

# Geochemical Controls on the Formation and Bioavailability of Imogolite in Volcanic Soils

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Podoconiosis is a debilitating disease prevalent in volcanic soil regions, particularly in East Africa and other tropical areas. This condition is characterized by progressive lymphatic obstruction and severe limb swelling, with no infectious agent identified. The disease is linked to prolonged exposure to fine-grained aluminosilicate minerals present in volcanic soil. This study is testing the hypothesis that a fibrous aluminosilicate mineral, such as imogolite, is the cause of podoconiosis. Fibrous mineral particles have known capability for tissue translocation, causing oxidative stress and stimulating chronic immune response.

We identified regions in Rwanda with podoconiosis prevalence and designed a field study to sample soils from locations with varying soil types and disease incidence. We collected rock, ash, and soil samples from two volcanic sites and one granitic site, and conducted elemental analysis, synchrotron X-ray diffraction, and electron microscopy. Chemical extraction performed on all the surveyed soils indicated varying Al<sup>3+</sup> pools, with volcanic soil samples showing greater potential for the precipitation of allophonic and imogolite minerals than granitic soil samples. However, podoconiosis is prevalent not only in volcanic regions but also in adjacent granitic soils, which sporadically received ash input from nearby volcanoes. Microscopy analysis revealed volcanic soils predominantly contained imogolite-sized fibers (2-4 nm diameter), while granitic soils with a potential ash input exhibited both smaller and larger particles (25-27 nm) with more complex compositions. Energy-dispersive x-ray showed the fibers incorporated Fe and Ti and had an unexpectedly low aluminum percentage in all volcanic soil samples (Figure).

We are developing a CrunchFlow model to simulate the weathering of volcanic soil from ash. Our model is based on the weathering model of Hawaii basalt developed by Perez-Fodich and Derry [1], modified to reflect the lower Al/Si ratio observed in the basalt parent rock of Rwanda. The clay fraction of the nanofiber content can be selectively extracted from the soils and will be used for *in vitro* cell toxicity studies at University of Grenoble in April 2025 to provide mechanistic insights into their

pathogenic potential.

Reference

[1] Perez-Fodich & Derry, *Geochimica et Cosmochimica Acta*, (2019) 173-198

