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Enigmatic 'TRM relaxation' in non-single-domain recorders: apparent bias in paleointensity analysis

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The Thellier-type paleointensity method and its derivatives are based on an assumption that the ancient process of thermoremanent magnetization (TRM) acquisition is entirely reproducible in the laboratory. This means that, theoretically, if viscous and alteration effects are ignored, a "fresh TRM" (acquired in the laboratory), and an "ancient TRM" (TRM after a long time) are the same physical phenomenon. Here we show new experimental evidence showing that this is not necessarily the case for non-single-domain (SD) recorders. In our experiments we collected 95 samples from various sources (volcanic, plutonic, and archaeological) that demonstrated pseudo-single-domain (PSD) or small multi-domain (MD) behavior in initial paleointensity experiments. Each sample was split to two sister specimens and was given a "fresh TRM". The first specimen was analyzed using the Thellier-type IZZI protocol immediately after TRM acquisition. The other sister specimen was kept in a fixed magnetic field equal to the original "fresh TRM" field for two years ("aged TRM" hereafter). After two years the specimens with the "aged TRM" were subjected to exactly the same Thellier experiment as the "fresh TRM" specimens. We compared the Arai plots of the "fresh TRM", the "aged TRM", and original "ancient TRM", and identified some striking effects:
1) The more "aged" is the TRM, the more curved and zigzaggy is the Arai plot, i.e. the "ancient TRM" yielded the worst Arai plot, the "fresh TRM" yielded the best Arai plot, and the "aged TRM" was in-between.
2) The "fresh TRM" and "aged TRM" had different unblocking temperature spectrum.
3) Paleointensity estimates of the "aged TRM" were consistently biased.

We conclude that TRM properties, in particular the unblocking temperature spectrum, are time dependent. Hence, TRM stability is much more complicated than previously assumed. As a result, paleointensity investigation of non-ideal paleomagnetic recorders should be designed and analyzed with extra caution. Furthermore, we have reasons to suspect that a significant portion of the global paleointensity database is consistently biased.