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The impact of the biosphere on the geochemistry of the critical zone

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Many potentially toxic elements such as Cd, Hg and Pb are enriched in soil and sediment horizons at the Earth surface. This observation is commonly considered to prove a massive global impact of anthropogenic activities on the critical zone. Whilst anthropogenic input undeniably exists, this interpretation neglects fundamental discoveries of Vernadsky, who highlighted the importance of the biosphere for geochemical processes at the Earth surface already in 1926 (Vernadsky, 1926), and Goldschmidt who described such biogeochemical processes more than 80 years ago (Goldschmidt, 1937). This neglect is manifest in the current tendency in environmental sciences to oversimplify quantitative estimates of anthropogenic impact. For example, metal concentrations in deep mineral soil (e.g., the soil C horizon) or even average values for the upper continental crust are often indiscriminatly used to present the 'geochemical background' against which the anthropogenic impact is assessed.
This approach completely disregards the complexity of the critical zone, where weathering and biogeochemical processes redistribute chemical elements between environmental compartments at the Earth's surface on a large scale. Based on several multi-element, multimedia (up to 15 different sample media collected at the same sites) investigations in northern Europe it is demonstrated that the biosphere is deeply involved in the weathering process and strongly interacts with the developing soil and sediments. Weathering involves a complete breakdown of rocks and minerals and leads to the formation of new minerals. Bacteria, plants and fungi all have specific needs or uses for chemical elements and enrich or deplete certain elements in different soil horizons. Because the biosphere applies its own strategies to get rid of or even use toxic elements, these elements are differently distributed in the critical zone compartments. In order to decide whether an observed enrichment of certain elements at the Earth surface is due to anthropogenic activities, the whole system needs to be studied. Examples of new statistical methods to investigate such natural shifts and their underlying processes will also be presented.

References

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