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Andic soils : mineralogical effect onto organic matter dynamics, organic matter effect onto mineral dynamics, or both?

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From a strictly mineralogical point of view, weathering of volcanic glass produces secondary phases that are short range ordered alumino-silicates (SRO-AlSi). These are imogolite tubes (2 to 3 nm of diameter) and allophane supposedly spheres (3.5 to 5 nm). Their local structure is composed of a curved gibbsite Al layer and Si tetrahedra in the vacancies (Q0). Proto-imogolites have the same local structure but are roof-shape nanoparticles likely representing the precursors of imogolite and allophanes (Levard et al. 2010). These structures and sizes give to the SRO-AlSi large specific surfaces and high reactivities. In some natural sites, imogolites and allophanes are formed in large quantities. Aging of these phases may lead to the formation of more stable minerals (halloysite, kaolinite and gibbsite) (Torn et al 1997).
In natural environments, when the weathering of volcanic glass is associated with the establishment of vegetation, the soils formed are generally andosols. These soils are particularly rich in organic matter (OM), which is explained by the high ability of SRO-AlSi mineral phases to form bonds with organic compounds. In a first order "bulk" approach, it is considered that these bonds strongly stabilize the organic compounds as their mean age can reach more than 10 kyrs in some studied sites (Basile-Doelsch et al. 2005; Torn et al. 1997).
However, the structure of the mineral phases present in andosols deserves more attention. Traditionally, the presence in the SRO-AlSi andosols was shown by selective dissolution approaches by oxalate and pyrophosphate. Using spectroscopic methods, mineralogical analysis of SRO-AlSi in andosols samples showed that these mineral phases were neither imogolites nor allophanes as originally supposed, but only less organized structures remained in a state of proto-imogolites (Basile-Doelsch al. 2005 ; Levard et al., 2012). The presence of OM would have an inhibitory effect on the formation of secondary mineral phases, by blocking the crystal growth of SRO-AlSi.
Conversely, the effect of minerals on the dynamics of organic compounds also deserves to be studied in greater detail. If the "bulk" approaches showed that proto-imogolites involve long-term stabilized OM, other approaches such as densimetric fractionation and C3/C4 chronosequences (Basile-Doelsch et al. 2007; De Junet et al. 2013) led us to consider a new model involving two types of organo-mineral interactions: (1) OM stabilized by strong bonds to proto-imogolite, leading to a slow OM turnover and (2) OM retained within the porosity of the 3D structure formed by the proto-imogolite (similar to a gel structure), leading to a faster OM turnover.
Understanding the mechanisms of organo-mineral interactions in andosols will open new research directions for understanding the mechanisms of stabilization of OM in any type of soil (Bonnard et al. 2012).

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