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Reply to Mitchell and Jing: True polar wander alone is insufficient to drive measured Paleoarchean lithospheric motions

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We thank Mitchell and Jing for their letter (1) in response to our article (2) and welcome the opportunity to clarify why true polar wander (TPW) is insufficient to drive the apparent polar wander (APW) we document.

Mitchell and Jing (1) first fit the APW path to a single TPW axis (assuming the very unlikely scenario of zero structural rotation of the Soanesville Syncline) which would be appropriate only if the path traces a great circle. We resampled the positions of each paleopole and calculated the rotation pole between each successive paleopole pair, which should coincide if both rotations share a single TPW axis (3). However, the distributions of these poles exhibit substantial angular discrepancy (Fig. 1). A shared I_{min} pole is thus a poor fit to the APW path, arguing instead for two successive plate motions (2).

Mitchell and Jing (1) offer another interpretation that invokes "orthoversion," in which the minimum and intermediate moment of inertia axes exchange between TPW events due to large-scale reorganizations of the solid Earth's mass anomalies (4). Proposed orthoversion events, such as between Rodinia and Pangea, take place over 300 to 500 My, longer than the <<160 My available for the postulated Paleoarchean orthoversion (4). As importantly, orthoversion has only been proposed as the result of reorganization of continents and underlying mantle flow during transitions between supercontinents (4). Thus, if the presented APW path recorded an orthoversion, this would actually imply Paleoarchean global-scale plate tectonics and a supercontinent cycle, a far less conservative and parsimonious interpretation.

Mitchell and Jing (1) also assert that the long persistence time of the geoid throughout the paleogeographic record (5) need not apply in the Archean, allowing any angular separation of successive TPW axes. This claim is not based on independent evidence or a physical argument for greater variability of the Archean geoid. Without such deference to known or expected solid Earth behavior, any APW in Earth history can be equally interpreted as an example of TPW. In contrast, we argue that TPW, as understood through its documented occurrences, is not consistent with our Paleoarchean data.

While TPW can attain rapid rates (1, 6, 7), this does not uniquely support its invocation here, as our measured rates are also consistent with plate motions. Rates alone are not diagnostic in the light of the poor fit, incongruent timescales, tectonic implications, and speculative underpinnings of purely TPW interpretations described above. Also, for at

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The authors declare no competing interest.

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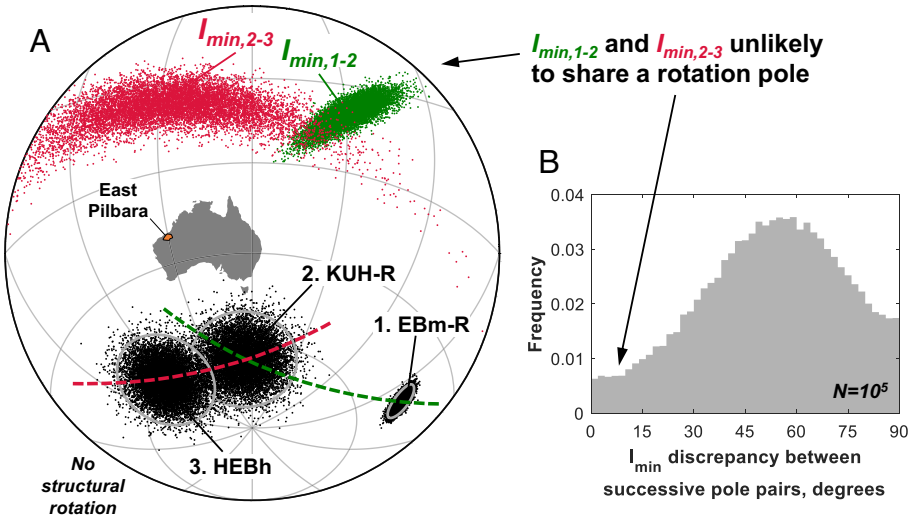

Fig. 1. (*A*) Map of resampled paleopole positions and their successive I_{min} poles. While single-axis TPW requires that these poles coincide, they are visibly distinct. (*B*) Uncertainty distribution of the angular difference between successive rotation poles.

least 75% of the last 2 Gy, the rate of TPW is consistent with zero, as large-amplitude TPW events are uncommon and most remain poorly constrained, in contrast to plate motions (7).

To conclude, while TPW may contribute partially to the APW path, it remains highly unlikely that it is the sole component, thus arguing for Paleoarchean plate motion of the East Pilbara.

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