Preliminary paleomagnetic analysis of the Sandfell laccolith, Iceland

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Abstract

Paleomagnetic data can be used to determine the orientation of Earth's magnetic field in the past. The rhyolitic Sandfell laccolith, Iceland is the cooled remains of a large body of magma that is thought to have been emplaced over a short period of time. It occurred when magma intruded between two layers creating a mushroom-shaped igneous formation beneath the surface. Due to the brief period of time in which the laccolith was emplaced, work was conducted to detect and determine significance of paleomagnetic signatures in the rock unit. These paleomagnetic signatures would indicate the usefulness of continued study of the laccolith and the best methods of testing. Prior successful studies have been conducted on this rock unit using other magnetic tests, suggesting that this unit has a consistent magnetic signature. In order to determine which method would successfully define a paleomagnetic signature, thermal demagnetization and alternating current demagnetization were applied to the same sample. The experiment consisted of taking six cores and splitting them into two groups of three. One group of samples were incrementally placed in a demagnetization oven up to 700˚C. After each increment, measurements were taken using the spinning magnetometer and the Kappenbridge to test remnant magnetization and magnetic susceptibility. The other group was analyzed with the alternating field demagnetizer and the magnetic remnant was measured with the spinning magnetometer. The alternating current method had successful results suggesting it is the proper method for testing paleomagnetic signatures in the Sandfell laccolith, Iceland.

