Dear editor, dear reviewers,

All technical comments were implemented in the manuscript. The issue of deformation or fluid flow as the reason for monazite (re)crystallization was the main point Dr. Brouwer felt had not been addressed in sufficient detail. The part explaining our reasoning why the analyzed grains date deformation now provides more details, was moved and is now included in the introduction.
We would like to express our gratitude to the reviewers for their thorough work that greatly improved the quality of the manuscript.

Yours sincerely,
Christian Bergemann

Review of Bergemann, Gnos, Berger, Janots and Whitehouse, Solid Earth Ms. Dating tectonic activity in the Lepontine Dome and Rhone-Simplon Fault regions through hydrothermal monazite-(Ce). - version 4, 28 October 2019.

Reviewer: Fraukje Brouwer, VU Amsterdam, Netherlands, 18 December 2019

Note: This review concerns version 4 of the manuscript that prepared in response to the review of Dr. M. Rahn of version 3, and focuses mainly on whether his comments were addressed satisfactorily. The response accompanying the revised version includes many questions throughout to Dr. Rahn. In some cases, the related comments were not addressed and the editor might want to check whether he feels further communication between the authors and Dr Rahn is necessary to address those points and could further improve the manuscript.

General assessment

In this version, the authors do a better job of presenting their data in a way that is intelligible to the reader and the manuscript has benefitted markedly from the revisions directed by the earlier reviews. I am disappointed by the quality of the English of the manuscript and recommend a thorough round of editing to improve its presentation. I started making specific comments for the Abstract but stopped after that, because it would take a considerable amount of time and I do not want to further delay my input.

The English was improved as much as possible by ourselves and given to another colleague for proof-reading (although also not a native speaker). We hope that upon reading the manuscript you will find the level of English acceptable.

Below, I list comments specifically related to the latest review of Dr. Rahn and the authors' response, Two additional, if related, comments of my own and finally a couple of pages of technical comments, which I emphasise, are far from exhaustive.
because of the interesting and extensive dataset, as well as the argumentation for its interpretation, I feel this manuscript is certainly worthy of further consideration for publication in Solid Earth, and I sincerely hope that with a final round of revisions, the authors address all remaining concerns and render the manuscript publishable. **I recommend that it undergoes minor revision before being accepted for publication in Solid Earth**.

Specific comments referring to the response accompanying v4 - remaining issues

4a The first part of the response asks further clarification and perhaps use of the figures from the reviewer. This is not a discussion I can or want to weigh in on and I suggest the editor decides what he feels is appropriate.

4i The response reflects confusion as the authors do not understand the reviewer's comments. I agree that they appear to have addressed the issue at hand under 4a.

The following comments concern the same general issue:

5 The authors state that fluid flow requires an 'event' and infer that such an event is most likely deformation. Dr. Rahn does not agree, and I feel that he is at least partly correct in his arguments. The authors make a strong case in the response that deformation is likely to play an important role, and this argument is now made more clearly in the manuscript (3.1) than in previous versions. In my view, two significant problems persist:

a) the authors fail to consider any alternative causes for fluid flow that might result in Mz precipitation, and

b) the position of this section in the manuscript, at the beginning of the methods section, is very strange. Section 3.1 in my view would be better placed in the introduction, because it presents the arguments supporting the basic premise of the study (all cleft Mz crystalisation is triggered by deformation-induced fluid flow). In the present form this remains an implicit assumption, rather than a well-argued premise. Alternatively, a sentence in the introduction could foreshadow this argument, and then 3.1 should be placed in the discussion of the manuscript.

Additional comments on v4.

Page 1
(Lines 12-13) 'The data-set shows that the fissure mineral crystal-rock interaction, fluid flow and resulting monazite-(Ce) age record are directly linked to the Lepontine Dome's evolution in space and time.' There is still a risk of circular argument here: if all ages are assumed to reflect deformation events, this is an unavoidable consequence.

Related to point 5, above. The implicit assumption of the abstract and introduction is that all fluid activity in veins that resulted in Mz growth was deformation induced. This is a basic premise of the paper and should be argued explicitly and convincingly in the Introduction. I don't necessarily disagree with the assumptions, but find the paper less convincing than it could be because the interpretations rely fully on this basic principle. In the end, this issue is the source of much of the criticism thus far.

As proposed by the reviewer, chapter 3.1 was moved to the introduction and expanded to discuss the issue of deformation vs other causes for fluid activity. The introduction was expanded to better explain that fluid flow is of little impact for most of the (re)crystallization history of hydrothermal monazite. Since generally only small fluid volumes that tend to stay within the cleft/fissure are involved.

