Geochronology Discuss.,
https://doi.org/10.5194/gchron-2020-33-RC1, 2021

Interactive comment on "Uranium incorporation in fluorite and exploration of U-Pb dating" *by* Louise Lenoir et al.

István Dunkl (Referee)

istvan.dunkl@geo.uni-goettingen.de

Received and published: 5 January 2021

This manuscript addresses an extremely important topic: the direct dating of mineralizations by an unconventional method/mineral pair. Such results are highly requested for the reconstructions of paleo-fluid paths, for understanding of ore-generating processes, but also in basin analysis & reservoir studies. Additionally we can not forget the missing explanations of the localized, well detected anomalies in the regional thermochronological studies that are usually related to "local hydrotherms", but their true reason typically remains only as an assumption. The selected fluorite-bearing site is lucky, the U content and the Pb/U ratio allowed generating well constrained Tera-Wasserburg plots and lower intercepts. However, unfortunately there are several aspects remained open both in the technical realization of the analyses and also in the

interpretation of the results. For the less important, minor corrections and suggestions see, please the decorated PDF file. Here I list my major concerns.

- The fibrous texture is mentioned, but not documented. Add a microphotograph, with proper resolution, please.

- Line 63: In this sentence there is a paradox. You can argue that no other geochronological method can be used in this paragenesis, thus the new results are unique and important. But you can not use it as a test site of the new method, when no other age control is available.

- You applied different laser beam diameters at the ablation analyses (40, 110, 135, 150, 155 μm are listed for different phases and different reference materials). This is a problematic point, as the fractionation, and its trend depend on the crater diameter and on the aspect ratio.

- What was the use of the analysis of carbonate primary and secondary reference materials (WC-1, DBT and AUG-B6)? It is difficult to trace in the text that actually how was considered the observed matrix-controlled fractionation from the NIST glass isotope ratios and/or the deviation from the nominal ages. Why did you use at all carbonate?

- It is not clear, what is the penetration of the SR-XRF method. What volume supplies the chemical information, when the X-Y pixel size is 50 nm-1 μm, what is the Z dimension? Indicate it, please in the method section. E.g. in Fig. 5 the Y pattern continues behind the pyrite inclusion, thus it seems that we got elementary signal from needle shaped volumes and not only from the surface.

- Fig. 5: The Ca-plot needs some more explanation. It is not clear how linear is the colour scaling, and actually what is the meaning of the red coloured horizontal patches at the top, only a few % Ca replacement or a non-Flt inclusion?

- The globular shape of the tiny pyrite crystals is not convincing. The zonation of the

pyrite in Fig. 9 can also be interpreted as cube + a small octahedron at the corners.

- I would suggest to replace in many sentences "metal" by "element". Please scan through the text.

- Figure 10. should be re-designed; e.g. explain better on the figure the "redox front".

- What can be the source of the F? Do you assume an external, F rich brine, or it can be related to the breakdown of biotite locally, in the granitoid basement?

- Line 391: "As the thickness of these bands is sometimes less than 10 μm, we suggest that the coloration was acquired through gamma irradiation, instead of α-irradiation, which would have caused larger bands" It is a very wild statement, as the penetration of gamma ray is much longer than the alpha particles. Without any detailed explanation and citations this assumption is not tenable.

- Fig. 11: The incorporation of Zr in the fluorite lattice is highly interesting and in the first glance rather difficult to explain. Add maybe some sentences about it.

- Line 400: Lead "seems to be correlated with Th". Just by visual observation it is difficult to evaluate, e.g. the U & Pb seems to be also correlated. Supposedly the SF-XRF data are not quantitative, but I guess that from the pixel intensities it would be possible to generate X-Y plots (having arbitrary, but linear scales) that may show correlations and trends between elements. Then the word "correlation" can be used at a higher significance.

Line 406: "To test the reliability of U-Pb dating in the fluorite rims of Pierre-Perthuis, we further discuss potential alterations by (1) the development of fractures and cleavages;" But in line 412: "these fractures only generated local alterations, and were consequently avoided in LA-ICP-MS analyses". It means that the reliability was actually not tested, just the most intact volumes were considered for analyses. I recommend the rejection from the text the goal formulated in Line 406 as it was not fulfilled. Similarly, from Line 413, it is not the test of reliability.

- Line 484: It is difficult to accept your view to consider two dates (ca. 130 and ca. 40 Ma) as the "lifetime" of the deposit was 90 Ma (better Myr) long. They can also be interpreted as two independent fluid circulation+mineralization events.

- I am just speculating, what is actually the speciality of this deposits having two phases of fluorite crystallisation. If we think about the regional events, the ca. 130 Ma would fit perfectly to the maximum burial and thermal climax of the basin and the Eocene age would fit well to the impact of the descendent meteoric, oxidative fluids. The former was reductive, thus no U mobilization had happened, while the second regime contributed to the further breakdown of biotites by oxidation and could carry U. It is only a guess.

- The suggested biogenic process-triggered change in eH is a plausible explanation, although not fully proven. Add, please in the text the calculated/measured basin-bottom burial temperature in Eocene time. It can be used as argument that the paleo-temperature did not exclude the bacterial activity.