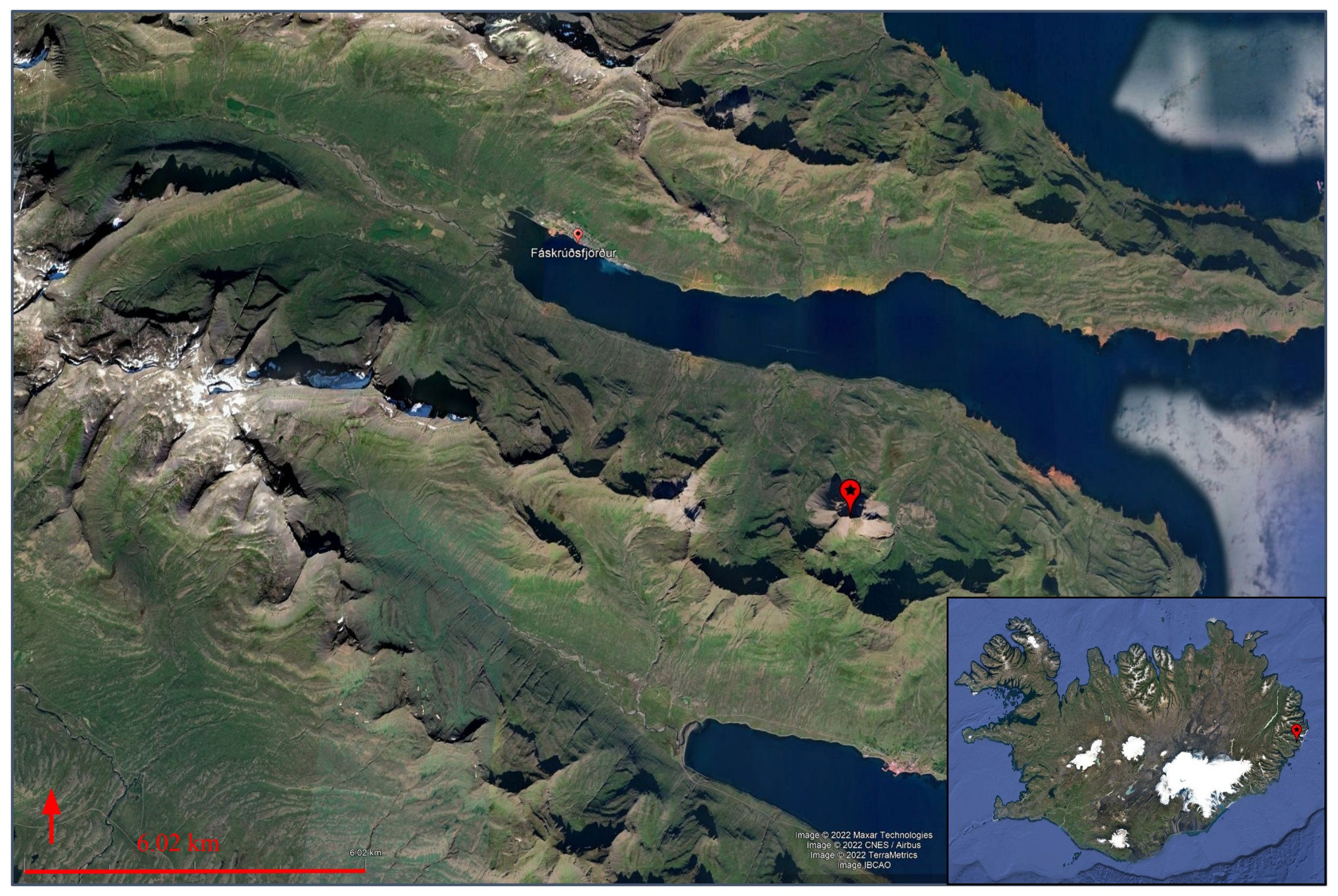

Figure 1. Map displaying the general location of the Sandfell laccolith, Iceland marked by the red pin with star. The village of Fáskrúðsfjörður is shown as reference (Google Earth Pro, 2022).

Introduction

The Sandfell laccolith resides in Eastern Iceland, near the village of Fáskrúðsfjörður (Fig. 1), and is exposed on the surface. This laccolith was formed 11.7 Mya at a depth of ~540 m below the paleo-surface. It is composed of feldspar- and quartz- phyric rhyolite. The bedrock surrounding the laccolith is comprised of a ~30 m thick rhyolitic andesite lava flow, and a ~10 m thick felsic tuff. The laccolith was formed from one pulse or a rapid succession of continuous magma flows (Mattsson et al., 2018). Six cores were drilled from one sample of the rhyolitic laccolith and orientation was noted so that their magnetic alignments could be determined in the lab.

Methods

The experiment consisted of taking six cores and splitting them into two groups of three. One group of samples were incrementally placed in a demagnetization oven up to 700˚C. After each increment, measurements were taken using the spinning magnetometer and the Kappenbridge to test remnant magnetization and magnetic susceptibility. The other group was analyzed with the alternating field demagnetizer incrementally from 0 to 200 milliteslas (mT). These samples were run through the alternating field demagnetizer in three different orientations at each step and then the magnetic remnant was measured with the spinning magnetometer.

