

Solid Earth Discuss., referee comment RC2
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Comment on se-2021-119

Anonymous Referee #2

Referee comment on "Application of litho-geochemical and pyrite trace element data for the determination of vectors to ore in the Raja Au–Co prospect, northern Finland" by Sara Raič et al., Solid Earth Discuss., <https://doi.org/10.5194/se-2021-119-RC2>, 2021

General Comments:

This manuscript, focussing on the Raja prospect, Finland, is an excellent study demonstrating the use of geochemical techniques and vector determination to aid in targeted mineral exploration. There is an abundance of detail throughout, though as a result the manuscript is longer than necessary. The authors should reduce the length of the text and avoid unnecessary background information. They should also avoid repetition, particularly in relation to principal component analysis discussions.

Within all figure captions, the analytical data sources should be stated – eg. In Figure 11, it should be stated that the data come from LA-ICP-MS analysis of pyrites. This allows the reader to assess the figures without reference to the text (they should be able to stand alone). Do this for all figure captions, where appropriate.

Specific Comments

Line 20 – “produces the robust” – remove “the”

Line 25 – Indicate whether “1.3‰” is negative or positive

Line 28 – “latter pyrite” – this is a potentially confusing way to refer to the Au-mineralised pyrite (if that is what you are referring to). Please rephrase.

Line 40 – Given the international scope of the journal, please express coordinates using a globally utilised coordinate system

Figure 1 – Excellent figure and very detailed, though this should be a full page landscape figure to ensure detail is not illegible in final publication.

Figure 1 caption - Data sources for maps (a) and (b) require citations.

Line 81 – remove the period after “rifting”

Lines 82-84 – Numerous peer reviewed publications support the statement regarding the favourable conditions for the concentration of metals in basinal deposits during periods of atmospheric oxygenation, including Lyons et al., 2014; Large et al., 2014, 2015, 2017; Gregory et al., 2017; Johnson et al., 2017; Armstrong et al., 2018. Reference to some of these works should be made.

Line 144 – remove “material-bearing”

Lines 205-222 – Was a hydrogen reaction cell utilised in the LA-ICP-MS analysis, to remove selenium analysis interferences? If not, the potential influence of this interference needs to be accounted for in the discussion. If a reaction cell was utilised in the analyses then this should be stated.

Lines 229-235 – Insert the reference value and analysed value for the PPP-1 external standard. The internal standards utilised in the S-isotope analysis calibration/QC span a very narrow $\delta^{34}\text{S}$ range (-1.2 to 0 ‰, including errors). The $\delta^{34}\text{S}$ values found during the sample analyses range outside the range of the standards (-1.76 to 7.40 ‰), making the calibration at the farthest ranges less reliable. This is a minor point as the difference between the standards and sample values is not substantial, but it is not good practice.

Line 272 – “In practice it turned out to work well” – this is an opinion with no clear justification or scientific merit to the statement. Please rephrase.

Lines 277-279 – Why were the subsets of 12 elements used different in the whole rock vs the LA-ICP-MS data? Did the statistical method not work on certain elements, or were these analyses not available from the given analytical methods?

Line 327-335 – This section does not appear to be providing results of the new analyses, but summarising the alteration events as identified in previous works. If there are no new results, this should be in the intro and/or discussion sections. If evidence of this alteration has been observed, then this information should be incorporated into sections 4.1 or 4.2.2. Either way, this section should be incorporated elsewhere within the text or removed.

Line 358 – Provide a numerical value for the pentlandite exsolution lamellae

Line 360 – Do the numerous Bi-Te-rich phases have a consistent composition (and thus potentially mineralogy?), or are they highly variable? As is mentioned, the size precludes accurate mineral identification, but does the composition appear similar across most/all of the Bi-Te-rich phases?

Figure 5 – Are all 12 images necessary to convey the extent of mineralisation? This seems excessive.

Line 416 – Replace “chapter” with “section”.

