

## S1 Application of $F_T$ calculation to a real dataset

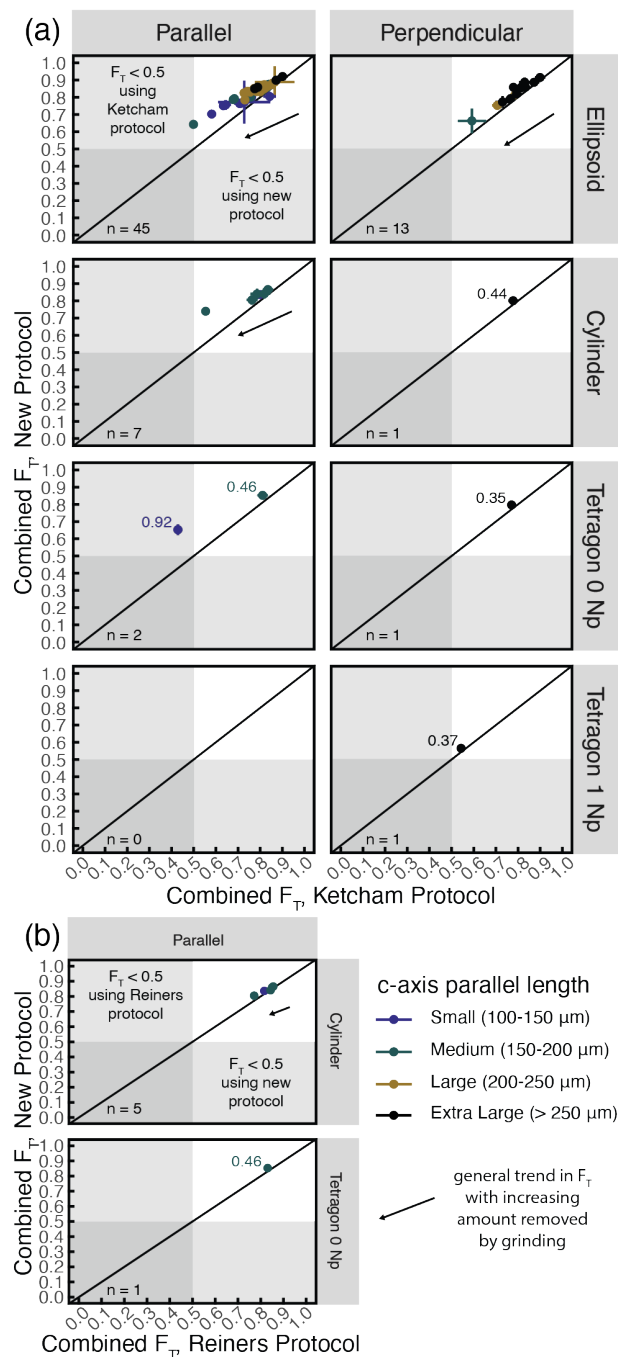
To illustrate the utility of the new protocol for detrital zircon studies, I apply it to a Neoproterozoic sandstone from the Michigan Upper Peninsula, USA (Table S2, Fig. S1). This dataset was generated at the University of Colorado Boulder Thermochronology Research and Instrumentation Lab (CU TRaIL). The sandstone sample was processed following standard CU TRaIL mineral separation procedures (e.g., Peak et al., 2023). Heavy mineral separates consisting mainly of zircon were dump-mounted on two mounts: one using Teflon as a mounting medium, and one using Epicure 2 epoxy. Glass spheres were mounted alongside the grains on both mounts. Mounts were ground and polished by hand using successively finer sanding paper and alumina polishing grit. Following polishing, individual zircon were plucked from the mounts using tweezers and acetone to dissolve the mounting medium in the vicinity of each grain. Grains were classified and measured following the protocol described in Section 2 of the main text. Each grain was then analyzed following standard CU TRaIL (U-Th)/He degassing and dissolution procedures (e.g., Peak et al., 2023).

The real dataset ( $n = 70$ , Table S2) includes a much more limited sampling of original grain geometries, grain sizes, aspect ratios, and width ratios than the synthetic dataset. Geometries include ellipsoids ( $n = 58$ ), cylinders ( $n = 8$ ), non-terminated tetragons ( $n = 3$ ) and tetragons with one termination ( $n = 1$ ). The high number of ellipsoidal grains is unsurprising given grain abrasion that occurs during sediment transport. Size (c-axis parallel length) ranges from 102 to 361.1  $\mu\text{m}$  with a median size of 199.3. Aspect ratio (the ratio between the c-axis parallel length and larger perpendicular axis) ranges from 0.3209 to 2.5222 with a median of 1.0669. Width ratio (the ratio between the two c-axis perpendicular axes) ranges from 0.3303 to 0.9929 with a median of 0.6528. The aspect ratios and width ratios present in the real dataset are similar to the ranges tested with the synthetic dataset. However, the real dataset only includes zircon with c-axis parallel size in the higher end of the range, or higher than sizes tested with the synthetic dataset. Grinding depth was calculated using measurements of mounted glass beads as in Section 2 of the main text and was significantly higher than the zircon average alpha stopping distance in all cases (Table S2).

Both alternative methods for calculating combined  $F_T$  underpredict  $F_T$  relative to the new protocol (Fig. S1), as expected based on the results of the synthetic dataset. This is true regardless of geometry, size, aspect ratio, width ratio, or grinding depth.  $F_T$  values differ the most between protocols when grains are small and more of the grain has been removed, which is only visible in comparison between the new protocol and Ketcham et al. protocol (Fig. S1a). This is also expected following the results of the synthetic dataset. However,  $F_T$  values differ less dramatically than observed for the synthetic dataset. This is likely due to the relative similarity between the real grains evaluated compared to the synthetic dataset, which includes many more possible grain sizes, aspect ratios, and grinding depths. The Reiners et al. protocol applies to only 6/70 analyses of the real dataset (Fig. S1b), which makes comparisons between the Reiners and new protocols inconclusive using these data alone. Regardless, the Reiners et al. protocol is less useful for this dataset by virtue of being inapplicable to the majority ellipsoid geometry present.

## References Cited in Solely in Supplementary Text and Tables

- Hiess, J., Condon, D. J., McLean, N., and Noble, S. R.: 238U/235U Systematics in Terrestrial Uranium-Bearing Minerals, *Science*, 335, 1610–1614, <https://doi.org/10.1126/science.1215507>, 2012.
- Peak, B. A., Flowers, R. M., and Macdonald, F. A.: Ediacaran-Ordovician tectonic and geodynamic drivers of Great Unconformity exhumation on the southern Canadian Shield, *Earth Planet. Sci. Lett.*, 619, 118334, <https://doi.org/10.1016/j.epsl.2023.118334>, 2023.



40 **Figure S1: Comparison between combined  $F_T$  calculated using the new protocol presented here and existing protocols for calculating  $F_T$  for a real detrital zircon dataset. (a) Comparison with the protocol of Ketcham et al. (2011) and (b) Comparison with the protocol of Reiners et al. (2007). Note Reiners et al. protocol only applies to cylindrical and non-terminated tetragonal geometries and grinding depths  $\leq 50$  % of the original width. In all plots colour corresponds to size defined as the c-axis parallel length. Black arrows indicate general trend of  $F_T$  with increasing fraction of the grain removed through grinding. Gray shaded regions correspond to  $F_T < 0.5$ ; these grains would typically be discarded from (U- Th)/He date interpretations.**

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