

Interactive comment on “LA-ICP-MS U-Pb carbonate geochronology: strategies, progress, and application to fracture-fill calcite” by Nick M. W. Roberts et al.

Troy Rasbury (Referee)

troy.rasbury@stonybrook.edu

Received and published: 18 December 2019

Review of Roberts et al. This manuscript is sort of a funny mix of a review and new datasets. While the title suggests it is about dating veins, much of the text is devoted to other types of carbonate dating. While it is nominally a review of vein dating, it is not a complete review of what is out there. My comments below are really specific to the sections I am making the comments on, but my overall take on the manuscript is that it could be more compactly packaged and could do a better job of reviewing all of the U/Pb dating of vein material- perhaps leaving off discussion of speleothems which is well covered by Woodhead and a laundry list of carbonate characterization techniques

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that aren't tied to examples. The modeling of initial disequilibrium is a very important contribution. Why is it so late in the paper? I think it should be upfront and that the ages that are being reported from various veins might be considered in light of this. Does the few million years matter? What is the question- and how accurate does an age need to be to answer it.

Introduction- It is clear that laser ablation dating of carbonates is going to take U-Pb carbonate dating to a new level. It is particularly clear that using the Drost et al. approach for extracting pixels from imaging is going to push the potential even further, and in terms of uncertainties, perhaps to the realm where it competes with isotope dilution. I feel like the either or aspect to this introduction is a bit off track. That is, it is clear one can get far more precise measurements with isotope dilution. The size of the error ellipses at the best one can do with laser ablation is far larger than for isotope dilution. Obviously, the system has to be pretty well behaved to give a good line and the uncertainties are a reflection of that. However, the error ellipses are so large that the MSWD should be very low and even so there is often over dispersion of data. So even though one can drive the uncertainties down by increasing the data spread in a very clever way, I do not believe that this in anyway replaces the importance of isotope dilution for establishing the reliability of these ages. This is addressed further into the document, but it is a little bit overstated in the Introduction in my opinion. Figure 1: This should include a concentration scale. There should also be plane light and crossed polar light photomicrographs of the sample to go with the laser ablation maps. Further, it would be useful to see these maps with respect to other elements, particularly Fe, Mn, Sr, and Mg- the usual calcite elements measured for comparison. This will allow researchers who are interested in dating their carbonates to compare to what you have successfully dated.

Figure 2: This is a nice figure. I think a stronger point could be made that based on the LA results it would be possible to sample the high and low μ areas and achieve closer to the same spread in the data with ID. Presumably, you have synthetic data that could

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be used to do more with this figure. For example is Figure 2B the U concentration? The U/Pb? What is the concentration? From the description you hold Pb constant and have a range of U. What did you use for the initial Pb? Does it have scatter? How did you create the data used for the two isochrons? I am wondering why there is so much scatter in the green points for the LA data?

Line 300-Just a personal preference, but I think starting a sentence with a call out to a figure is awkward. Instead, I recommend making a statement about what the figure indicates and then calling the figure out. I won't repeat this for the remaining examples, but I think this should be changed throughout the text. I would also break this up into multiple sections which could call out figure 5 rather than as this lab project looking list you have. Line 358 is not accurate. There is no indication that having reduced U is more stable or more common than oxidized U. Both oxidized and reduced U have been observed and the U/Pb systematics, and even the U concentrations have not been shown to be controlled by this. Line 366 is also not accurate. U(IV) is insoluble in reducing fluids but is easily oxidized when oxidizing fluids interact with it. The Drake et al 2018 result on high concentrations of U assuming that the U is reduced and that explains elevated concentrations is not supported. It could be that the U is reduced, but stating that here without real evidence is propagating a myth. A really important question is how U(IV) could remain in solution to be incorporated in carbonates? The is particularly important for vein calcites as fluids can be meteoric, or have a deep source, or may be a mix of these. I bet you can't find a speleothem calcite that doesn't have U(VI) and yet your figure and discussion shows that they have equally high to higher U concentrations to veins. Line 411 is not exactly correct. Even if a fluid goes through a Pb rich rock it doesn't necessarily become high in Pb. It depends on the solubility. An example of one of the highest μ 's ever measured is from David Richards, 1998 paper from speleothems in Winnats Head Cave, Peak District UK which I understand is near a galena mine.

If the discussion of the various techniques for detailed investigation of carbonate tex-

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tures and element zoning could be put into the context of their application to dating veins rather than leaving that to the imagination (I am thinking back to figure 2 here) I think it would be a whole lot more digestible for researchers who are wondering how to get started. If you don't think phosphor imaging is good for this application, you could state that in a sentence rather than discussing how it works. This has been published and is used by others. The statement that speleothems have more U than other samples is not supported by your own figure 6.

Line 519- The title destructive techniques sounds so final! A small line left by a laser ablation traverse is hardly visible on a thin section or slab and as the paragraph accurately states can give important information on the potential for U/Pb dating. Line 605- it could result in meaningless ages- but this isn't required Line 870- I would be a little careful about the wording. Pb derived from ancient source will have a high 207/206. I think you mean instead source that have a relatively high U/Pb with a long enough evolution to give lower 207/206 which is then leached or dissolved and incorporated as initial Pb in the calcite you are dating. In carbonates an easy way to do this is to somehow preserve aragonite through early diagenesis and then have it exposed to a fluid which will quickly dissolve it and take the radiogenic Pb that it produced (as well as the U). Line 906- the example of the Moab fault seems out of place. I don't understand why it follows a discussion of common Pb corrections. Line 1063 I think you mean have a high likely of not being in secular equilibrium. Your discussion at the bottom of page 42 makes a good case for ID for samples that you want to know more about secular disequilibrium in. Line 1289 I think you mean data instead of date Line 1303 applied to a range of applications – should be reworded Line 1329 record and archive say the same thing. Pick one.

Interactive comment on Geochronology Discuss., <https://doi.org/10.5194/gchron-2019-15>, 2019.

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