Effects of hydraulic sorting on geochemical baseline concentrations in moderately polluted fluvial archives: River Morava, Czech Republic

Ondřej Bábek[1], Tomáš Matys Grygar[2], Martin Faměra[1,3], Tereza Nováková[2,4] and Jan Sedláček[1]

1 Department of Geology, Palacky University, 17. listopadu 1192/12, 771 46 Olomouc, Czech Republic

2 Institute of Inorganic Chemistry AS CR, v.v.i., 250 68 Rez, Czech Republic

3 Department of Geological Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

[4] Charles University in Prague, Faculty of Science, Albertov 6, 128 43 Prague, Czech Republic

ABSTRACT

Separating anthropogenic impact by heavy-metals from lithogenic background concentrations represents a key issue in contamination studies and environmental risk assessment. Normalizing toxic metal concentrations to “lithogenic“ elements such as Al and Rb represent a useful approach. The geochemical baseline can be represented by a robust linear regression line in “toxic”/”lithogenic” element biplots, aggregating data points from “safe depths” of a sedimentary archive. However, definition of what is a safe depth requires cost-demanding dating and, regardless of its results, can be a subjective measure. In this study, we investigated stratigraphic distribution of normalized toxic elements in well-dated, contaminated lacustrine (oxbow lake) and floodplain archives of the River Morava, eastern Czech Republic. The aim was to quantify the effects of hydraulic sorting on normalized element concentrations and investigate the applicability of the geochemical baseline.

The maximum sediment accumulation rates, based on ^{137}Cs and ^{210}Pb dating and historical river regulation data reached 7 cm per year in the oxbow lake and 0.5 cm per year in the floodplain. Stratigraphic framework of the archives was established from high-resolution (cm-scale) measurement of magnetic susceptibility (MS), X-ray densitometry and diffuse reflectance spectroscopy (DRS). Combined with the age model, this resolution provides a robust framework for tracing of historical trends on sub-annual to decade scale.

The oxbow lake archive recorded several coarse-grained event beds, whose position in the age model correlate with major historical floods in the catchment. The concentrations of Pb, Zn, Cu and Ni show a distinct saw-tooth pattern whereby low concentrations are associated with coarse-grained flood beds while higher ones occur in fine-grained “background” deposits. Normalized to lithogenic Al, this saw-tooth pattern is even more marked showing that simple normalization does not filter out the effect of grain size changes. The short-term, flood-related fluctuations generally overdrive the long-term historical contamination trends. The stratigraphic patterns in floodplains are typically smooth due to bioturbation. The normalized concentrations of toxic elements shows gradually increasing levels starting from the end of 19th century, but the general contamination in floodplains is much lower than in the oxbow lake. The underlying pre-industrial sediments are strongly affected by fluctuating water table (reductiomorphic zone) between 90 and 120 cm depths, which affects the MS, DRS as well the normalized element concentration data. The lithogenic background data from “safe” depths are therefore prone to diagenetic changes. Our case studies show simple statistical approach to geochemical baseline calculation can be misleading due to physical processes such as hydrodynamic

sorting and early diagenesis. This work was supported by Czech Science Foundation project GACR P210-12-0573.