

Comment on gchron-2022-8

Anonymous Referee #2

Referee comment on "Constraining the geothermal parameters of in situ Rb–Sr dating on Proterozoic shales and their subsequent applications" by Darwinaji Subarkah et al., Geochronology Discuss., <https://doi.org/10.5194/gchron-2022-8-RC2>, 2022

General comments

The study uses in situ Rb–Sr dating of shale unit fragments and thermal modelling of literature data to constrain the thermochronological evolution with depth of an Australian Proterozoic basin site. It represents an important contribution towards increased understanding of the effects of heating and diffusion from secondary events on isotopic Rb–Sr systematics of basin rock units since few natural studies occur on the matter. The study also highlights the use for coupling knowledge of the thermal evolution in multiple dimensions when interpreting the significance and meaning of geochronological data. The utilized methodology offers a route to achieve that. However, the strength of each specific method and the combination of them is not demonstrated in much detail, as outlined by the following points.

- 1) The modelling of literature thermometry data with time is considerate and useful with vast amounts of input data, but since secondary mechanisms causing isotopic disturbance also can move laterally, the limit of a one-well model increases the interpretation uncertainty. In the absence of a horizontal modelling dimension, the following considerations should be discussed or clarified regarding the central issue of estimating the boundary conditions isotopic disturbance:
 - a) How may any lateral variations in the geological setting and the processes and events affecting the rock sequence impact the conclusions drawn on the timing, spatial occurrence and sheer cause of isotopic disturbance given that conclusions are based on a modelled vertical line?
 - b) Migrating fluids are inferred as cause for isotopic resetting beneath 900m depth. Can these fluids be traced by veins, mineralizations, crystal zonations or else? If so, can direct thermometry or other geochemical characterization be applicable of such? Has this been observed and considered in any previous study of the site? Indifferent of negative or positive answers to these questions, the matter should be mentioned in the manuscript.

- 2) The in situ Rb–Sr dating is the only new data collected in the study, and the technique

is indeed promising and applicable for dating of diverse processes affecting shale units. In order for this analytical campaign to demonstrate the utility of the method, improvements in sample selection, presentation and discussion are due as outlined in the following points:

- a) Given the spot size used and the fine-grained nature of illite, each isochron point represent a mixture of grains that may have stabilized isotopically at different times. The authors mention that each sample is predominantly composed of either unaffected or reset authigenic illite as observed by mineralogy alone. If XRD has been used to identify these in this or previous studies of the site, please provide and explain more explicitly the basis of the illite generation identifications. Is it verified that no mixtures of clay mineral phases or multiple clay growth generations (including detrital) are present in any of the samples? If so, how was this verified? If not, please comment on the implications for the age results and the interpretation of its meaning that multiple generations may exist. Please also clarify reasons for excluding grain size separation and Illite Age Analysis (Pevear, 1999) from the study.
- b) Continuing on the illite mixing topic, estimates of the illite homogeneity can also be provided by dissecting isotopic ratios in each LA spot signal in the absence of grain size separation. Please provide a detailed account on how the procedure of analysing spot homogeneity was carried out, on the outcomes and conclusions drawn from the observations, and mention any implications for the age results going from single downspot time frames to the combination of spots in the isochron diagram.
- c) Relating to the above points, inclusion of other minerals than illite in the LA signals is mentioned and disregarded as merely quartz in the Supplementary Material and therefore irrelevant for the Rb-Sr contents. Relating to the multimineral mineralogy maps, have the signals and spot locations been checked for mineral occurrence? If so, how was this performed? Were any spots rejected for the sake and if so, for what reasons? It was made sure that no K-bearing minerals interfered down-hole in each spot? Clarifying notes of these procedures and results should be contained at least in the supplementary information.
- d) the illite crystal textures and intermineralic textural relationships are qualitatively described without detailed petrographic images or accounts on variations within samples. Can such be added for the specific samples in this study and compared to previous studies describing these features at the site?
- e) The in situ Rb-Sr dating sample set consists of five samples over a ca. 800m depth interval. Given the discrepancy of several hundreds of meters (most shallow effect from the sill is interpreted at 600m or 800m) in the different thermal modelling predictions, please comment on how the sample interval larger than 200m below 696m depth affects the interpretation and uncertainty of the results regarding potential isotopic disturbance of fluid migration.
- f) The initial Sr values are not anchored to actual data but rather inferred from the isochrones and comes with large error ranges. Since the importance of initial Sr values for tracing crustal fluids and their sources is indeed stated in the manuscript, have any previous data source been considered for narrowing down on them in the stratigraphic sequence, or may new data collection on this be advisable? Given the spread in initial Sr values and their inference from large-error and low-Rb isochrons, it should be explicitly stated that
- g) The isochrons produce age errors ranging up to 300 Ma. Many of them overlap each other and several other dating results in the area, and yet their interpretation and meaning is provided without any note or disclaimer. The age errors and their implications for the conclusions based on the dating should be discussed. In addition, the concluding reasoning of the method as a useful discriminator of geological events in sedimentary units should regard the large age error ranges.

3) The combination of the methods have been shown to provide thermochronological constraints, but since the authors repeatedly emphasize its utility, may it be described what actually makes this particular combination so powerful and how it distinguishes from other thermochronological methodological schemes?

Specific comments

L161 Are there any tectono-thermal perturbation that would be expected to have affected the area, and if so, when and of what type? Any orogeny that may have disturbed radiogenic isotopic system?

L167 Word missing after terminated? Otherwise the sentence does not make sense.

L280, L365 Avoid subjective adjectives such as good, here and on later places in the text.

L382-384 How can such a specific statement be motivated considering the large age errors?

L456-458 Generally, chapter 5-8 contains multiple repetitions which can be slimmed. The sentence starting with "This event.." is one of those that includes statements already appearing repeatedly up to this point in the manuscript.

L488-501 Contains statements repeated from previous sections, but if this has the function of a concluding section it should work.

L493 Ages are in the text not seldom referred as comparative and relative, e.g. here in mentioning "younger ages". Precise age ranges would have made the text more concise and apt to follow in instances such as this.

Figure text Figure 6. Avoid the use of "better" and possibly the whole last sentence that can be deemed obvious and irrelevant.

Figure 5. The color scheme indeed needs adjustment, too many undistinguishable green colours.

Supplementary Material

L21 What is the last sentence supposed to mean? The signal interval selected in the data reduction procedure? Please clarify, and it is not helpful to put an explanatory word in apostrophes and then not explain it.

L45 Ideal is an interesting word of choice, would not more ideal for in situ spot-based LA dating at least be that individual grains can be targeted?

L56 Expressing that the textures do not look detrital should be replaced with a description and/or a detailed, high magnification petrographic photograph forming the basis of these genetic interpretations, which is also a general remark for the mineral texture descriptions (see comment 2d above).

References

Pevear, D.R., 1999. Illite and hydrocarbon exploration. Proc. Natl. Acad. Sci. USA 96, 3440–3446. <http://dx.doi.org/10.1073/pnas.96.7.3440>.