Spot the difference: Zircon disparity tracks crustal evolution

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We thank Mitchell (2019) for his interest in our paper concerning temporally-framed detrital zircon disparity analysis, and its example application to understanding crustal evolution. Our colleague presents two main, but ultimately flawed, comments taking issue with our use of (i) geographic grouping, and (ii) Kolmogorov-Smirnov (KS) tests.

While disparity-through-time analysis is established in some areas of geoscience (e.g., palaeontology; Guillerme and Cooper, 2018), its use with detrital zircon data is novel. Mitchell inaccurately conflates the approach with classic source-to-sink detrital zircon provenance studies. Although the temporal-disparity approach we present could be applied at the basin scale, we evaluate global-scale homogeneity/heterogeneity of zircon populations. The justifications for, and limitations of, the geographic grouping of detrital zircon data were discussed at length by us (Barham et al., 2019). It is abundantly clear that we recognize that the aggregated mosaics of crustal fragments constituting the current continental groupings of detrital zircon data were discussed at length by us (Barham et al., 2019). It is abundantly clear that we recognize that the aggregated mosaics of crustal fragments constituting the current continental groupings do not necessarily reflect geologically coherent entities throughout Earth history. Geographic grouping is used only as a spatially unitized reference frame for the purposes of disparity analysis through time.

Mitchell claims geographic grouping renders a “majority of each data set essentially arbitrary”. However, this statement is demonstrably incorrect. Statistical tests of disparity versus the supercontinent cycle presented by us prove that this grouping remains sensitive to at least the last 2 Ga of global continental break-up and assembly (50% of the timeframe). Mitchell’s error appears, in part, to be assuming we are only looking for local similarities within and between geographically restricted terranes, rather than attempting to capture global disparity using geographic binning as a reference frame. Further support for our interpretation is evident when a completely different geographic grouping is used. Tracking detrital zircon disparity through the same 4 Ga of Earth history (200 Ma intervals) using a hemispheric division (North vs. South), reveals a statistically correlated pattern tracing the supercontinent cycle (Table 1). Although more muted, this simplistic geographic grouping still demonstrates increasing “global” detrital zircon similarity during supercontinent intervals, and decreasing similarity during continent dispersion.

Table 1. Pearson correlation of disparity versus supercontinent cycle for different geographic groupings

<table>
<thead>
<tr>
<th>Confidence of correlation with supercontinent timings of Barham et al. (2019)</th>
<th>Nearest Neighbor Centroid distance from MDS (CD) from MDS</th>
<th>SH-NH from MDS</th>
<th>SH-NH from KS from MDS</th>
</tr>
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<tbody>
<tr>
<td>&lt;99%</td>
<td>&gt;99%</td>
<td>&gt;99%</td>
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Note: ANN—approximate nearest neighbor; MDS—Multi-Dimensional-Scaling; SH—Southern Hemisphere; NH—Northern Hemisphere; KS—Kolmogorov-Smirnov.

Whilst any geographic grouping could potentially homogenize age signatures of amalgamated crustal regions, this cannot increase absolute disparity measures. Consequently, Mitchells suggestion that a pronounced disparity at 2.5 Ga is “largely an artifact of the cratons being grouped having no geologic meaning” is erroneous, given the inability of mixing to make a merged age population more age-peak-distinctive than its component sub-populations. Mixing will effectively smear age peaks, pushing grouped age populations towards a more homogeneous average that, when compared against other groups, would only act to conceal genuine disparity excursions. For all of the above reasons, the issue of geographic grouping raised by Mitchell is moot.

Mitchell accepts that the KS test similarity metric (KSD) is a standard technique in detrital zircon studies, but contends that a major limitation (i.e., that the technique is based on the single maximum difference between samples) was omitted from our work. In reality, this fundamenta...