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Observations of the early geomagnetic field by paleomagnetism and possible temporal trend in paleointensity

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The nature of the ancient geomagnetic field constrains the core evolution. Here we present the Paleoarchean magnetic record in single silicate crystals obtained using DC SQUID magnetometry and IR heating techniques. So far, the oldest geomagnetic field intensity records were from 3.44 Ga and 3.2 Ga rocks from the Kaapvaal craton (Usui et al., 2009; Tarduno et al., 2007, 2010). Among those two, the estimated virtual geomagnetic dipole moment is lower for 3.44 Ga by ca. 50% than for 3.2 Ga, which in turn is comparable to the modern field. This led some to hypothesize growing field intensity with time during this period. On the other hand, analysis of a database implies opposite trend of decreasing field intensity with time from Archean to Proterozoic, though the accuracy of the individual record in the database may be questioned. To clarify the nature of the ancient field, we examined granitic rocks from ca. 3.3 Ga Mt. Edgar complex from the Pilbara craton using the single crystal technique. Analysis of feldspar crystals from some sites yielded paleointensity data that pass experimental reliability criteria. Rock magnetism of the feldspar crystals indicated the presence of near single-domain, pure magnetite inclusion. The blocking temperature is high enough for the remanence to survive the low grade regional metamorphism. Because the single crystals measured were unoriented, we do not yet have constraints on paleolatitude to calculate a virtual dipole moment. Nevertheless, assuming an equatorial paleolatitude, the estimated paleofield is only ca. 60% of the modern value; higher paleolatitude would indicate even lower dipole moment. Together with the existing data from the Kaapvaal craton, our results support growing geomagnetic intensity during Paleoarchean. This implies a delayed onset of the geodynamo.

Keywords: geomagnetism, paleomagnetism, early Earth, paleointensity, single crystal, Archean