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Simple approach to sediment provenance tracing using element analysis and fundamental principles

Tomas Matys Grygar (1,2), Jitka Elznicova (2), and Jan Popelka (2)

(1) Institute of Inorganic Chemistry AS CR, Rez, Czech Republic (grygar@iic.cas.cz), (2) Faculty of Environment, J.E. Purkyne University in Usti nad Labem, Czech Republic

Common sediment fingerprinting techniques use either (1) extensive analytical datasets, sometimes nearly complete with respect to accessible characterization techniques; they are processed by multidimensional statistics based on certain statistical assumptions on distribution functions of analytical results and conservativeness/additivity of some components, or (2) analytically demanding characteristics such as isotope ratios assumed to be unequivocal "labels" on the parent material unaltered by any catchment process. The inherent problem of the approach ad (1) is that interpretation of statistical components ("sources") is done ex post and remains purely formal. The problem of the approach ad (2) is that catchment processes (weathering, transport, deposition) can modify most geochemical parameters of soils and sediments, in other words, that the idea that some geochemistry parameters are "conservative" may be idealistic.

Grain-size effects and sediment provenance have a joint influence on chemical composition of fluvial sediments that is indeed not easy to distinguish. Attempts to separate those two main components using only statistics seem risky and equivocal, because grain-size dependence of element composition is nearly individual for each element and reflects sediment maturity and catchment-specific formation transport processes.

We suppose that the use of less extensive datasets of analytical results and their interpretation respecting fundamental principles should be more robust than only statistic tools applied to overwhelming datasets. We examined sediment composition, both published by other researchers and gathered by us, and we found some general principles, which are in our opinion relevant for fingerprinting: (1) Concentrations of all elements are grain-size sensitive, i.e. there are no "conservative" elements in conventional sense of provenance- or transport-pathways tracing, (2) fractionation by catchment processes and fluvial transport changes slightly but systematically element ratios in solids, (3) the geochemistry and fates of the finest particles, neoformed by weathering and reactive during transport and storage in fluvial system, are different than those of the parent material and its less mature coarse weathering products, and (4) most inter-element ratios and some grain-size effects are non-linear that endanger assumption on additivity of properties in components mixing. We are aware we offer only a conceptual model and not a novel algorithm for quantification of sediment sources, which could be tested in practical studies. On the other hand, we consider element fractionation by exogenic processes fascinating as they are poorly described but relevant not only for provenance tracing but also for general environmental geochemistry.