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Protoimogolite - oxyanion sorption properties and significance in boreal forest soils

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The fate and transport of several environmentally significant oxyanions in young boreal forest soils are strongly governed by surface complexation reactions with oxides and aluminosilicates. Protoimogolite (PIM) is a non-crystalline aluminosilicate that, together with ferrihydrite (Fh), occurs in appreciable amounts in the sesquioxide-rich horizons of boreal forest soils [1]. Both PIM and Fh form surface complexes with oxyanions such as phosphate (PO_4), arsenate (As(V)), and molybdate (Mo(VI)).

Using acid–base titrations, batch adsorption experiments, and EXAFS spectroscopy, we investigated the oxyanion adsorption properties of synthetic PIM. PIM contains both proton-active Al–OH and Si–OH groups, with Al–OH sites contributing approximately 400–500 $m^2\ g^{-1}$ of specific surface area. While As(V) forms corner-sharing bidentate complexes with Al–OH groups on PIM, Mo(VI) forms edge-sharing bidentate complexes. The relative affinity of the studied oxyanions for PIM follows the order PO_4 > As(V) > Mo(VI).

For soils from spodic Bs horizons, linear combination fitting with PIM and Fh standards as end-members shows that most of the added As(V) is adsorbed to Fh, whereas a majority of the added Mo(VI) is adsorbed to PIM.

[1] Florén T., Bartolomé Díaz M., Cornelis G., Hillier S., Gustafsson JP., 2025. Characterization of imogolite-type nanoparticles in Podzols: morphology and association with iron, Geoderma 459, 117376. https://doi.org/10.1016/j.geoderma.2025.117376.