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Illitization of smectite influenced by chemical weathering and its potential control of anatase formation in altered volcanic ashes

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Abstract

Illitization of smectite in sedimentary systems, a process akin to "reverse weathering," is a diagenetic process that has significant implications for sediment paragenesis and hydrocarbon exploration. However, the potential influence of chemical weathering on the illitization of smectite and its possible control of the neogenesis of titanium (Ti)-oxides remain unclear. Altered volcanic tephra layers (i.e., K-bentonites) characterized by an interstratified illite-smectite (I-S) clay mineralogy serve as an excellent medium to investigate the illitization of smectite. In this study, we first investigated the fine structure of clay minerals and in situ nano-mineralogy of Ti-bearing minerals from altered volcanic ashes and then undertook a meta-analysis of geochemical compositional data for bentonites spanning a wide range of ages and depositional environments globally. We found that Ti mainly occurs as discrete micrometer-scale magmatic srilankite and nanoscale authigenic anatase crystals. During the weathering process, the magmatic srilankite partly dissolved under acidic conditions, resulting in a local buildup of Ti in porewaters. The I-S displays a platy habit and curved edges and is found closely associated with anatase crystals under TEM. Our compilation results combined with microscopic evidence suggest that chemical weathering may potentially promote the illitization reaction by changing the chemical composition of the fluids through increased terrestrial inputs and by creating larger pore spaces through the decomposition of weatherable components. Positive correlations between K and Ti are especially common in (K-)bentonites that are dominated by I-S, suggesting that I-S can adsorb Ti during the weathering process and provide a suitable site for the nucleation of anatase. Our study highlights the role of chemical weathering in the illitization of smectite and their combined effect on the formation of Ti-oxides.

Keywords: Nanoscale, meta-analysis, illite, Ti-oxides, diagenesis, mixed-layer