Aeolian dust deposition and the perturbation of phosphorus transformations during long term ecosystem development

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Aeolian dust deposition is an important phosphorus (P) input to terrestrial ecosystems, but its influence on P dynamics during long-term ecosystem development remains poorly understood. We characterized P speciation using P K-edge XANES spectroscopy in surface soils and contemporary aeolian dust collected at each site of a 3000-ky semi-arid volcanic soil chronosequence. We found that P speciation in the dust was dominated by calcium-bound P (Ca-P; 54–74%), with 11–23% Fe/Al-P and 7–25% organic P (P_o). In the soils, P_o contributed 1–23% of total P, more in older soils; however, both the proportions of Ca-P (16–39%) and Fe/Al-P (48–82%) fluctuated with increasing weathering degree over the soil chronosequence. These soil fluctuations resulted from the accumulation and preservation of alkaline aeolian dust during pedogenesis in the semi-arid climate, which significantly increased Ca-P while decreasing Fe/Al-P and altering their relative abundance. We suggest that the effects of dust deposition on soil P transformations are functions of the relative magnitude and chemical composition of the dust input and the soil weathering intensity. When the dust flux is greater than the weathering rate, dust accumulates and thus alters the pattern of P transformation during pedogenesis; otherwise, the perturbation is negligible. Our work demonstrates how dust inputs can modify the Walker and Syers model of pedogenic P transformations. Overall, this work provides a foundation for understanding how dust influences P cycling during soil and ecosystem development.