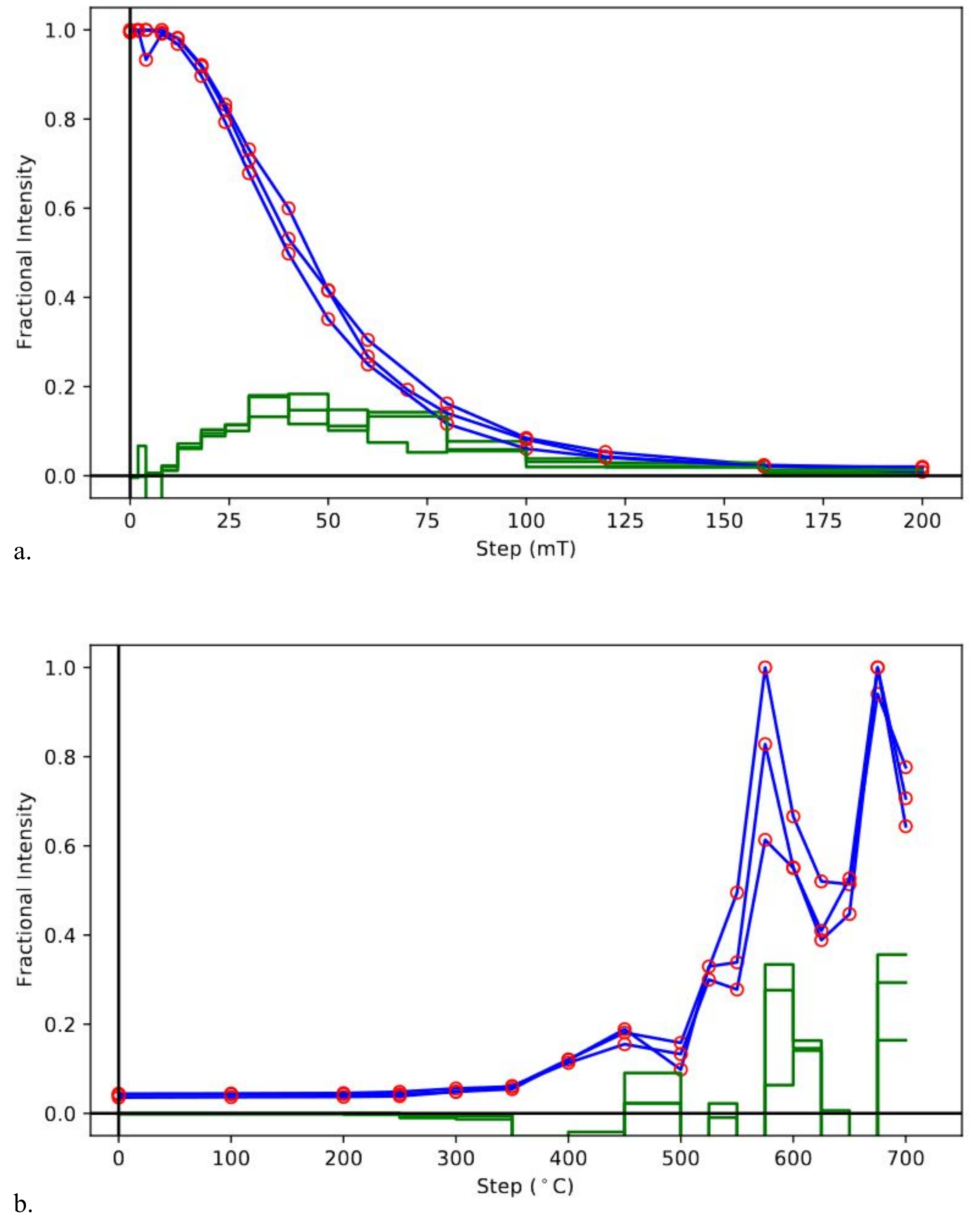

Figure 2. Magnetic susceptibility at each step of the alternating field demagnetization experiment (a) and the thermal demagnetization experiment (b). The alternating field demagnetization graph (a) shows a consistent downward trend to almost no signal, which suggests that we successfully removed any remnant magnetization. Then the thermal demagnetization graph (b) shows an upward trend suggesting that a new magnetic field was formed during the heating process due to the formation of new minerals such as hematite at higher temperatures, which means we did not remove any remnant magnetization.

