: Carbonatite-carbonated melt and basalts.

Near solidus melts are dominated by carbonate-rich compositions, evolving towards basaltic compositions at higher temperatures. However, this carbonate-silicate transition is complex, abrupt, and dependent on temperature, pressure and the chemical composition of the system. In order to simulate partial melting in a variety of mantle conditions, we established a parameterization of the mixing properties allowing the complex activity-composition relationships for multi-component hydrated carbonated melts to be accounted for. Using the Margules formalism, this parameterization is calibrated on crystal-liquid, redox, fluid-liquid and liquid-liquid equilibria obtained by experimental studies in the P-T range 1-10 GPa and 900-1800°C (more than 500 data points). We so far adjusted the activity of the SiO₂ and CO₂ melt components which constitutes the main part of the silicated and carbonated frameworks. The SiO₂-CO₂ interaction reveals a strong non-ideality requiring a strongly asymmetric Margules formulation. We also determined the standard thermodynamic properties for the CO₂ melt component.

As applications, we define the composition of incipient melts as a function of depth underneath MORs and Hot-Spots and identify regions of CO₂ saturation for kimberlitic melts.

Multiple sulfur isotopic evaluation of porewater sulfate profiles

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Modern marine sediment porewater sulfate concentration profiles provide information about total and depth dependent rates of organic carbon remineralization. These profiles only provide net rates, however, as oxidative sulfur cycling is a challenge to uniquely quantify. Researchers have demonstrated active oxidative sulfur cycling in organic rich sediments (where sulfate reduction otherwise dominates) using the δ¹⁸O of porewater sulfate. The utility of this approach, which still carries great promise, relies on a robust understanding of *in situ* sulfur oxidation processes. Furthermore, recent work targeting the oxygen isotopic consequences of the sulfate reduction network, and experimental work on oxygen isotope exchange with sulfur intermediates, demonstrates a complexity to interpreting these records that is to date not fully explored.

Aimed at improving the estimates of net and gross sulfate reduction derived from porewater sulfate profiles in organic rich sediments, we present multiple S (³⁴S/³²S & ³³S/³²S) and sulfate oxygen (¹⁸O/¹⁶O) isotopic profiles from 5 anoxic basins within the California Borderlands and Mexican Margin (Alfonso, Mazatlan, Soledad, Santa Monica, San Blas). All sites exhibit linear sulfate concentration profiles that are used to infer rates of methanotrophy using simple flux balance models, and thus extracting rates of sulfur recycling complements those estimates. We discuss the utility of applying coupled minor sulfur isotope (³³S/³²S) and ¹⁸O/¹⁶O systematics in improving estimates of sulfur recycling processes in these oxidant limited systems, and their implications for improving early diagenetic models of sulfur mediated remineralization reactions.