Weathering within soils developed on a chronosequence of glacial moraines in the French Alps

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Samples of recent glacial sediments and 9 soil profiles ranging in age from 360 years to ~300Ky were collected from near Chamonix toward Lyon. The mineralogy of the <2 mm size fraction of each soil as a function of depth was analyzed by quantitative XRD. Soil profiles 17 Kyr and younger were derived almost exclusively from crystalline rocks. Older morraines also contained significant limestone and dolomite.

The 360 yr moraine has a well developed organic horizon, suggesting the high availability of nutrients in the till, but no clear indication of silicate weathering. Within the ~10 Ky till, chlorite (formed by retrograde alteration of biotite) was weathered to smectite in the upper ~20 cm, but there is no major change in plagioclase or other primary silicate concentrations or kaolinite formation. The ~17 Ky till showed plagioclase weathered in the top 15 cm, and an incipient A horizon.

The older tills (>100 Ky, and closer to Lyon) all have well developed A and B horizons, with the B horizon depth increasing with the till age from ~65 to ~150 cm. Weathering of plagioclase and K-feldspar in the soil horizons increases with age, as does the development of an argillic kaolinite horizon. Carbonates in the A and B horizons are severely depleted, but abruptly reach concentrations near that of the unaltered till at the base of the B horizon, the same depth at which silicate weathering appears to cease.

The mineralogy of some <2 µm fractions were also analyzed. Suspended stream sediment and till from modern glaciers has mineral compositions of the <2 µm fraction that are nearly identical to the bulk tills and bedrock. Alteration of the <2 µm fraction of older tills is similar to the <2 mm fraction, with feldspar weathering above the base of the B horizon, but little alteration below. This suggests that the high surface area of the primary silicates in the clay-size fraction of till played a subordinate role in controlling the rate of chemical weathering, and weathering models with a large dependence on mineral surface area may not describe the weathering behavior of this chronosequence. Rather, other factors such as the evolution of solution chemistry may have a major control on weathering rates.

A diverse ecosystem response to volcanic ash falls

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Marine and terrestrial ecosystems exhibit a diverse response to volcanic ash falls. Through simulation of the mixing of pristine volcanic ash leachate with fresh water and seawater, we found that volcanic aerosols may act as fertilisers in marine environment and show opposite, toxic effects in soils and fresh water systems. The toxic effect in fresh waters is a result of the combination of high aluminium (Al) and fluoride (F) concentrations of the ash leachate. Owing to the mixing of acid ash leachate with fresh water, aluminofluoride complexes (AlF_x^{+3-x}) persist in aqueous systems with low turnover rates and become toxic to both plants and animals. The combination of high Al and F concentrations thus contributes to fluorosis and Al toxicity in terrestrial ecosystems. In contrast, due to the well-buffered and relatively high pH in seawater, the speciation of the ash leachate/seawater mixture shows that complexes of fluoride and aluminium will not be formed in this system. The geochemical modelling of the mixing of ash leachate with seawater shows as pH increases and F concentration decreases with dilution (logarithm of the dilution ratio > 1.0), $Al(OH)_x^{+3-x}$ species exceed AlF_x^{+3-x} complexes. Hydroxo-aluminum complexes are more important at low levels of dilution than in freshwater systems. Consequently, when ash is falling over the marine environment aluminium will form $Al(OH)_x^{+3-x}$ species and aluminium will not persist in large concentrations in the surface water because of low solubility of Al-hydroxides at near neutral pH.

The result by this study supports the volcanic ash fertilization hypothesis as important nutrients were released from the ash material and some oceanic phytoplankton species tolerate extreme concentrations of fluoride [1].

Reference

[1] Oliveira, L., Antia, N. J., & Bisalputra, T., 1978, Culture studies on the effects of fluoride pollution on growth of marine phytoplankters. J. Fish Res Board Can, 35: 1500-1504.