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The long-term history of the Mesozoic geodynamo: A paleointensity perspective

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The history of the Earth's magnetic field, comprised of geomagnetic polarity reversals, secular variation and field strength, is crucial for understanding the geodynamo and planetary evolution. However, the question whether the long-term variations of these basic features of geomagnetic field have been intrinsically related, or they have varied independently throughout the geological history remains open. In particular, while a large class of geodynamo models predicts an inverse relationship between geomagnetic reversal frequency and paleointensity, the paleointensity data - dominated by results from bulk volcanic rocks – remain inconclusive. One reason for this is that the paleointensity record in rocks may be adversely affected by a plethora of physical processes, which must be taken into account when analyzing the paleointensity database. To address this problem, we have updated the global paleointensity database for 65-200 Ma using a set of paleointensity quality criteria (QPI) at the site-mean level. Selected paleointensity data were split into five time bins - the early Jurassic (200-171 Ma), the Jurassic hyperactivity period (JHAP, 171-155 Ma), the late Jurassic – early Cretaceous (155-126 Ma), the Cretaceous normal polarity superchron (CNS, 126-84 Ma), and the late Cretaceous (84-65 Ma) - representing the full range of reversal rate variations during the Mesozoic. For the QPI screened database, the non-parametric Kolmogorov-Smirnov (KS) test indicates that JHAP paleointensity values are significantly lower than the mean values for the other investigated periods (values are 40-60 per cent of the present-day intensity). The KS test also shows that, while high field values (those exceeding present day intensity) are rare, there is still a significant difference between the CNS period and the moderate reversal rate periods for relatively weak set of QPI's. A stricter subset of QPI criteria substantially reduces the number of accepted pre-CNS data in each time bin to a statistically insignificant level making results of the statistical test rather ambiguous. When tested against all pre-superchron data, the CNS set also appears statistically different. In addition, inverse correlation between the reversal rate and geomagnetic field intensity is supported by the high-fidelity paleointensity data from single silicate crystals that consistently indicate high field strength during the superchron and low field strength during the period of very high reversal frequency during the JHAP. Overall, our analyses confirm an inverse relationship between geomagnetic reversal frequency and paleointensity, supporting the idea that reversal rate and paleointensity are governed by the same geodynamic processes rather than decoupled. We note that acquisition of new high-quality paleointensity data, particularly for the Jurassic, is crucial to resolve ambiguities in the paleointensity database. We will discuss our results in the context of current models of the long-term geomagnetic and thermal evolution of the Earth.