Supplementary Material

Characterizing the Geomagnetic Field at High Southern Latitudes:
Evidence from the Antarctic Peninsula

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S1. Location Descriptions

Samples from Cockburn Island (Fig. 2(2), 3a) were taken from the lowest flows of an uncorrelated lava-fed delta formation with an age of ~2.9 Ma (see Smellie (2021) for a review of all JRI age data and associated references). Two flows were sampled at this location.

The Naze (Fig. 2(7), 3b) is a complex locality with multiple flows, sills, dikes, and volcanic necks. The surrounding sediments are extensively altered, suggesting that a large degree of heat transfer or hydrothermal circulation took place during igneous activity here. We sampled five units: three flows, one small sill (Fig. 3b), and one small dike. No samples from the northern portion of the Naze have been dated yet, but a nearby laccolith has a K-Ar age of $3.57 \pm 0.34$ Ma. It is not clear if this laccolith is cotemporal with other igneous activity on the Naze.

Keltie Head (Fig. 2(5),3c) is the youngest formation that we sampled (0.99 Ma), and we sampled at least two lava flows here. The flows have a distinct taupe color that is dissimilar to the dark grey or dark brown color of all other lavas that we sampled. It is also clear that the original glassy flow tops are no longer present here, likely due to glaciation.

Taylor Bluff (Fig. 2(10), S1) is another complex locality with multiple igneous products. The bluff is made up of the Taylor Bluff formation, consisting of pillow-breccia foresets (heavily palagonized) which are extensively intruded by dikes of ~2(?) Ma in age (Fig. S1a). Overlying this are Neogene sediments, followed by the Forster Cliffs formation (Smellie et al., 2013). Atop the bluff is an eroded palagonite tuff cone (Fig. S1a). The relationship between the Forster Cliffs formation and the tuff cone is not certain (Fig. S1b, S1c), but based on results from this study, they are cotemporal at this locality (see Section 5.3). We sampled a dike intruding the Taylor Bluff formation (Fig. S1d), an unusual columnar intrusion in the Forster Cliffs formation (Fig. S1b), and the summit tuff cone (~2 Ma; Fig. S1c).
Smellie Peak (also known as Cerro Santa Marta; Fig. 2(9), S2) is the most complex of all the localities that we sampled and has been described in detail by Calabozo et al. (2015). We sampled two lava flows (Fig. S2a) and some pillow basalts (Fig. S2b) from the Smellie Peak formation (5.14 Ma), as well as an eroded scoria cone (Fig. S2b; 5.91 Ma). The two lava flows are probably tilted (Fig. S2a), so we have applied a tilt correction to these units which we measured in the field (160° strike, 18° dip). Some of the pillow basalts that we sampled were brecciated and yielded scattered paleomagnetic directions (see Section 4.3.2). We also sampled a large landslide block of the Lookalike Peaks formation (5.89 Ma) to act as a crude fold test (see Section 4.3.2).

Davies Dome (Fig. 2(3), S3) is a large ice cap sitting atop a volcanic mesa. We sampled four lava flows here, all from the Kipling Mesa formation (~5.36 Ma).

Humps Island (Fig. 2(4)) consists of K-Pg sediments capped by two small volcanoes. The western volcano is better preserved, while only the neck of the eastern volcano is still present (Fig. S4a). We sampled the eastern volcanic neck, which is of unknown age.

Lachman Mesa (Fig. 2(6), S4b) is a prominent lava-capped mesa on the Ulu peninsula. We sampled two flows here, both from the Johnson Mesa formation (5.04 Ma). There was no sun available for orienting, so we used sighting to five landmarks to calculate a declination correction.

Seymour Island (Fig. 2(8), S4c) is composed mostly of K-Pg sediments, but a few JRIVG dikes are also present. We sampled one of these dikes (~6.8 Ma) that formed a prominent ridgeline on the island. It appears that extensive hydrothermal alteration of both the wall rock and dike occurred during intrusion, likely due to the heat from the dike combined with abundant water trapped in the sediments.

Finally, we attempted a baked contact test at Leal Bluff, to the north of Cape Lamb (Fig. 2(1)), using palagonite breccias, a dike, and a connected pillow basalt (Fig. S5). To conduct the
test, we collected nine cores from the palagonite (wall rock), five cores from the dike, and six cores from the pillow. The results of the test are discussed in Section 4.3.2. These samples are all part of the Sandwich Bluff formation (5.42 Ma).
S2. Supplemental Figures