10 There is quite a fundamental difference in opinion here between the authors and Dr. Rahn. I feel that the text has been changed enough that the reader may form their own opinion on this matter and that the manuscript does not suggest this interpretation is fact.

11 By their very nature the discussion and summary (or conclusions) must be repetitive, which means I disagree with Dr. Rahn on this point. I feel the present structure is clear and do not mind the repetition. It might be clearer yet to combine 3.1, 5 and 6 into a single discussion (section 5), with three or more subsections.

As mentioned above, section 3.1 was expanded and moved to the introduction. Chapters 5 and 6 were kept separate, but are now subsections of the discussion chapter 5.

Page 3, fig. 1: adding the 500°C isotherm is an excellent suggestion and make the location and shape of the Lepontine dome much clearer to the reader less familiar with the study area. I feel the authors should adopt this suggestion of Dr. Rahn.

The 500 °C isotherm available for the area has been added to the map. In lack of this for the south-western part of the study region, the albit-oligoclase mineral zone boundary was used.

Technical corrections

The numbers below refer to line numbers in v4 of the Ms.

Page 1

(5) Replace 'and' by 'to'.

Changed

(6) 'this' should be 'these', as data is always plural.

Changed

(7) 'In' should be 'at' or 'near', as an edge is a 2D, rather than 3D feature.

Changed to "at"

(8-9) '…started in the eastern Lepontine Dome later at 15-10 Ma.' should be '…in the eastern Lepontine Dome started later, at 15-10 Ma.'

Changed

(9) To my understanding mineral names should in almost all cases be used in singular, rather than plural (one wouldn't write 'quartzes', where it now says 'monazites'). The exception is when the word refers to different forms (e.g. solid solutions) of a mineral (garnets could be pyrope and almandine, as opposed to multiple grains). Therefore, in line 9 'Fissure monazites-(Ce) are younger…' should be replaced by 'Fissure monazite-(Ce) is younger…'.

Changed

(10) ‘A youngest…’ should be ‘The youngest…’. This statement is a bit confusing given the earlier statements that ages range to 2.7 Ma.

Changed to “A younger…”

(11) ‘data set’, instead of ‘data-set’.

Changed

(12) ‘fissure mineral crystal-rock interaction’ - it is not clear to me what the authors are trying to say. This needs to be rephrased again.

Changed to “interaction between fissure mineral and host rock”

(13) ‘and’ is missing: monazite-(Ce) AND thermo-chronometric data

Changed

As indicated above, I have stopped suggesting text edits after the abstract. Below are a few points that are simply wrong or unclear, but many more improvements can and should be made to the text throughout.

Page 2

(13) ‘Compared to this…’ should be ‘In contrast, …’

Changed

Page 5

Table 1 - It is unclear what the significance is of the two reference numbers in the table header. Three localities are not all aligned to the column (e.g., DURO; should this be DORU, like the locality itself)

The reference numbers were moved to the the analytical techniques section in the form of the sentence “Sample GRAESER 1 was provided by the Natural History Museum of Basel (identification number NMBa 10226) and VALS was provided by the Natural History Museum of Bern (identification number NMBE43124).”. The issue concerning the locality names in the table was solved.

Page 6

(3-4) ‘…Fault in the west/southwest south of the Centovalli Fault,…’ - confusing use of directions.

Please rewrite more clearly.

Changed to "…across the central Lepontine Dome to the Simplon Fault in the west/southwest, to south of the Simplon Fault, …"

(22-23) A verb is lacking in the part '…meaning that…deformation of the system.'

Sentence changed to "The fissure/cleft remains fluid filled and behaves for considerable parts of its history as a closed system, meaning that during deformation of the system, repeatedly recycled small volumes of fluid suffice for the (re)precipitation of large mineral volumes (Sharp et al., 2005)."

Page 8

(2-4) There's an overload of parentheses in this section, which do not make the text clearer. I'd suggest '…fractures in monazite-(Ce) crystallized during the initial formation of the grain (primary Mz) and monazite-(Ce) formed at a later time or recrystallized/reprecipitated (secondary), induced by…'. Note that there is a typo in initial.

Changed

(9) ()Grand0Homme et al., 2018). Correct parentheses.

Changed

Page 12

(21) The use of phases for deformation is confusing. It would be better use 'deformation phases', 'stages', instead, to avoid confusion with phases in the thermodynamic sense.

Changed

Page 14

(25) …younger than or equal to…

Changed

(32) …age record whereas ZFT ages…

Page 20

(16) delete first comma

Changed

(24) … window or if the analyzed…

Changed

Page 24

(23) '…may indicate a localized resetting…' - addition needed to address Dr. Rahn's comment.

Changed