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Magnetic Mineralogy of Fluvial Sediments: Challenges and Chances

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A b s t r a c t

The complex magnetic mineralogy of fluvial sediments reflects the environmental and climatic evolution of their catchments and is thereby a potential source of information in areas were no other archives are available. However, the analysis of these sediments with rock magnetic methods is a challenging task. The contributions from various sources along the course of the rivers results in a multi-component magnetic mineralogy. Additionally, variable and frequently unsteady redox-conditions during multiple burial-transportation cycles may alter individual grains differently. As a result of these diverse pathways, grain size variations of the bulk sediment material as well as of the magnetic components induce further complications to the analyses. Nevertheless, the identification of the magnetic mineralogy is vital for both, palaeo-magnetic investigations, and enviromagnetic analyses.

Here, we present an outline of the course of action used to analyse drill cores from three sites (Viernheim, 350 m; Heidelberg, 500 m; Ludwigshafen, 300 m) within the Heidelberg Basin (Scheidt *et al*. 2015, 2017). The Heidelberg Basin is a large subsiding structure in the northern part of the Upper Rhine Graben (URG) in Germany and hosts a quasi-continuous sedimentary sequence of > 2000 m thickness (Buness *et al.* 2008). The sediments are delivered from the River Rhine and the Palaeo-Rhine, respectively, and their tributaries. The site Heidelberg is additionally heavily influenced by Triassic red clastics of the River Neckar alluvial fan.

Since no template for mineral magnetic analyses of fluvial clastics was available, our approach was not straight forward at all. At the beginning, the measurement routine scheduled the following procedure: determination of the NRM and the susceptibility, AF-demagnetisation for palaeomagnetic analysis (for results see Scheidt *et al.* 2015), ARM acquisition measurement with subsequent AF-demagnetisation and IRM acquisition measurement with subsequent back curve determination. Finally, the hysteresis loop was observed before thermal experiments (I_S(T) and κ(T)) were started. These first analyses indicated that

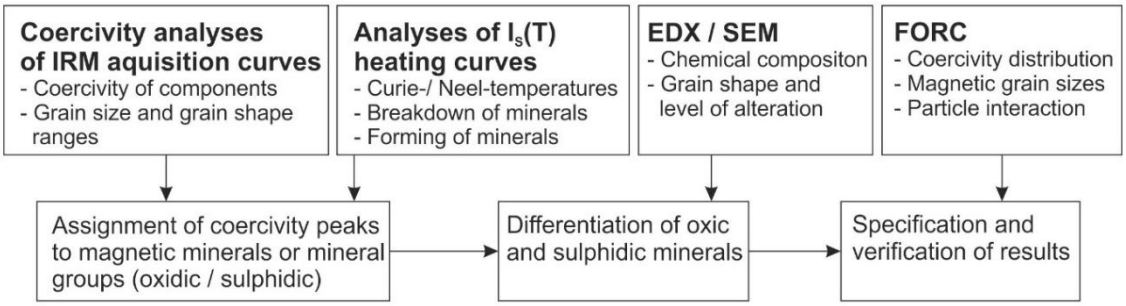

Fig. 1. Illustration of the analytic procedure applied to unravel the multi-component magnetic mineralogy of fluvial sediments. The main objectives of the individual methods are shortly mentioned with bullet points.

the distribution of antiferromagnetic and ferromagnetic minerals cause the Pliocene sediments to be magnetically much weaker than the Pleistocene sediments. However, due to natural variances in grain size, content, and composition of the magnetic components, classical rock magnetic proxies were not able to provide detailed information on magnetic grain sizes or magnetic mineralogy. Only a combination of alternative approaches led to unravelling of the multicomponent systems and identification of involved magnetic minerals. In the first instance, the coercivity analyses of the IRM acquisition curves indicated the simultaneous presence of up to five magnetic components. The identification of these components succeeded by linking the data with the results of the evaluation of their I_S(T) heating curves. SEM/EDX analysis of magnetically extracted minerals gave additional hints on the interpretation of the measured data. FORC analyses of selected samples were finally applied to confirm the finding and specify the magnetic grain size ranges.

In this study, the applied combination of data allowed for unravelling of the multicomponent magnetic mineralogy, and for reconstructions of palaeo-environmental processes and settings (for details see Scheidt *et al.* (2017)). The combination of magnetic polarity stratigraphy and detailed magnetic mineralogy provided thus, new insights into the development of the climatic conditions of continental Western Europe (Scheidt *et al.*, in prep.). Despite the challenges fluvial sediments reveal for rock magnetic methods, we therefore propose the systematic environmental magnetic analysis of geologically young fluvial sequences throughout Europe in order to enhance our understanding of the palaeoenvironmental evolution of the recent past.

Keywords: magnetic mineralogy, fluvial sediments, palaeoclimate, palaeoenvironment.

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