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Interactive comment on "Resolving multiple geological events using in situ Rb-Sr geochronology: implications for metallogenesis at Tropicana, Western Australia" *by* Hugo K. H. Olierook et al.

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Reviewer #2: Thomas Zack

This manuscript is a very good illustration of the new opportunities of in-situ Rb-Sr dating. It combines a range of state-of-the-art techniques relevant to mineral exploration (e.g., automated full thin section mineral identification) with texturally controlled in-situ Rb-Sr dating of micas. In the following a range of suggestions are presented how to improve this contribution. As it is a fully public review (something I need to get used to), I hope I can also convince other colleagues to follow some of those suggestions.

We thank the reviewer for their time to provide insightful comments for this paper.

1.) Novelty of contribution: As it is stated in the introduction, it is not the first publication dating two generations of mineral assemblages in the same sample. Therefore please remove “for the first time” in line 16 in the abstract. Instead, it could be stressed stronger that this study demonstrates that in-situ Rb-Sr dating allows tying microtextures to several geological events, as correctly stated in the last line of the abstract.

AGREE. This has been removed.

2.) Better microtextural documentation: although a big strength of this manuscript is the combination of microtexture and dating, this connection could and should easily be improved by adding BSE images of selected areas where LA-ICP-MS spots are visible. In general, BSE images give a clearer overview of where exactly spots were drilled and if any fractures, veinlets, inclusions were accidentally hit. In this study specifically, it is important for the reader to judge independently if a biotite 1 or 2 domain was sampled. A critical question is: are those mixed ages (in between 2.5 and 1.2 Ga) due to a partly resetting or by a mixed analysis? Figure 3c is a good example. The biotite 2 looks “bleached”- well, it could be different chemistry (less Fe and/or Ti), finer grain size or even a mixture of different minerals. This can only be solved by showing higher magnification images by BSE (alternatively reflected light can suffix; however, if there is a change in chemistry, this may be visible by a change in gray scale).

AGREE. We thank the reviewer for raising this point – it has yielded some interesting discoveries. BSE images have been added as a new figure (4) and across the transects. Biotite 1 in the ca. 2.5 Ga samples is really ‘clean’, whereas biotite 1 in the other three samples with younger apparent isochron dates show exsolution lamellae of rutile that probably occurred during the formation of biotite 2. Thus, these laser spots have hit physical mixtures of biotite 1 and 2, with the ages younger than 2.5 Ga having no geological significance.

3.) Combination of ages and chemistry: do you have any additional information on the chemistry of the dated micas? Again, there could (should?) be a difference in chemistry if there are different mica generations (here perhaps visible in different Fe and/or Ti contents). This is not only relevant for distinguishing biotite 1 and 2, but also I do wonder why you distinguish between muscovite (s.s.) and phengite? Is it based on the Si-content? In this case microprobe data must exist, and it would be important to report. If not, then how? Unfortunately no other major (except Ca) and trace elements were measured along with the Rb and Sr isotopes by LA-ICP-MS. This is a pity as it is one of the unique advantages of quadrupole ICP-MS to combine dating and concentration determination (for the future. . .).

AGREE. In retrospect, additional chemistry would have been a useful technique to help discriminate between the two biotite phases. Unfortunately, this was not done. For the biotite chemistry, see above point. For muscovite and phengite, the differentiation was purely petrographic, with muscovite being in larger sheets (e.g., Fig. 3h) and phengite being microcrystalline (Fig. 3f). We have stated this now in various places in the results section.

4.) How many age domains? Are there really “only” two significant ages extractable from the biotite data? A close inspection of figure 4b and 4d seems to show a clear linear trend of your “biotite 1” that falls on an isochron somewhere between the 2.5 Ga and 1.2 Ga. It could well be in this 1.8-1.6 Ga interval mentioned in chapter 2.1. I strongly recommend replotting the data from figure 4 in a histogram where x-axis is single spot model ages (like kernel density plots typical for detrital zircons). With a bit of statistics it can be tested if this third age is significant. For me it looks to regular to be a product of partial resetting (in contrast, the scatter visible by the grey circles in Figure 4a is a convincing example of partial resetting). IF such a third age can be established, the next question is: what distinguishes “biotite1” from samples in fig 4b and d from biotite from samples in fig 4a?

AGREE. As the above points, these dates younger than 2.5 Ga are physical mixtures

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Discussion paper

and geologically meaningless.

5.) Closure vs formation ages: as far as I can see, the difference between closure and formation ages has been handled in a succinct matter. Still, I think the manuscript will benefit by giving this topic a bit more prominence (e.g., defining those topics in the introduction and devoting a chapter in the discussion). It is currently a hot topic (“petrochronology” vs “thermochronology”), not always trivial to say which process is dominating in specific cases. Here you have (at least) two age populations of biotite not governed by volume diffusion (still, it is worth mentioning grain size effects on closure temperatures). Furthermore, muscovite is supposed to have higher closure temperatures than biotite, yet muscovite is younger than biotite 1, a clear indication that muscovite ages are formation ages.

PARTLY AGREE. The muscovite ages have high uncertainties (+/- 170 Ma) that overlap with biotite 1; thus, it is not possible to say that the biotite 1 is younger than the muscovite. Thus, we find it difficult to comment on the closure temperature and formation ages.

Specific edits: - abstract, line 16: instead of "K- and Rb-bearing", say "K-rich" or "Rb-bearing".

AGREE. Changed.

- abstract, line 20: replace "second assemblage" with "younger assemblage" (second and first are not defined in abstract)

AGREE. Changed.

- introduction, line 47: papers by Wolfgang Muller are good examples for texturally-controlled micromilling Rb-Sr dating (e.g., EPSL 180, 385-397).

AGREE. This paper has been cited.

- methods, line 193: instead "zero counts" (which do not exist), rather say "< xx cps".

AGREE. We have changed this to <7 cps.

- methods, line 217: please say a few more words on the biotite secondary standard CK001B. What chemistry does it have (annite vs phlogopite, etc)? Micas are a very large group with very different chemistry- it may turn out that "matrix" effects may even operate within a mica group, so it is good to have the chemistry specified.

We currently have another paper under review that specifically characterises this secondary standard.

- results, line 237-243: out of curiosity: do you have any constraints on the temperature conditions during mylonite formation? Would be nice to state if you can, as it will give important constraints that biotite 1 can statically survive a certain heating episode without diffusional resetting.

AGREE. Unfortunately, we have no calculation of temperature based on petrology. We believe that a mineralogy of the Assemblage 2 indicates ingress of fluids during the shearing and demonstrates an open thermodynamic system, which makes any PT calculations unreliable. Textural evidence shows brittle deformation of K-feldspar supporting greenschist facies temperatures.

- results, line 271: "fractures were intercepted". Again, this is not clearly visible in the petrographic image. A BSE or reflected light image would be better.

AGREE. Following the comment above, we have taken selected BSE images to demonstrate this.

- discussion, line 313-316: please delete the last two sentences, as they are too speculative!! You can ask Steve Reddy how messy cite occupancy of radiogenic isotopes are on an atomic level. Unless somebody is doing AFM on a mica, we simply do not know.

AGREE. We have deleted these.

- figure 1b: please note that yellow diamonds are gold occurrences. Best wishes,

AGREE. This has been added to the legend map.

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