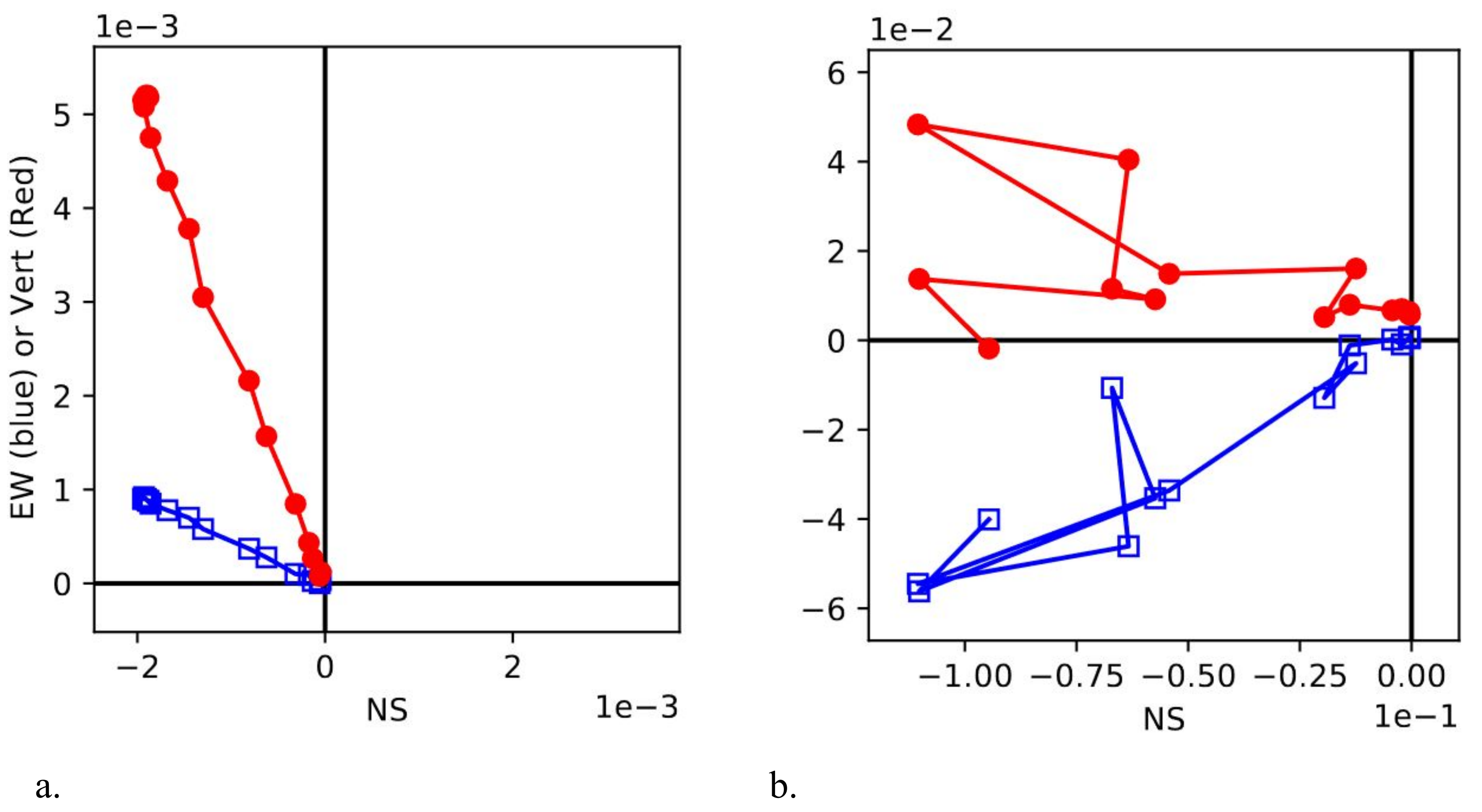

Figure 3. Representative vector component diagrams of cores subjected to alternating field demagnetization (a) and thermal demagnetization (b). Chart (a) shows a linear trend of the magnetic signature as the study progressed, with the plotted points approaching the origin, meaning that it was consistently demagnetized. Chart (b) depicts a more chaotic trend that does not approach the origin smoothly which suggests that demagnetization did not occur correctly.

