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Reliability of palaeomagnetic poles from sedimentary rocks

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Palaeomagnetic poles form the building blocks of apparent polar wander paths and are used as primary input for quantitative palaeogeographic reconstructions. The calculation of such poles requires that the short-term, palaeosecular variation (PSV) of the geomagnetic field is adequately sampled and averaged by a palaeomagnetic dataset. Assessing to what extent PSV is recorded is relatively straightforward for rocks that are known to provide spot readings of the geomagnetic field, such as lavas. But it is unknown whether and when palaeomagnetic directions derived from sedimentary rocks represent spot readings of the geomagnetic field and sediments are moreover suffering from inclination shallowing, making it challenging to assess the reliability of poles derived from these rocks. Here, we explore whether a widely used technique to correct for inclination shallowing, known as the elongation-inclination method (E/I), allows us to formulate a set of quality criteria for (inclination shallowing-corrected) palaeomagnetic poles from sedimentary rocks. The E/I method explicitly assumes that a sediment-derived dataset provides, besides flattening, an accurate representation of PSV. We evaluate the effect of perceived pitfalls for this assumption using a recently published dataset of 1275 individual palaeomagnetic directions of a >3 km-thick succession of ~69-41.5 Ma red beds from the Gonjo Basin (eastern Tibet), as well as synthetic data generated with the TK03.GAD field model. The inclinations derived from the uncorrected dataset are significantly lower than previous estimates for the basin, obtained using coeval lavas, by correcting inclination shallowing using anisotropy-based techniques, and by predictions from tectonic reconstructions. We find that the E/I correction successfully restores the inclination to values predicted by these independent datasets if the following conditions are met: the number of directions N is at least 100, the A95 cone of confidence falls within a previously defined $A95_{min\text{-}max}$ reliability envelope, no negative reversal test is obtained and vertical-axis rotation differences within the dataset do not exceed 15°. We propose a classification of three levels (A, B, and C) that should be applied after commonly applied quality criteria for paleomagnetic poles are met. For poles with classification ‘A’, we find no reasons to assume insufficient quality for tectonic interpretation. Poles with classification ‘B’ could be useful, but have to be carefully assessed, and poles with classification ‘C’ provide unreliable paleolatitudes. We show that application of these criteria for datasets of other sedimentary rock types classifies datasets whose reliability is independently confirmed as ‘A’ or ‘B’, and that demonstrably unreliable datasets are classified as ‘C’, confirming that our criteria are useful, and conservative. The implication of our analysis is that sediment-based datasets of quality ‘A’ may be considered

statistically equivalent to datasets of site-mean directions from rapidly cooled igneous rocks like lavas and provide high-quality palaeomagnetic poles.