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Geomagnetic Field Morphology and Inner Core Growth

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Thermal models suggest that Earth's solid inner core started to grow no earlier than $\sim$2.7 to 2.5 billion years ago (Ga). A reversing, dipolar dynamo has been proposed for earlier times, but such interpretations are uncertain because paleomagnetic directions show anomalous dispersion and most available rocks have seen prolonged low-grade metamorphic conditions. Here we present data obtained using a CO_2 laser/SQUID magnetometer approach to analyze for the first time the paleodirectional and paleointensity signatures of single, oriented silicate grains. These grains contain single to pseudo-single domain magnetite inclusions that can preserve original thermoremanent magnetizations. High unblocking temperature data from quartz and feldspar grains separated from $\sim$3.2 Ga plutons of the Kaapvaal Craton (South Africa) show evidence for field reversals, but also for vastly divergent stable magnetic directions that suggest non-dipolar fields. This pattern is sharply different from the dipole-dominated geomagnetic field of the Late Archean-Early Proterozoic to present. This change in dynamo behavior may reflect the beginning of compositionally-driven convection associated with inner core formation and/or changes in core-mantle boundary heat flux associated with the onset of deep subduction.