Aspartate transformation under hydrothermal conditions with brucite [Mg(OH)2]

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The role of hydrothermal systems in origins of life scenarios has been debated due to the perceived instability of amino acids at high temperatures. However, little is known about the stability of amino acids in the presence of mineral surfaces and reducing conditions that reflect the geochemical complexities of hydrothermal environments such as serpentinite-hosted hydrothermal vents. We investigated the decomposition of 25 mM aspartate at 200 ºC and 15.5 bars in gold tubes both with and without brucite [$Mg(OH)_2$], a stable mineral during serpentinization, and reducing conditions (NH_4Cl and $H_{2(aq)}$). We observed that the reaction kinetics of aspartate are complex and vary significantly with the initial reaction conditions. Fluids containing aspartate alone decomposed to fumarate, maleate, malate, acetate, and minor amounts of succinate and glycine. Under reducing conditions (2.4 ± 0.6 mM NH_4Cl and 13 ± 10 mM $H_{2(aq)}$), the main product was succinate (8 mM), together with a total of ~1 mM of the amino acids glycine, α-alanine, and β-alanine. In the presence of brucite, we detected up to 2.6 mM α-alanine and glycine, but no β-alanine, which suggests that the addition of a mineral surface could play a stereoselective role in the formation of α-alanine. The presence of brucite was also associated with a decrease in the fumarate concentration by a factor of three whereas maleate concentration decreased by over a factor of ten, leading to an overall increase in the fumarate-to-maleate ratio from 0.9 to 4.5. This increase in the cis/trans ratio might have been caused by stereoselective adsorption, a pH shift, or increased Mg^{2+} concentrations. The results of this study provide clear evidence that the fundamental properties of a hydrothermal system, including mineral assemblages, reducing conditions, and dissolved species concentrations, may directly influence the fate of amino acids at high temperatures.