- Figure A3: This SEM images unfortunately are not informative and not proper. Replace them by other SEM images that show the craters in an oblique view without any overlay (please no blue staining and circles). It would be crucial to document that using the applied ablation settings the craters have been developed by a continuous ablation and they have regular U-profile or the formation mechanism was a sequence of explosions and the bottom has irregular, fractured, zig-zag shape.

- Supplementary material:

Table A3: Two columns can be deleted (surface of the sample & bottom of the crater), as these are unimportant raw data. The craters are very deep, and their aspect ratio seems to be not usual at LA geochronology. In case of such deep craters the down-hole fractionation can be extremely high.

Review_Fig. 1; Left panel: WC1-20191219 sample as it is presented in the supplementary Excel file, Right panel: all data plotted by IsoplotR. Could you please explain

the selection criteria applied at the reduction from the total 45 data to 23 that were used.

Review_Fig. 2; Left panel: AUG-B6-20191219 sample as it is presented in the supplementary Excel file, Right panel: data plotted by Isoplot R considering at the input 2 se for the uncertainties. The error ellipses are different (see just above the number "50"). Control, please, this deviation; at the input the uncertainty should be set according to the data table.

In summary this manuscript can be a useful contribution to the topic of direct dating of mineralizations, but the inconsistencies should be fixed.

Please also note the supplement to this comment:
https://gchron.copernicus.org/preprints/gchron-2020-33/gchron-2020-33-RC1-supplement.pdf

---

Interactive comment on Geochronology Discuss., https://doi.org/10.5194/gchron-2020-33, 2020.

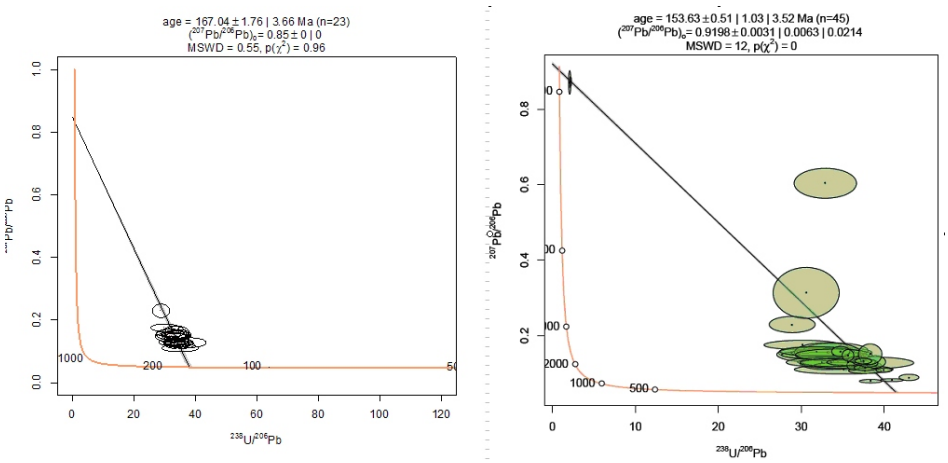

Fig. 1.

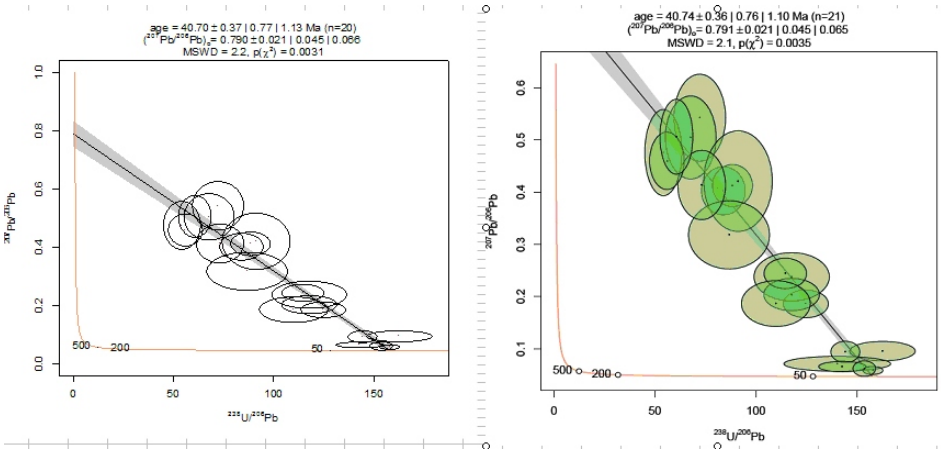
age = 40.70 ± 0.37 | 0.77 | 1.13 Ma (n=20)
(207Pb/235Pb)o= 0.790 ± 0.021 | 0.045 | 0.066
MSWD = 2.2, p(χ2) = 0.0031
207Pb/235Pb
235U/235Pb
500
200
50
age = 40.74 ± 0.36 | 0.76 | 1.10 Ma (n=21)
(207Pb/206Pb)o= 0.791 ± 0.021 | 0.045 | 0.065
MSWD = 2.1, p(χ2) = 0.0035
207Pb/206Pb
238U/206Pb

Fig. 2.