

## Acid-base and ion exchange properties of two thermophilic bacteria at different growth times

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Acid-base titrations, electrophoretic mobility measurements, and cadmium adsorption experiments were conducted with the thermophilic bacteria *Anoxybacillus flavithermus* and *Geobacillus stearothermophilus* at two different growth times corresponding to exponential and stationary-death phase. The data showed significant differences between the two investigated growth times for both bacterial species. In stationary-death phase samples, cells were disrupted and their buffering capacity was lower than that of exponential phase cells. For one species the electrophoretic mobility profiles changed dramatically. The adsorption experiments revealed release of the cations Na<sup>+</sup>, K<sup>+</sup>, H<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup> in response to adsorption of Cd<sup>2+</sup>.

Chemical equilibrium models were developed to describe the experimental data, and a simple approach was employed to determine confidence intervals for the overall variance between the model and the experimental data, in order to identify statistically significant changes in model fit and thereby select the simplest model that was able to adequately describe each dataset. Exponential phase cells of the investigated thermophiles had a higher total site concentration than the average found for mesophilic bacteria (based on a previously published generalised model for the acid-base behaviour of mesophiles), whereas the opposite was true for cells in stationary-death phase. The results of this study indicate that growth phase is an important parameter that can affect the acid-base and ion exchange properties of bacteria, such that growth phase should be considered when developing or employing chemical models for bacteria-bearing systems.

## Investigating the dissolution behavior of serpentine

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Despite the relative importance of serpentine weathering processes in mid-ocean ridge environments and continental ophiolite complexes, as well as potential importance for CO<sub>2</sub> sequestration, little is known concerning its dissolution behavior, especially at elevated temperatures.

Our ongoing investigation is focused on the dissolution kinetics and stoichiometry of lizardite (nominal composition: Mg<sub>3</sub>Si<sub>2</sub>O<sub>5</sub>(OH)<sub>4</sub>) based on experiments in continuously stirred flow-through reactors at acidic to circum-neutral pH, at temperatures ranging from 25 to 90°C, and in the presence or absence of high partial CO<sub>2</sub> pressures (*p*CO<sub>2</sub> = 60 bar). Our preliminary data (atm *p*CO<sub>2</sub>) are representative of far-from-equilibrium conditions. In the pH range 3.3 to 6.7 the dissolution kinetics decrease exponentially with pH, yielding a partial 'U-shaped' relation between rate and pH (the rates at basic pH have not yet been measured). The exponent describing the pH-dependence of the rate is 0.48 at acid pH (90 °C). This value can be compared to that determined by Carroll and Walther (*AJS*, 1992) for the dissolution of another sheet silicate (kaolinite) at 80°C (0.48). At 90 °C, the apparent release rates show transient non-stoichiometry, with release Mg > release Si during the initial 15-40 days of dissolution. The time necessary to reach stoichiometric dissolution varies with pH; stoichiometric dissolution is reached more rapidly at low pH. The evolution of the elemental ratio  $q = \text{Mg/Si}$  is found to decrease following a power rate law with time:  $q = a \cdot t^b$  with  $a = 0.98\text{pH} - 1.03$  and  $b = -0.08\text{pH} + 0.14$ .

Current research is directed to ascertaining whether the formation of a silica rich surface altered layer is due to the preferential release of Mg over Si, coupled with counter diffusion of H<sup>+</sup> from solution (i.e. leached layer theory). Alternatively, it may form by an interfacial dissolution-precipitation mechanism, as proposed by Hellmann and co-workers (*PCM*, 2003). Direct nanoscale measurements of the altered layer using focused ion beam milling (FIB) and TEM techniques will help resolve this question.