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Geochemical fingerprinting and source discrimination in soils at the continental scale

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Agricultural soil (Ap-horizon, 0–20 cm) samples were collected from a large part of Europe (33 countries, 5.6 million km2) at an average density of 1 sample site per 2500 km2. The resulting 2108 soil samples were air dried, sieved to <2 mm, milled and analysed for their major and trace element concentrations by wavelength dispersive X-ray fluorescence spectrometry (WD-XRF).

The main goal of this study is to provide a global view of element mobility and source rocks at the continent scale, either by reference to crustal evolution or normalized patterns of element mobility during weathering processes. The survey area includes several sedimentary basins with different geological history, developed in different climate zones and landscapes and with different land use.

In order to normalize the chemical composition of soils, mean values and standard deviation of the selected elements have been checked against values for the upper continental crust (UCC). Some elements turned out to be enriched relative to the UCC (Al, P, Zr, Pb) whereas others, like Mg, Na, Sr and Pb were depleted with regards to the variation represented by the standard deviation. The concept of UCC extended normalization patterns have been further used for the selected elements. The mean value of Rb, K, Y, Ti, Al, Si, Zr, Ce and Fe are very close to the UCC model even if standard deviation suggests slight enrichment or depletion, and Zr shows the best fit with the UCC model using both mean value and standard deviation. Lead and Cr are enriched in European soils when compared to UCC but their standard deviation values show very large variations, particularly towards very low values, which can be interpreted as a lithological effect. Element variability has been explored by looking at the variations using indicator elements. Soil data have been converted into Al-normalized enrichment factors and Na was applied as normalizing element for studying provenance source taking into account the main lithologies of the UCC. This latter normalization highlighted variations related to the soluble and insoluble behavior of some elements (K, Rb versus Ti, Al, Si, V, Y, Zr, Ba, and La, respectively), their reactivity (Fe, Mn, Zn), association with carbonates (Ca and Sr) and with phosphates (P and Ce). The maps of normalized composition revealed some problems with use of classical element ratios due to genetical differences in composition of parent material reflected, for example, in large differences in titanium content in bedrock and soil throughout the Europe.