Why are geomagnetic excursions not always recorded in sediments?

Andrew P. Roberts[1]; Michael Winklhofer[2]

[1] National Oceanography Centre, University of Southampton; [2] Department of Earth and Environmental Sciences, University of Munich

It has been suggested that a large number (10 or more) of geomagnetic excursions occurred during the Brunhes Chron. Nevertheless, many high-resolution studies provide evidence of far fewer excursions and some fail to document any excursions. By modelling the post-depositional remanent magnetization (PDRM) lock-in process with a range of lock-in functions (linear, cubic and exponential) and lock-in depths, we investigated the fidelity of the modelled paleomagnetic record when a high-frequency geomagnetic input signal is convolved with the sediment lock-in function for a wide range of sedimentation rates. At low sedimentation rates (1 cm/k.y.), an input signal containing abundant excursions (with 1 k.y. duration) is attenuated so that the amplitude of all excursions is substantially decreased. Some excursions are not evident at all and others are indistinguishable from red-noise that was added to the input signal. Attenuation of excursions increases with increased lock-in depth. For lock-in depths of 5-10 cm/k.y., the signal is substantially attenuated at sedimentation rates below 3-4 cm/k.y. Above this sedimentation rate, much of the structure of the input geomagnetic signal is preserved, although sampling at discrete intervals will cause additional smoothing and/or aliasing of an ideal signal (and adds noise). Sedimentation rates can fluctuate substantially (up to a factor of 50 in extreme cases), so we have modelled cases where the sedimentation rate is modulated by a climatic forcing function (e.g., insolation). Even though the average sedimentation rate might be substantial, PDRM recording becomes much less reliable in parts of the climate cycle where the sedimentation rate is lowest. In these cases, some excursions (when the local sedimentation rate is above 3-4 cm/k.y.) are reliably recorded in detail, while others (when local sedimentation rate is below 3-4 cm/k.y.) may not be recorded at all. Our modelling suggests that in order to obtain high-fidelity records of geomagnetic field behaviour, it is ideal to work with sediments that maintain minimum sedimentation rates above 3-4 cm/k.y. If the normal spectrum of geomagnetic field behaviour contains abundant excursions, the failure of many apparently high-resolution records to document this behaviour might result from PDRM lock-in within slowly deposited sediments, or to intervals of slow sedimentation within sediments with higher average sedimentation rate.