

Variations in Amino Acid Selectivity during Adsorption to Smectite and Serpentine Clays

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The concentration of simple organic molecules, such as amino acids, onto mineral surfaces via adsorption may have aided the condensation reactions necessary for the formation of more complex bio-macromolecules on the early Earth. Prior work has established a relationship between the structural charge of a clay mineral and amino acid adsorption, suggesting that interactions between these biomolecules and diverse clays present on the early Earth would differ. This study evaluates the adsorption behavior of amino acids to smectites and serpentines, which are clays expected to be found in early submarine hydrothermal systems and subaerial shallow water basins. The pH of the fluid was controlled to reflect various environments: pH 5 (e.g., basalt-hosted hydrothermal systems), pH 7 (e.g., seawater), and pH 10 (e.g., alkaline lakes). At both pH 5 and 7 in a sodium chloride fluid, amino acids with basic sidechains (L-arginine and L-lysine) are selectively adsorbed to montmorillonite through a cation exchange mechanism into the mineral interlayer. L-arginine and L-lysine are primarily cationic under these conditions and show Langmuir constants much greater than amino acids that are predominantly zwitterionic (glycine, L-asparagine, L-tryptophan, L-serine, L-threonine, L-leucine, and L-alanine) or anionic (L-glutamic acid) in solution. On average, the Langmuir constants for the cationic amino acids are 30 (pH 5) and 60 (pH 7) times greater than for the zwitterionic amino acids and 120 (pH 5) and 80 (pH 7) times greater than the constants for L-glutamic acid. Results for montmorillonite at higher pH as well as for a range of clays with different compositions and structures (e.g., nontronite, saponite, lizardite) will also be presented.