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Synergistic chemical evolution of Fe-smectite and glycine during mineral crystallization

Organo-mineral interactions involving swelling clay minerals are pivotal in biogeochemical processes across modern and ancient surface environments (e.g., soils, sediments), where these minerals often dominate fine-grained fractions. Due to their physicochemical properties and high specific surface area, they adsorb and concentrate organic molecules. Although sometimes viewed as passive supports, studies of clay synthesis and dissolution indicate that these minerals are highly reactive. When interacting with organic precursors, they can alter clay formation mechanisms, generating new reactivities that influence the behavior of chemical species.

This study examines the dual role of glycine in Fe-smectite crystallization under hydrothermal conditions (150 °C, 5 days, inert atmosphere), exploring how this amino acid affects mineral formation. X-ray diffraction verified Fe-smectite crystallization over a range of glycine concentrations (0.08 to 0.6 M). Higher glycine levels reduced tetrahedral Fe(III) and promoted Fe(III) to Fe(II) reduction, as shown by XRD, FTIR, and electrochemical data, resulting in changes to the cation exchange capacity. Glycine polymerization was significantly enhanced in the presence of Fe-smectite compared to controls without minerals, favoring linear peptide chains over diketopiperazine (DKP). These results reveal a mutual interaction between glycine and minerals, producing phases with distinct structural properties that enhance organic matter transformation.
Overall, this study highlights how the co-evolution of smectite and organic molecules under hydrothermal conditions can yield specific reactivities and enrich organic complexity. It offers new insights into the intricate mechanisms governing organo-mineral interactions in both past and present biogeochemical processes.

Keywords: Fe-smectite, hydrothermal synthesis, polymerization, Glycine

Biography

My academic journey began with a Bachelor's degree in Physics and Chemistry, where I discovered my passion for chemistry. Driven by this enthusiasm, I pursued an engineering degree in Analytical Chemistry and Instrumentation. During my final internship, I studied amino acids, known as the basic building blocks of life, focusing on their functionalisation and detection by GC-MS for space applications. This experience led me deeper into the study of the origins of life and inspired my current PhD thesis, which investigates organo-mineral interactions between smectites and amino acids as a potential key to understanding the origin of primitive life on Earth.

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