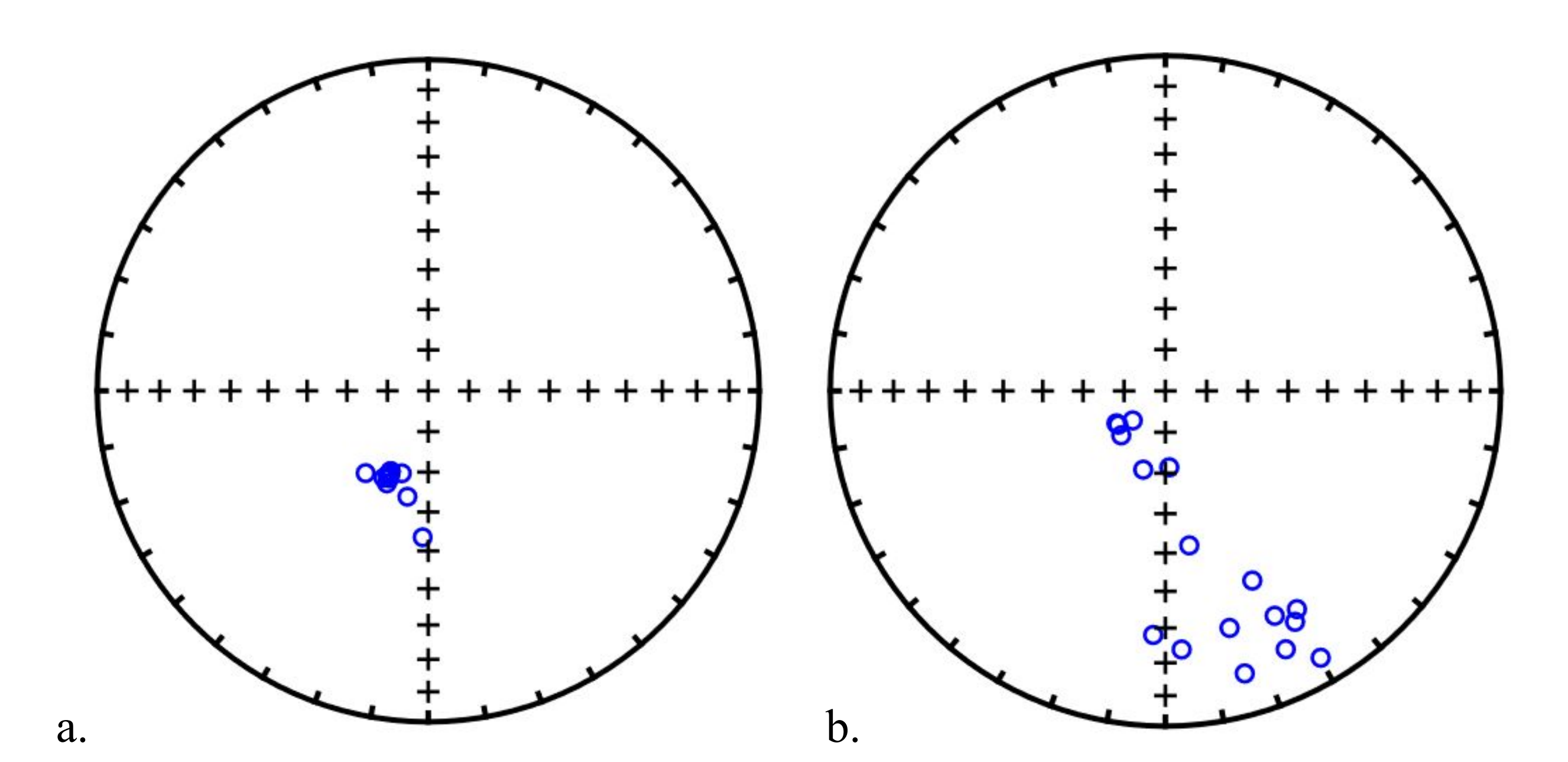

Figure 4. Stereonets depicting the orientation at each step of the demagnetization experiments. Stereonet (a) is from one of the cores that was run through alternating field demagnetization and stereonet (b) is from the thermal demagnetization experiment. The circles are the orientation of the magnetic signatures. The clustering of the points on (a) suggest that it has an oriented remnant magnetization.

