Testing the Geocentric Axial Dipole hypothesis:

Palaeomagnetic analysis of the Westfjords lavas, Iceland.

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From geomagnetic observations and palaeomagnetic records, we know that the Earth's magnetic field is dominated by a dipole component, which is also dynamic and changing in terms of both its direction and intensity. Central to much palaeomagnetic research, e.g., plate tectonic reconstructions, is the assumption that the time-averaged field (TAF) is a dipole aligned parallel with the Earth's spin axis, the so-called geocentric axial dipole (GAD) hypothesis. Over very long periods of time, i.e. 200 million years, this hypothesis has been shown to hold. However, it has been known for some time that there are systematic departures from this simple model over shorter timescales. Direct field observations only encompass the last 400 years or so, and reveal a strongly non-GAD field. If undetected, these non-GAD fields can have a major impact on palaeogeographical reconstructions creating spurious mismatches. For example, palaeomagnetic results from the timespan 0-5 Ma suggest a significant non-GAD contribution to the TAF of the order ~5% that can correspond to c. 500 km reconstruction-mismatches. **Deviations from GAD are greatest at high-latitudes**, but the exact nature and duration of these deviations is still controversial (Muxworthy et al., 2024a). A pivotal question remains: Are the non-GAD features a permanent feature of the geomagnetic field? **The deviations from GAD at high-latitudes are greater in the ancient geomagnetic field intensity (palaeointensity) record** than the directional record (Muxworthy, 2017).

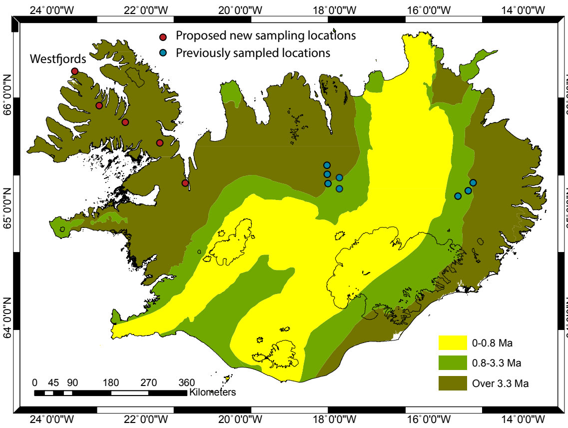

Figure 3. Proposed sampling in Iceland. In 2013 we sampled in eastern Iceland. We propose to sample in in Eyjafjardardalur and the Westfjords. The age of the rocks increases on moving away from the central spreading ridge.

Figure 1. Proposed sampling localities in the Westfjords. The previously studied regions (Døssing *et al.*, 2020; Muxworthy *et al., 2024a,b) are marked in blue. The age of the rocks increases on moving away from the central spreading ridge.*

The overall of aim of this project is to test key features of the time-averaged geomagnetic field:

(1) The long-term relationship between the ancient field and the dipole field at high-latitudes (the GAD hypothesis).
(2) The importance of field polarity on anomalous features.

To achieve these aims we require sequences of accurately dated lavas from high-latitudes; absolute palaeointensity determinations can only be made from igneous rocks. Previous studies by us (e.g., Døssing et al., 2020; Muxworthy et al., 2024a, 2024b) investigated the time-period covering the last 7 Ma using lava sequences in eastern and northern Iceland: This time window was found to be too short for the TAF to be treated as a GAD.

It is therefore imperative to sample deeper in time, across a longer timescale. We propose to sample a sequence of older rocks in the Westfjords of Iceland covering the time window 8 – 15 million years, and to conduct a full-vector palaeomagnetic study. Over several fieldtrips combined with laboratory work at Imperial College, the student will use full-vector palaeomagnetic analysis to test the accuracy of the GAD hypothesis at high latitudes.

Student Profile: This project is a combined field and laboratory project, and would suit a candidate with strong interest field-based Earth Sciences. Candidates should have a degree in Earth Science or Physics. Fieldwork will involve wild camping in remote areas in potentially cold and wet environments. Good laboratory skills also desirable.

Døssing, A., et al., 2020., Geophys. J. Int., 222, 86-102, doi:10.1093/gji/ggaa148.

Muxworthy, A.R., 2017., Front. Earth Sci., doi:10.3389/feart.2017.00079.

Muxworthy, A.R., et al., 2024a., Geophys. J. Int., doi:10.1093/gji/ggae182.

Muxworthy, A.R. et al., 2024b, Jökull, *submitted.*