Geochronology Discuss., referee comment RC1
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Comment on gchron-2021-20

Anonymous Referee #1

Referee comment on "The μDose system: determination of environmental dose rates by combined alpha and beta counting – performance tests and practical experiences" by Thomas Kolb et al., Geochronology Discuss., https://doi.org/10.5194/gchron-2021-20-RC1, 2021

General comments:

In trapped charge dating, U, Th, K contents are routinely measured to calculate the environmental dose rates. In the manuscript of Kolb et al. (2021), the authors have systematically studied the performance of the μDose-system in determining U, Th, K contents by a combined alpha and beta counting technique. The accuracy and reproducibility of the μdose-system is tested by repeated measurements on IAEA U, Th, K standards and two loess standards. The minimum measurement time needed for reliable results with the μdose-system is obtained by comparing the results from different measurement durations. Comprehensive inter-laboratory comparisons have been carried out by the μDose-system and other commonly used methods (TSAC, ICP-OES, gamma spectrometry) on ~ 50 natural sediment samples from various environments. Finally a conclusion is drawn that the μDose-system, as a fast and cost-effective new method, is capable of measuring radionuclide contents with good accuracy and precision.

This manuscript talks about the new technique in determining the environmental dose rates for trapped charge dating, which fits the scope of Geochronology journal. The data produced in this manuscript is profound and the conclusion is solid. The good performance of the μDose-system in determining the environmental dose rates would be of interest to researchers expertized in luminescence dating and electron spin resonance dating. It would also give guidelines for the researchers who are currently using or going to use the μDose-systems in the luminescence or ESR dating labs. Therefore, I recommend this manuscript to be published in the Geochronology journal after minor revision.

Specific comments:

- Because of the algorithm used in uDose-system, the U and Th contents are negatively correlated. We can see from Figures 3, 4, 7, 8 that, when the Th content or activity is higher (assume it is overestimated), the corresponded U is lower (underestimated), and vice versa. I think it might be more helpful to add the bulk U+Th activity as another parameter for comparison. Even though the individual activities of Th and U are deviated from the expected values, as long as the bulk U+Th activity is close to the expected value, it might still be treated as a successful measurement regarding the calculation of environmental dose rate. The conversion factor from activity to beta dose rate is higher for U and lower for Th, while the conversion factor from activity to gamma dose rate is higher for Th and lower for U. They compensate each other, and the total dose rate does not vary much with the exact Th/U ratio (e.g. section 4.3.1 in Aitken 1985; Li and Tso, 1995). For example, in thick source alpha counting (TSAC), sometimes we can simply assume that the sample has equal activities of U and Th series. So, I think the bulk U+Th activity would be another evidence for the reliability of μDose-system to accurately determine the environmental dose rate.
- Maybe, it would be even more straightforward to calculate the final environmental dose rates for comparison. Dose rates can be calculated according to the true settings of individual samples (grain size, mineral, water contents, etc). Alternatively, dose rates of all samples can be simply calculated based on etched quartz with a fixed diameter (e.g. 150-200 μm) by U, Th, K measured from μDose and other methods (TSAC, ICP-OES, gamma spectrometry), and just assume constant cosmic ray and water content. Comparison of dose rates can directly give the readers an impression about the performance of μDose in determining the environmental dose rate.

Aitken, M.J., 1985. Thermoluminescence dating. London. Academic Press.

Li, S.H., Tso, W.M., 1995. Systematic error from Th/U ratio in luminescence and ESR dating. Nuclear Science and Techniques 6, 113–116.

- To study the impact of measurement duration on the results, the authors have made repeated measurements with different durations. As the data can be stored during the measurements, I have a concern: are the short-measurements separate measurements or are the short measurements the former parts of long-measurements? I guess the former strategy is more reasonable, otherwise there would be correlation between the short and long-measurements.

- When comparing the results of the 47 natural sediment samples, the discrepancy of

several samples is attributed to the disequilibrium in U and Th decay chains. For example, fluvial flood plain sediments may have strongly alternating ground water levels which can increase or/and decrease specific radioactive daughter nuclides in the U and Th decay chains (line 483). In the beginning, I thought you meant the radon-loss induced disequilibrium, then I got confused. Because for the TSAC and gamma spectrometry measurements, the samples have been stored for 4 weeks before measurements and for μDose-system the samples have not been stored before measurements. If the discrepancy is caused by radon, the problem would exist for all samples. Now, I guess you meant the disequilibrium caused by long-lifetime daughter nuclides, right? Could you give examples of the daughter nuclides that might be influenced by the ground water level change, and if possible, list a reference? That may help the readers to better understand what you mean.

- In the sample preparation step (line 195), the samples were pulverized in a ball mill (29.5 Hz for 45 minutes) and then dry sieved restricting the grain size diameter to < 63 μm. Do you assume that grain size < 63 μm would be fine enough for alpha counting? And usually how much sample would be left coarser than 63 um after being pulverized in a ball mill for 45 minutes? I am a little worried that this sieving step may cause fractionation of the sample component. For example, if the quartz is more difficult to grind than feldspar, the left residue of > 63 um will contain more quartz and the fine powder will have higher K (as well as Th, U) contents. Or maybe, the left residue of > 63 um contains more heavy minerals which have high Th, U contents (e.g. zircon), and the fine powder will have lower U, Th contents. Would it be better that we extend the grinding time and avoid the sieving process?

Technical corrections:

Line66: ‘disk’ is used here while ‘disc’ is used in line 197. Please make it consistent.

Line79: ‘These pairs are the result of…’ change ‘result’ to ‘results’.

Line174: ‘16.5 ± 1.5 mg/kg for K’, change to 1.65 ± 0.15.

Line 197: ‘sample carrier’, could you please indicate in Fig. 1a which one is sample carrier? And also give the name for that metal base.

Line 385: ‘of only view hours’, change ‘view’ to ‘a few’.

Line 443: I think it is not necessary to use a separate paragraph here.

Table 4: Maybe it is better to also convert the activities of Murray et al. (2018) into the concentrations. That would give the readers a direct comparison of the results measured by different methods or labs.