Geophysical Research Abstracts
Vol. 16, EGU2014-3317-1, 2014
EGU General Assembly 2014


# An empirical attempt to measure NRM lock-in depth in organic-rich varved lake sediments

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The growing awareness of significant magnetosomal contributions to natural assemblages of magnetic minerals means that much remains to be discovered about how sediments become magnetised by the geomagnetic field and, therefore, the fidelity of the information provided by post-depositional remanent magnetisations (pDRMs). We have investigated the palaeomagnetic properties of organic-rich varves retrieved from Gyltigesjön (southern Sweden). An earlier study of this site by Snowball et al. (2013) compared centennial-millennial trends in inclination, declination and relative paleointensity (RPI) to a regional reference curve, which indicated that the natural remanent magnetisation (NRM) lock-in depth is at least 21 cm. This result prompted us to attempt to improve the recovery of the uppermost sediments and magnetically characterise them to assess the effect of consolidation on NRM acquisition. Fixed piston cores recovered in 2 m drives were kept vertical before capping, and discrete palaeomagnetic subsamples were obtained as close as possible to the sediment-water interface. The timescale was validated by establishing the concentration of lead (Pb) in the palaeomagnetic samples and comparing the downcore trends to the well-known regional atmospheric pollution history. Induced magnetic remanence and magnetic grain-size parameters (including the median destructive field of the anhysteretic remanent magnetization [mdfARM]) show that the concentration of single-domain magnetite grains (magnetosomes) are relatively uniform in the sediments, suggesting that they are produced in the water column. However, the mdfNRM in the uppermost sediment is several mT lower than the mdfARM (approx. 45 mT). The mdfNRM increases downcore and it agrees with the mdfARM at a depth of approx. 80 cm, which corresponds to an age of ca. 210 yrs. These observations suggest that a coarse grained clastic component contributes to the NRM close to the sediment surface, while magnetite magnetosomes become more important deeper down, which should cause smoothing of the palaeomagnetic signal. Despite the care we took, the sediment type made it practically impossible to recover precisely oriented subsamples for measurements of palaeomagnetic secular variation (PSV), and scattered results were produced. This empirical study emphasises the fact that a significant palaeomagnetic lock-in delay applies to organic-rich varves, in which magnetite magnetosomes are preserved.