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# *Interactive comment on* "Resolving the effects of 2D versus 3D grain measurements on (U-Th)/ He age data and reproducibility" *by* Emily H. G. Cooperdock et al.

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General comments

Dear Authors, Overall I found the manuscript well written, structured and the topic is of interest for the thermochronological community. The applied analysis is of high quality, but lacks some comments on accuracy and general applications to 'normal' samples (fewer grains). See my Scientific and Technical comments below for details.

Scientific comments 1) I am not totally convinced that the 3D-CT measurements are accurate enough to judge the quality of 2D measurements. The resolution of the voxel



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Discussion paper

is 4-5 $\mu$m, relatively large compared to a typical grain size of 100 $\mu$m. The authors should convince the reader that the resolution is high enough to use their CT measurments as reference. Maybe you provide some real/synthetic data to prove that the resolution is good enough. You have provided some information in the text, but I am not totally satisfied with that. 2) You have estimated the hexagonal cross-section assuming an equal-sided hexagonal cross section and state correctly that this is not an adequate assumption for all grains. Since it is quite easy to measure the cross section for each grain with a bit more effort, please state why you haven't done this and/or calculate for extreme cases how much uncertainty you add by assuming the equal-sided cross section. 3) You conclude that although estimates of volume, surface area, ESR and Ft are deviating significantly for individual grains they partly average out or in average (for all measured grains) do not deviate from the CT derived values. You have not considered that the usual amount of grains measured in a bedrock sample is around 3 or 4 and in this case the deviations you observed are very likely not cancelling out. You could for instance provide the reader with some estimates of the possible deviation for 3-4 grains by (1) randomly resample 3-4 grains for each sample and (2) calculate the deviation from the complete dataset of different parameters (e.g. ESR, Ft). I hope you find my comments and suggestions helpful.

Technical corrections: Page 2, Line 10-30: No references here, please add relevant references. Page 3, Line 3: Herman et al. (2007) and Glotzbach et al. (2019) did this before. Page 3, Line 5: You do report results from the study of Evans on the accuracy of Ft values, why not reporting results from Glotzbach et al. (2009) on grain measurements? Page 7, Line 6: Not all reader might know what you mean with UFt and ThFt, please explain and probably use U-Ft and Th-Ft which is easier to read. Page 7, Line 7: Some or most of your grains do have tips, why have you not included them in this calculation? There are equations to do that, e.g. Ketcham et al. (2011). Page 7, Line 8: Here you use W for half-width, but further in the equations you use r. Please be consistent. Page 7, Line 18: I would prefer to write ESR = 3 * V/SA Page 7, Line 21: My understanding is that the density of apatite is closer to 3.2 g/cm3, maybe 3.18.

A reference would be nice to have. Page 7, Line 23: Give reference, e.g. Farley 2002. Page 8, Line 10: Please can you add a few examples of how you fit the CT-scanned grains with boxes. Please show examples where this method works fine and if present also some examples that could maybe not fit that easily. Page 9, Line 18: Do you start from the center of the voxel, or somewhere within the randomly chosen voxel? Since the voxel resolution is not that high (4.6-5 microns), starting from the center of the vexel may bias the calculation. Please clarify. Page 9, Line 25: If stopping distance/voxel size > 4 means the resolution is high, the sign should be opposite <!? Can you clarify for which sample/isotope this is true for your dataset and when you have used this super-sampling approach. Page 10, Line 32: Although the result will be quite identical, you have to correct the He content and not the uncorrected age (put the ejected He back in the grain). Page 11, Line 15-18: I would simply omit the grain and you can delete this section. Page 11, Line 29-30 and Page 12, Line 1: How serious is this issue, please report how this can happen and how often and to what degree. You could make repeated measurements on the same grain. Our microscope system is saving the magnification of each picture taken and we do not have yet found any errors. Please also have a look if the grains are somewhat different from other grains (more complex geometry). Page 15, Line 6: Please explain what you mean with simple geological histories Page 15, Line 18: Please explain why you have not used the equations of Ketcham et al. (2011) and did some measurements of the hexagonal cross section, e.g. using double-sided tape. On page 16, Line 20 you indirectly suggest that this should be done. Page 17, Line 10-12: This might be true for the average, but we should still care about the deviation of single grains since deviations might not cancel out if only a few grains are analyses. I would suggest you to randomly (maybe 1000 times) sample 3 or 4 grains from one sample and measure the mean deviation in Ft for those grains. Make a figure with deviation in Ft (x-axis) against probability (y-axis). In this way the results can be better transferred to normal bedrock samples. Page 18, Line 7: Where do you get this from, please provide some evidence for this conclusion (refer to a figure or table). Page 19, Line 7-9: Make sure you pronounce that this is really

only true for these two samples (with fast cooling history). I would expect that even though inclusions may not be always of minerals with high U-Th concentrations they still have a considerable effect on He diffusion. Please mention this to make sure that the reader does not get it wrong and start to pick grains with inclusions. Page 19, Line 14: Please provide the reader with some figure that supports your conclusion. To help the reader to better estimate the importance of broken grains, please report how large the deviation in Ft will be for a range of broken grain scenarios. Maybe you calculate for a few grains of your samples the Ft assuming that the grain broke (1) during mineral separation and (2) broke before cooling. We presented a method to account for this (e.g. Fig. 9 in Glotzbach et al. 2019) and show an example that yield a deviation of 'only' 5% which might be not detectable with your dataset since it is in the same range as other uncertainties. Page 19, Line 29-31: I am not an expert, but I guess you also have to calibrate a CT-scanner or? Page 20, Line 11: The optical microscope along cannot measure eU, please add that you have used an ICP-MS.

Table 1: Can you also report the difference (with sign) not only the absolute of it. Not sure if you really have to report the U Ft and Th Ft, just show the total Ft. Fig. 5: Could you colour-code the relative differences (deviation from the 3D model) and make a small legend in one of the plots?

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