Low-density geochemical mapping at continental scale reveals background for emerging tech-critical elements

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Low-density geochemical mapping at continental scale reveals background for emerging tech-critical elements.

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The demand for a variety of mineral and/or element resources (e.g., rare earth elements, platinum group elements, cobalt, beryllium, lithium. . .) has increased with the continued consumption in developed countries and the emergence of developing economies. These elements are essential for maintaining and improving future quality of life, including many high-technology yet low-carbon industries. Two factors have been used by the NRC (National Research Council) to rank criticality: the degree to which a commodity is essential and the risk of supply disruption for the commodity. Further, the demand for energy-related minerals has increased, as global energy production diversifies beyond carbon and nuclear-based sources. A critical mineral and/or element is both essential in use subject to the risk of supply restriction and at the same time may induce environmental impacts. To provide a solid base for future generations, it is necessary to identify the spatial distribution of critical elements at a large scale, and additionally to study possible environmental consequences of the increased use of these resources. The average concentration, transformation and transport within and between the different environmental compartments of many chemical elements, which are now key components for the development of new technologies, are poorly known.

Here we investigate three critical elements (Sb, W and Li) using low-density geochemical mapping at the continental-scale. In order to detect and to map the natural element variation at the European scale, we use agricultural soil samples (Ap-horizon, 0–25 cm) collected within the GEMAS (GEochemical Mapping of Agricultural and grazing land Soil) soil-mapping project in 33 European countries and covering an area of 5.6 million km2.

The Sb map shows one of the most striking differences in concentration between the soil of north-eastern Europe (median 0.11 mg/kg) and south-western Europe (median 0.35 mg/kg). This pronounced disparity is most likely an effect of soil age and weathering. Though, the W map shows somewhat lower W values (median 0.058 mg/kg) in northern Europe than in southern Europe (median 0.083 mg/kg); here the boundary does not exactly follow the limit of the last glaciation. Many unusually high W values are observed in central Europe and especially in Germany. The Li map shows a distinct difference between northern Europe with predominantly low concentrations (median 6.4 mg/kg), and southern Europe with evidently higher values (median 15 mg/kg). Here again the map shows the maximum extent of the last glaciation as a discrete concentration break. The principal Li anomalies occur spatially associated with the granitic rocks throughout Europe (Portugal, France, England). The Central Scandinavian Clay Belt is also clearly visible as a Li anomaly, and this feature emphasizes the tendency of Li to bind to clay.

The Sb, W and Li data provide a general view of the mobility of these elements at the continental-scale. The composition of agricultural soil represents largely the primary mineralogy of the source bedrock, the effects of pre- and post-depositional chemical weathering, formation of secondary products, such as clays, and element mobility, either by leaching or mineral sorting.