Line 422 - Replace “chapter” with “section”.

Line 432 – Figure 8

Line 509 – Replace “present” with “represent”

Line 514 – “MER” – this acronym has not been stated in the text. This should be given in brackets after the term on line 508.

Line 519 – The use of the word “chapter” is not appropriate as this is not a book. When referring to a specific section, state the section number clearly for the reader.

Figure 10 – (e) and (f) require legends for Au and Co. Presumably they are the same as those used in (b) and (c), but this is not clearly stated nor very obvious.

Lines 535-537 – Alternatively/additionally, have you considered whether this pre-mineralization chemical alteration resulted in host rock compositions where later Co and Au mineralization was more favourable?

Lines 549-551 – Core to rim variations are potentially important in determining the timing of elemental enrichment/depletion from these pyrites. Are the rims consistently enriched in all elements vs the cores, or vice versa? Are some elements consistently enriched/depleted in rims/cores. This needs to be explored further and discussed. You could potentially assess the timing and extent of enriching fluids through these direct observations.

Line 552 – The latter of what? You haven't made a statement relating to two things previously.

Line 559 – It should be noted in the text that pyrite C also has a wide range of values for Se/S, not just the mean.

Line 576 – Table 4 figure caption states "first four principal components", however only three PC's are given in the table.

Line 620 – remove comma after both.

Line 623-624 – From the data discussed, Pyrite A has a 'lighter' (lower) max $\delta^{34}\text{S}$ (+5.9‰) than pyrite B (+7.3‰) or pyrite c (+7.4‰). This therefore does not constitute "the heaviest $\delta^{34}\text{S}$ signatures". This statement needs to be changed. Also, use higher/lower, rather than lighter/heavier when discussing $\delta^{34}\text{S}$ values.

Lines 787-789 – What is the spatial resolution of the LA-ICP-MS analysis that was conducted? This would provide an approximate value for which the potential nanoparticles would be smaller, if present.

Line 805 – As mentioned earlier in the text, the Se/S ratios for pyrite C are similarly wide ranging, so using mean Se/S for a comparison between Pyrites A and C is misleading. Rephrase this statement.

Line 814 – "...formation of some of orogenic...". There is a typo here I think

Line 851 – Change "to" to "of distinguishing"

Line 857 – Delete "essence of"

Line 872 – B pyrites show a wider range of $\delta^{34}\text{S}$, not just a more negative shift.

Lines 865-879 – Given the overlapping ranges of $\delta^{34}\text{S}$ in all the pyrite types, it should be stated that sulphur isotopes are not a distinguishing factor between different pyrite generations (and thus mineralization zones).

Lines 816-879 – Much of this section is repetition of previous sections with limited further discussion. Re-write and distil this section down to key points regarding the "Implications for mineral exploration". Lists of positive and negative PC loadings of elements are not warranted here.

Line 883 – Revise the word choice of "multiply"

Line 885 – As mentioned before, you have not utilised the high spatial resolution of LA-ICP-MS in this study by assessing the variation in trace element concentrations between pyrite rims and cores. You have averaged out the elemental concentrations within each pyrite, potentially missing important evidence for the timing of mineralizing fluids. I suggest re-visiting this data, where feasible.

Lines 880 onwards – Much of this section is repetition and/or unnecessary statements regarding the purpose of the study. Please rework this section to be more succinct.

Lines 893-897 – These statements/ore formation models should be made explicitly in the discussion section and summarised in the conclusions. Ore-formation models should not be first proposed in the conclusions.

References

Armstrong, J.G.T., Parnell, J., Bullock, L.A., Perez, M., Boyce, A.J., and Feldmann, J., 2018, Tellurium, selenium and cobalt enrichment in Neoproterozoic black shales, Gwna Group, UK: Deep marine trace element enrichment during the Second Great Oxygenation Event: *Terra Nova*, v. 30, p. 244–253, doi:10.1111/ter.12331.

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