The time-averaged palaeomagnetic field during 3-7 Ma at high northern latitudes

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The geocentric axial dipole (GAD) hypothesis states that when we average the geomagnetic field over sufficient time intervals, the time-averaged field (TAF) behaves like a dipole aligned along the Earth's spin axis and positioned at the Earth's centre. This hypothesis is crucial in palaeomagnetic research such as palaeosecular variation, palaeoclimate and plate tectonic reconstruction. However, the time interval to average the field to achieve a GAD is still debated. For example, there is some evidence for the persistence of long-term hemispheric asymmetry on time scales of 10^5-10^6 yr, particularly at high-latitudes. As most palaeomagnetic research is conducted under the GAD hypothesis, the hypothesis needs to be rigorously tested. In this research we aim to investigate the symmetry of the palaeomagnetic field and to test the GAD hypothesis during 3-7 Ma using full-vector palaeomagnetic data - including palaeodirection and palaeointensity - from dated lava piles in northern Iceland.

The demagnetisation measurements including alternating field (AF) and thermal were made to determine palaeomagnetic directions. In order to improve quality of high-latitude data, approximately 6-10 directional data per site were used to calculate mean directions. We found mean declination and inclination of 355.0˚ and 72.0˚ with 95% confidential limit of 2.2˚. The modelling of the field was performed by adding 4% of quadrupole and 11% of octupole to the model; the model returns the inclination of 72.1˚ at 65˚N. Our dataset passed the reversal test with Class A which is indicative of high accuracy. The directional data were converted to virtual geomagnetic pole (VGP) which is located at 81.3˚ N and 180.2˚E.

The Curie temperature determination was performed using strong field thermomagnetic analysis prior to palaeointensity experiment. Evidence from strong field thermomagnetic curves indicates the presence of Ti-rich titanomagnetite, Fe-rich titanomagnetite and titanomaghemite in samples across the lava flows. Palaeointensity experiment was conducted in a helium atmosphere in order to prevent oxidation on the samples. We used the infield/zero-field and zero-field/infield protocol with partial thermoremanent magnetisation (pTRM) checks. Samples from 20 lava flows yield successful results. We found the mean intensity of 22.0±2.7 μT, which is lower than the intensity of the GAD field (55.9 μT) at 65˚N, and the virtual dipole moment (VDM) of 32 ZAm^2. The investigation of palaeomagnetic data from Icelandic basalts reveals that the non-dipole field persists during 3-7 Ma at high-northern latitudes. However, the results of this study should be compared with the time-averaged field data at high-southern latitudes especially at 65˚S to see the symmetry of the field during 3-7 Ma.

Keywords: Iceland, Geocentric Axial Dipole (GAD) hypothesis, Palaeomagnetism