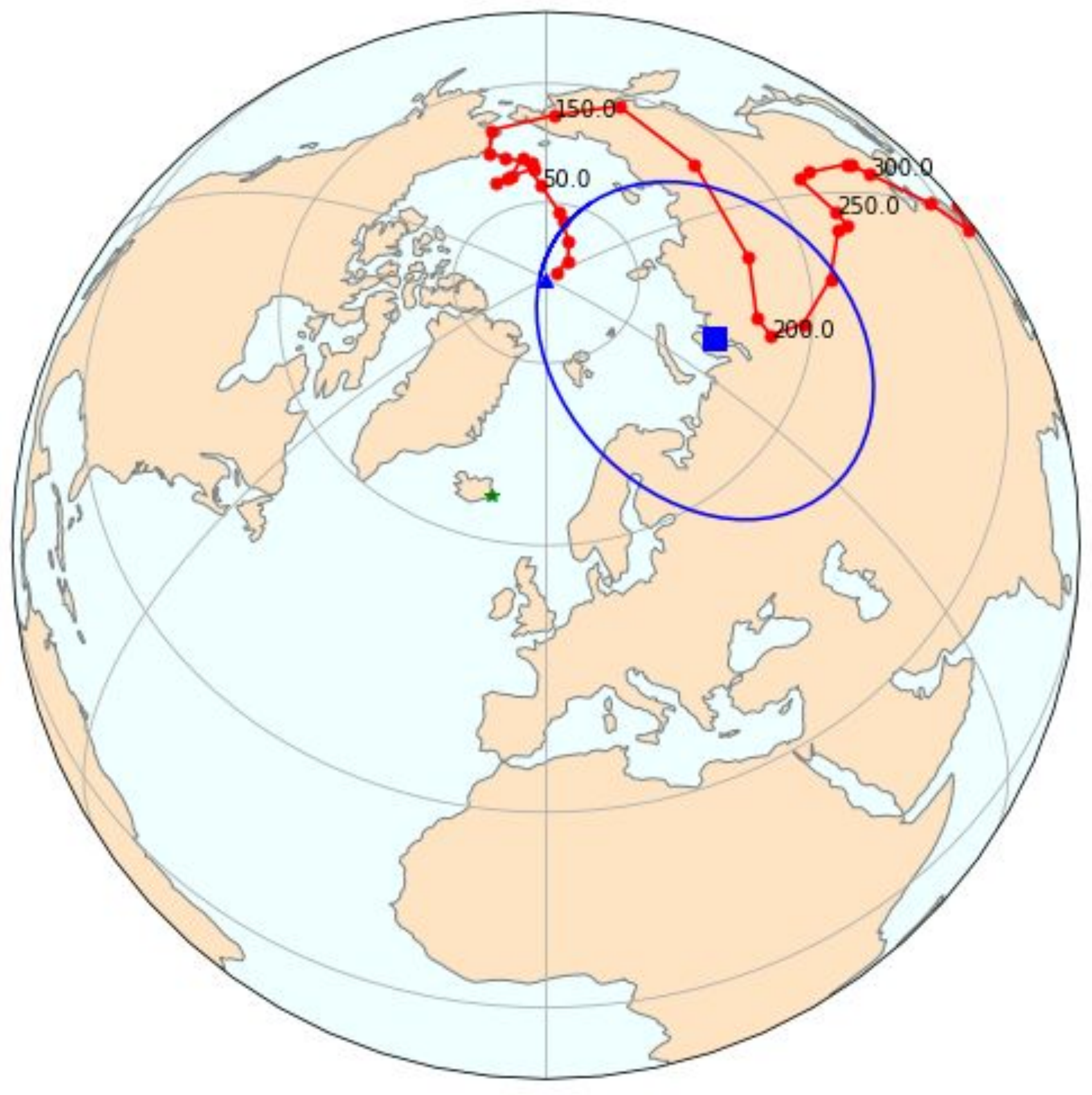

Figure 5. A map of the northern hemisphere showing the 95% uncertainty for the study which expands over much of Russia and extends into eastern Europe, also covering Iceland. The red line with markers shows the change in the magnetic pole for every 10 thousand years. The study has proven that this data is viable because the determined area of uncertainty includes eight of the previous magnetic pole locations. (Torsvik et al., 2012).

Results and Conclusion

The alternating current method had successful results showing a consistent demagnetization trend (Fig. 2, 3, 4). This suggests that it is the proper method for isolating paleomagnetic signatures in the Sandfell laccolith, Iceland. In contrast, the thermal data is scattered while the alternating field demagnetization data creates a neat trend. The fact that the uncertainty ellipse encompasses the youngest parts of the paleomagnetic wander path (Fig. 5) suggest these rocks are promising for future study.

References

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