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Geochemistry and Geochronology of Circumferential Dykes of the Franklin LIP: A Rotated Perspective on Plate Reconstruction

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In addition to an extrusive volcanic component and associated sills, the Neoproterozoic Franklin Large Igneous Province (LIP) comprises a giant radiating dyke swarm spanning an arc of ca. 110˚, as well as a less-prominent circumferential set of dykes at a radius of ca. 1200 km from a proposed plume source. While the radial Franklin dykes were emplaced rapidly at 721 Ma (Denyszyn et al. 2009a), the circumferential dykes are uniformly ca. 8 Ma younger, with the Clarence Head dykes at the eastern extent dated to 713 Ma (Denyszyn et al. 2009b), and the Lasard River dykes to the south dated at ca. 710 Ma (Ernst et al. 2004) defining an arc of ca. 120˚.

The Tatonduk dykes of northwestern Canada have a trend that is consistent with being part of the larger circumferential swarm, and are located ca. 1250 km southwest of the proposed plume source. We present a new, high-precision U-Pb ID-TIMS age from baddeleyite of 713.7 ± 0.9 Ma, indistinguishable from that of the Clarence Head dykes on the opposite side of the swarm. This defines a western extent of the circumferential dykes, expanding the swarm in size to ca. 180˚ of arc and with a diameter of ca. 2500 km. This makes the Franklin LIP's circumferential component by far the largest known example of this type, and is on a scale comparable to the coronae of Venus (cf. Buchan & Ernst 2016) though the mechanism of emplacement may differ.

While their affiliation is made on the basis of age and trend, the geochemistry of the Tatonduk dykes significantly differs from that of the Clarence Head dykes. In fact, across the sweep of the Franklin LIP, there are significant mineralogical and geochemical differences. Generally, the intrusions are geochemically similar to others in the area, regardless of orientation, and different to coeval equivalents elsewhere in the swarm. This indicates that while the Franklin magmatism may have a common mantle source, the melt is interacting with a heterogeneous mantle lithosphere on the scale of the width of the Laurentian paleocontinent before emplacement.

These observations have implications for paleocontinental reconstructions that rely upon dyke trends, ages, and chemical affinities. While dykes of similar age are commonly used as piercing points in order to constrain a reconstruction, the growing dataset of identified circumferential swarms (e.g., Buchan & Ernst 2016), combined with the range in geographic extent of these swarms, raises the possibility of a 90˚-rotated configuration in the absence of absolute azimuthal information (such as paleomagnetism). Caution is further advised when making connections between sets of intrusions based on geochemistry (e.g., Denyszyn et al. 2009a), as the composition of the relatively-local mantle lithosphere has a significant effect.

References

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