



Spatial distribution pattern of vanadium in hydric landscapes

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The geochemical behavior of the trace element vanadium (V) is strongly influenced by its oxidation state (+2 to +5). Consequently, oxidation/reduction reactions play an important role in controlling the mobilization and immobilization of V in soils. Translocation processes of V within soil profiles (pedons), including podzolization and clay illuviation, are well-documented. With regard to its lateral redistribution in landscapes, V is widely regarded as being immobile.

Our investigation focused on the fate of V along a moisture gradient in different temperate humid spruce forest ecosystems in Southwest Germany (MAP 1,200-1,600 mm, MAT 6°C). The areas under investigation are characterized by lateral water flow, caused by a physically pre-weathered periglacial layer with poor water-permeability characteristics at the interface between pedo- and lithosphere. We selected different catenas derived from sandstone, gneiss, and granite, respectively. The soil associations occur along moderately inclined slopes and include common forest soils of three redox categories: an anaerobic Histosol, oxic Cambisols, and Stagnosols with an intermediate redox state. The soils are linked to each other by the lateral subsurface transport of solutes, which allows the investigation of the horizontal (i.e. within pedons) and lateral redistribution (i.e. between pedons) of the redox-sensitive elements V and iron (Fe).

The redox potential of V and Fe in different soil depths along the hydrological pathway was both measured in the field and subsequently analyzed in 48 soil horizons to deduce the total content of V and Fe using aqua-regia digestion and element spectrometry (ICP-OES and ICP-MS).

The different parent materials result in significant differences in V content. The V content in the sandstone soils (0.2 – 30 mg kg⁻¹) was lower than the V content in granite and gneiss soils (up to 75 and 100 mg kg⁻¹, respectively). Our results demonstrate that V is a highly mobile element in hydric landscapes. Independent from the parent material, we found a distinct spatial pattern of V, which reflected that of the local redox environment: Horizons/pedons with oxic conditions revealed a positive correlation between V content and Fe content. In this case, iron oxides act as an important sink for dissolved V which originated from other locations of the catena.

Poorly drained soils, such as Stagnosols for example, promote both Fe and V reduction, which is coupled to their removal from the pedons by leaching. It can be demonstrated that the element-specific Eh window for differential reduction is very narrow. The spatial distribution of both elements shows that high V contents are often associated with low Fe contents. It is therefore assumed that a reducing environment promotes Fe³⁺ reduction, while maintaining while maintaining V stable.