



Magnetic minerals in the environment: a journey between physics and biogeochemistry

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Magnetic minerals are universally present in rocks and sediments. Their abundance and variety in sediments is controlled by several processes taking place at the Earth's surface, which include erosion, transport in water and in the atmosphere, and a variety of diagenetic processes where iron is chemically cycled. Each process imprints a particular signature on the magnetic minerals affected by it, either through grain size sorting, transport paths connected to different reservoirs, or crystal growth. This in turn controls the bulk magnetic properties of sediments, which can be used as a proxy for given environmental processes. Magnetic proxies have the advantage of being based on inexpensive, non-destructive measurements. On the other hand, a disadvantage of such proxies is the lack of strict physical models needed to understand the magnetic properties of non-ideal magnetic particles on one hand, and of accurate models for physical, chemical and biological processes affecting their occurrence. Early environmental magnetism studies were based on simple bulk magnetic measurements, such as susceptibility and hysteresis parameters. Such studies were able to discriminate among different chemical compositions (e.g. ferrimagnetic vs. antiferromagnetic minerals), as well as providing a rough grain size estimate. Because of the simultaneous occurrence of different magnetic minerals with distinct grain size distributions (e.g. ultrafine authigenic vs coarse detrital particles), the need of appropriate unmixing techniques became soon evident. Along with this approach, the sediment is supposed to contain a certain number of magnetic grain families, called magnetic components. Each component is generated by specific environmental processes. Examples include loessic components, generated by the aeolian transport of dust, pedogenic components, generated by weathering of parent material and iron cycling in topsoils, and biogenic components, which are given by iron biomieralization products, such as magnetosomes. Different methods spanning from cluster analysis to coercivity analysis have been recently used to identify such components. By comparison with end-members, obtained by measuring reference samples, it is possible to calibrate magnetic measurements in order to obtain parameters such as mass concentration and grain size, that can be directly used to model specific processes that affect those components. This approach requires knowledges spanning from rock and mineral physics, to geochemistry and biology, and provides precise parameters, such as concentration, that, unlike magnetic measurements, can be compared directly with geochemical proxies. I will discuss a few examples based on authigenic minerals formed in lake sediments and soils, showing how certain interpretation problems can be solved and new questions are raised at the same time.