Geophysical Research Abstracts
Vol. 19, EGU2017-2797, 2017
EGU General Assembly 2017

Geochemical normalization of magnetic susceptibility – a simple tool for distinction the sediment provenance and post-depositional processes in floodplain sediments

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Magnetic susceptibility is highly appreciated in sedimentary and environmental geology. It may also reflect provenance of the sediment and post-depositional changes therein, including soil-forming processes. We studied the applicability of Fe-normalization of mass-specific magnetic susceptibility (MS) and Ti-normalization of Fe concentrations in description of fluvial sediments from five different catchments. We dealt with two catchments with some "mafic" source rocks (Fe-rich rocks) and three almost purely "felsic" catchments (source rocks with dominant quartz and feldspars). The fine-grained floodplain sediments (from clayey silts to fine sands) were obtained by drill coring and analysed for Fe and Ti concentrations using X-ray fluorescence spectroscopy (EDXRF) and MS using kappabridge. To correct MS for the sedimentological grain-size effects and possible magnetic enrichment, we used background functions constructed in the same way like for heavy metals.

The representative profiles downward the floodplain sediments demonstrate the following MS stratigraphy: (1) 15-50 cm thick top stratum A, usually with MS and heavy metal enrichment, (2) underlying stratum B with stable values of MS, MS/Fe and Fe/Ti and (3) the lowermost stratum C with variable Fe concentrations and MS and high-chroma reductimorphic features due to micro-accumulations of Fe and Mn oxides in discoloured matrix, or grey colour due to permanently removed Fe(III) oxide pigment. The boundary between strata B and C can be at a depth of several decimetres to more than 1 metre depending on the thickness of floodplain fines, site-specific river incision and water table fluctuation.

For the construction of MS background functions we used Fe concentrations as an independent variable (a predictor). It allows for calculation of MS of sediments as it would not be affected by post-depositional changes and pollution. Pristine MS is than predicted for any sample using formula

MS_PRISTINE = const·cFe + const′,

where cFe is concentration of Fe. Background functions must be obtained empirically from collection of samples of stratum B that needs qualified sampling strategy and informed data evaluation. Local enrichment factor of MS is then defined as

LEF MS = MS/MS_PRISTINE.

LEF MS is useful for study of MS depth profiles in both strata A and C. Floodplain sediments in river systems with catchment with "mafic" rock outcrops have MSPRISTINE by up to two orders of magnitude larger in comparison to systems with "felsic" source rocks. The carriers of magnetic signal in the "mafic" rock-derived sediments are affected by soil-forming processes, which gradually decrease their original MS, in particular in strata B and C. Post-depositional processes including pedogenesis, in particular reductimorphic processes, may thus alter MS/Fe. The reductimorphic processes in floodplain sediments may be revealed by "erratic" variations or a permanent increase of the Fe/Ti ratio.

The advantage of using geochemical normalization of MS is that chemical analyses are currently nearly routinely performed in geochemical and pollution mapping studies and thus Fe concentrations are thus available for data processing. The combination of the mentioned handy proxies (MS and element composition) would definitely deserve broader use in environmental geology and monitoring.