**Figure S1** – MagIC database sites ([https://www2.earthref.org/MagIC](https://www2.earthref.org/MagIC)) with at least one Virtual Geomagnetic Pole (VGP), sorted into 10° latitude bins. Contributions with at least one young (<10 Ma) VGP are in light grey, contributions with only older poles are in dark grey. Note that the large majority of high-latitude data are from Iceland. MagIC method codes DE-DI, DE-POLE, and DE-VGP were used to select the data. Data are from April 2021 or earlier.
Figure S2 – A) Photo of Taylor Bluff (looking south) showing typical lithologies found in the JRIVG. B) Photo of a small columnar intrusion(?) into thin ice, a tuff cone, or both (Smellie et al., 2008), taken near the top of Taylor Bluff. C) Photo showing the relation between the intrusion in panel B and a (mostly eroded) tuff cone (seen in panel A). D) Photo of paleomagnetic cores taken from a dike on Taylor Bluff. Glassy margins of the dike are no longer present, and zeolites can be seen occasionally filling vesicles.
**Figure S3** – **A**) Photo (looking north) of a portion of the Smellie Peak formation. A tilt correction was applied to two lava flows that were sampled here (160° strike, 18° dip). **B**) Photo of the north-face of Smellie Peak (a.k.a. Cerro Santa Marta), looking southwest. Note the unconformity between the scoria cone and overlying Smellie Peak formation. See Calabozo et al. (2015) for detailed descriptions of this area.
Figure S4 – A) Photo (looking southeast) showing the stratigraphy of the western Davies Dome area. B) Photo (looking northwest) showing the main lava-cap that forms a prominent mesa to the west of Davies Dome. C) The mesa itself is heavily affected by frost heaving, so in-place outcrops are found at cliff edges.
Figure S5 – A) Photo of Humps Island, looking south east. B) Photo from atop Lachman Mesa, looking northwest. C) Outcrop photo of a dike wall on Seymour Island. Both sides of the dike were sampled. Photo credit: Jennifer Buz.
Figure S6 – A) Photo of Leal Bluff, near Cape Lamb, looking east. The lava cap is not well preserved here but the pillow breccia foresets (a common feature in the JRIVG) are clearly visible. B-E) Outcrop photos of the dike, pillow, and palagonite sites. Samples were collected here for a baked contact test, see Section 4.3.2 for discussion. R = reversed, all other samples were normal. Photo credit: Sarah Slotznick.
Figure S7 – IRM acquisition curves of representative JRIVG lithologies. Lower cross-over points (where the curves intersect) signifies greater degrees of particle interaction (Cisowski, 1981). Lava flows have cross-over values of 0.48-0.54, indicating moderate-strong interaction. Other lithologies have crossover values of 0.42-0.63. IRM derivative curves show the presence of one magnetic phase (panel A) or two phases (panel E). See Section 4.2 for discussion.
Figure S8 – ARM acquisition curves of representative JRI lithologies. Reference curves for chiton teeth and magnetotactic bacteria signify strong/weak particle interaction, respectively (Cisowski, 1981; Kobayashi et al., 2006). See Section 4.2 for discussion.
Figure S9 – Lowrie-Fuller tests of representative JRI lithologies. Overall, a mixture of L- and H-type behavior is seen here (Xu and Dunlop, 1995). See Section 4.2 for discussion.
Figure S10 – Fuller test of NRM (Fuller et al., 1988) on representative JRI lithologies. Some samples show signs of alteration (Fuller et al., 2002), which is expected given their palagonized nature. See Section 4.2 for discussion.
Figure S11 – Hysteresis loops from representative JRI lithologies. Some samples show strong paramagnetic behavior (panels A, F, G), while the majority show single to pseudo-single domain signatures. See Section 4.2 for discussion.
Figure S12 – Thermal-susceptibility curves from representative JRI lithologies. Heating steps are shown in red, cooling steps are shown in blue. See Section 4.2 for discussion.
Figure S13 – Orthogonal projections of representative samples from this study. Declination is shown in red, inclination is shown in blue. Some samples show a zig-zag pattern (e.g. panel F), which is discussed in Section 4.3.1.
**Figure S14** – Comparison of AF demagnetization data to thermal demagnetization data of different specimens from the same sample. **A)** A sample from The Naze, showing the worst zig-zag pattern seen during AF demagnetization of all 251 samples. Symbols as in Figure 10. **B)** Another specimen from the same core, which was thermally demagnetized during Thellier-Thellier paleointensity experiments. **C)** Equal area projection showing that least-squares fits at a site are similar regardless of the technique that is used. See Section 4.3.1 for discussion.
Figure S15 – Thellier-Thellier results from two flows on Davies Dome. A) A sample that passes the criteria of Lawrence et al. (2009), the associated orthogonal projection is shown in the upper-right. B) Sample that does not pass the selection criteria, showing a two-component Arai plot likely due to multidomain magnetite.
Figure S16 – Pseudo-Thellier results from three samples. A) High-quality result that passes the selection criteria of Paterson et al. (2016). B) Less reliable result that passes the selection criteria of de Groot et al. (2013). C) Sample that does not pass either set of selection criteria.
Figure S17 – Tsunakawa-Shaw results from three samples. A) High-quality result that passes the selection criteria of Yamamoto and Yamaoka (2018). B) A sample that barely passes the selection criteria. C) Sample that does not pass the selection criteria.
References


Lawrence, K., Tauxe, L., Staudigel, H., Constable, C., Koppers, A., McIntosh, W., and Johnson, C., 2009, Paleomagnetic field properties at high southern latitude: Geochemistry, Geophysics, Geosystems, v. 10.


