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Revising the Trace Element Abundances of the Upper Continental Crust: New Insights from Global Sedimentary and Igneous Data

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We present updated estimates for the trace element composition of the upper continental crust (UCC) by integrating newly acquired geochemical data from 139 loess samples across Asia, Europe, North America, and South America with a comprehensive compilation of data from loess, shales, diamictites, and continental igneous rocks. The new concentration estimates for first-row transition metals, Li–Be–Ba, Zr–Hf, and Ga–Tl–Pb are within ± 20% of those suggested by Rudnick and Gao [1]. However, our results yield markedly lower Cs (~50%) and higher REEs–Y–Rb–Nb–Ta–Th–U (25–65%) and Bi (120%) abundances. These discrepancies primarily arise from differences in La concentrations, which we constrain using La/TiO_2 correlations in sediments. We demonstrate that loess can provide robust constraints on UCC composition owing to its lower chemical weathering intensity and greater homogeneity than shales and glacial diamictites. Nevertheless, using simple averages of absolute concentrations in loess may result in unreliable estimates due to mineral dilution or enrichment effects. Furthermore, correlation-based methods may suffer from mineral sorting effects, leading to biased estimates; for example, anomalously high La/Al_2O_3 ratios in European loess reflect enrichment of accessory minerals such as titanite. Employing element pairs that exhibit consistent correlations across sedimentary rock types mitigates many of these biases. The elevated abundances of heat-producing elements (K, Th, and U) in our UCC estimates suggest that the deeper continental crust, excluding the UCC, is unlikely to be dominantly felsic; instead, it is probably mafic to intermediate, depending on the assumed mantle heat flux. The new UCC composition estimate is consistent with many key geochemical ratios proposed in previous UCC estimates, such as Nb/Ta, Zr/Hf, Zr/Sm, Ni/Co, Cr/Zn, Th/U, and La/Th. Notably, the high La/Nb ratio (~2.6) supports the dominant role of arc magmatism, rather than intraplate magmatism, in crustal growth, while the Nb/Ta (12.6), $(La/Yb)_N$ (8.3), and $(Dy/Yb)_N$ (1.1) values underscore the importance of subduction-related magmatism in thick continental arcs in generating the modern continental crust.

[1] Rudnick & Gao (2003), Composition of the Continental Crust, in Treatise on Geochemistry, 1st ed. Pergamon, pp 1-64.