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Long-term strength of the time-averaged geodynamo based on Thellier analyses of single plagioclase crystals

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The basic features of the geomagnetic reversal chronology of the last 160 million years are well-established. The relationship between this history and other features of the field, however, has been elusive. The determination of past field strength (paleointensity) is especially challenging. Thellier paleointensity data from many lavas show effects of in situ and laboratory-induced alteration. Single plagioclase crystals can contain minute magnetic inclusions, 50-350 nm in size, that are an alternative high-fidelity field recorder; they are less susceptible to alteration than bulk lava samples. The silicate host can also protect the magnetic inclusions from weathering. If there is a relationship between geomagnetic reversal frequency and paleointensity, it should be best expressed during superchrons, intervals with few (or no) reversals. Paleomagnetic dipole moments based on Thellier analyses of single plagioclase crystals from lavas erupted during the Cretaceous Normal Polarity Superchron (~83-120 Ma) suggest a strong, stable field (Tarduno et al., Science, 2001; Proceedings National Academy of Science, USA, 2002). Thellier data from single plagioclase crystals formed during times of moderate (less than 1 reversal/million years) and very rapid (more than 10 reversals/million years) reversal occurrence suggest a weaker and more variable field (Tarduno and Cottrell, JGR, 2005). These data suggest an inverse relationship between reversal frequency and paleointensity (Cox, JGR, 1968). This relationship is also supported by new analyses of the relative strength of NRMs of oceanic basalt with time (Wang et al., Geosphere, 2005). Interestingly, Thellier results from basalt are much more variability; available results suggest low field strengths (often at, or less than 1/2 the present-day field). On the basis of direct comparisons of basalt and plagioclase, we attribute these differences to whole rock alteration in nature and in the laboratory, and to non-ideal (MD) magnetic carriers. The plagioclase-based data are consistent with numerical simulations that suggest superchrons reflect times when the nature of core-mantle boundary heat flux allows the geodynamo to operate at peak efficiency (e.g. Glazmaier et al., Nature, 1999; Olson and Christensen, Geophys. Jour. Int., 2002; Christensen and Olson, PEPI, 2003). The succeeding period of reversals may signal a less efficient dynamo, with a lower and more variable dipole intensity. The timescale for the transition between these states is consistent with an active lower mantle, controlling the nature of the geodynamo. Progress using the single silicate crystal method to define the Archean geomagnetic field will also be discussed.