

# ***Interactive comment on “Magmatic sulphides in high-K calc-alkaline to shoshonitic and alkaline rocks” by Ariadni Georgatou and Massimo Chiaradia***

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Received and published: 11 September 2019

I agree with Dan Smith that the contribution presents a useful and interesting dataset on the variation of sulfide melt inclusions in porphyry copper deposits, and shows that they can be used to provide information on their genesis. I also agree with the comments regarding discussion and interpretation of the data as presented. However, it is not clear how the modelled sulfide inclusion compositions (Table 2), which all subsequent discussion and conclusions are based on, are derived from the primary analytical data. Fig. 4 shows that the analysed sulfide inclusions are heterogeneous and comprise multiple phases. In addition, other than “The reconstruction of the bulk sulphide

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composition was based on area (%) of mineral modal abundances calculated by an image analysis software (ImageJ<sup>®</sup>1.38) and on EPMA analysis” [from the supplementary information], there is no description as to how this heterogeneity is accounted for in Table 2. Furthermore, a single microprobe analysis will only be a sub sample of the bulk composition and will be heavily reliant on the area selected for analysis, for example, in Fig 4. vi, dependent on placement of the EPMA beam, it is possible to get a range of “sulfide melt” analyses from a pure pyrrhotine to almost a pure chalcopyrite. The authors don’t state how the EPMA analyses of the sulfide droplets were undertaken – for example, do the reported data represent a single point, or are they the “best attempt” at ascertaining the bulk composition of the sulfide droplet?. I don’t feel that the methodology as described in the paper and the supplementary materials is sufficient. The authors need to be more critical of the limitations of the methodological approach. The statement [lines 242-244] “One could question that this approach may yield biased results (because of cut effects and crystal orientation), but averaged out over a large number of sulphides we think we obtain a significant first-order estimate.” is not really adequate to address the somewhat complex problem that original sulfide melts have now crystallised, are now heterogeneous and it is not clear what the EPMA analyses represent. Also, estimating the composition from the area occupied by mineral phases will be dependent on the section that is cut through the sulfide droplet – there are methods, such as stereology, to enable 3D volumes to be calculated from 2D sections –the authors do not state if these are appropriate or used, and if they are not appropriate, then how they justify their approach.

Overall the manuscript represents a valuable contribution in this relatively poorly understood area and should be published subject to revision. Any revised manuscript needs to specifically address this issue described above and any conclusions derived from the modelled sulfide melts need to take into account the limitations of the analytical methodologies in reconstructing original melt compositions in more quantitative a manner. I think the above criticism can be dealt with by some clear worked examples

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of how the sulfide droplet compositions were modelled as supplementary information plus a more in depth critique of the limitations of the method in the main text. The sulfide droplet samples depicted in Fig. 4 would be good cases for worked examples and would link the supplementary information directly to the main text.

The usage of English is generally good, but there are some areas that need attention (e.g. comment on Line 284 below). I would recommend that someone with a good understanding of written English, read and correct the final version of the MS. I have provided some guidance on English usage, but it is not comprehensive.

#### Specific comments

Line 31: “Historically, petrographic” is the correct usage here.

Line 64: “to the Ecuadorian study. . .”

Line 70: Why is this threefold approach important?

Line 107: “Early- to Mid-Miocene” – check consistency of hyphenation throughout.

Line 115: “is recognised” not “has been”.

Line 146: Subscript for SiO<sub>2</sub> – check throughout that subscripts are used where appropriate.

Line 169: Capitalization of “Figure”. Check for consistency throughout.

Line 174: “The common occurrence of voids/bubbles in contact with the sulphide phases is noteworthy” – frequently refers to “time” and common to “place”.

Line 193: Type-3 and -4

Line 196: replace “and altogether hosted by the same magnetite crystal” with “, all hosted by the same magnetite crystal”.

Line 210: How much of this compositional variability is due to the analysis of multiple phases? E.g., the electron beam excites a phase beneath the surface being analysed.

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For example, in Fig 4x it would be very difficult to analyse bornite without incorporating some signal from chalcopyrite.

Line 220: Use “the most Cu-rich sulfides” instead of “Cu-richest sulphides”, check usage elsewhere and amend.

Line 224: “detection limits” not “determination limits”?

Line 256: Use “Nonetheless, “. For information, when using this type of sentence construct, that is starting a sentence with a “conjunction”, you should follow it with a comma. E.g. “However, ...”; “Furthermore, ...”; “In addition, ...”; “Moreover, ...”. Check usage throughout and amend.

Lines: 270-278: Using “shorthand” symbols (cp, py, pn etc) is not really necessary. Space is not an use and readability will be much improved by using the mineral names in full.

Line 279: “Two main stages of sulfide evolution were observed in this study...”.

Line 284: “The second stage consists of sulphide type 4, characterised by iss-only, sulphide liquid rich in Cu (since all Ni has been exhausted) now consisting of chalcopyrite and bornite ( $\pm$ dg).” reads better as “The second stage consists of Type 4 sulfide droplets characterised by iss-only and a copper-rich sulfide liquid (as all the Ni has been exhausted), which now comprises chalcopyrite and bornite ( $\pm$  digenite)”.

Line 291: Consider deleting “latter” to improve clarity.

Line 303: Consider “In this study, no early and late sulphides co-hosted by the same mineral were observed.” See comment on Line 256 above for comma usage close the start of a sentence.

Line 303: “rich” should be “reach. Also, consider “This suggests two distinct saturating stages, where the system has to first undergo magnetite crystallisation to reach the second stage”.

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Line 326: Don't use T as an abbreviation for temperature write in full "... to a temperature drop ..."

Line 328: "... which in turn ..."

Line 357: Consider "... pyrite. This suggests ..."

Line 373: "In the barren Quaternary volcanics, ..." see comment on Line 256

Line 391: Reference for the Inlice deposit?

Line 394: The use of "remarkable" is hyperbole in this context, please rewrite this sentence in more circumspect terms.

Line 402: Write CSE out in full – I don't think abbreviation has been defined and it is not common knowledge like EPMA.

Line 414: "independent of" not "independently from the"

Line 416: Consider "Concerning the amount of water in the source, it is possible that different water contents of the primitive magmas correspond to different geodynamic settings and may play an important role for both sulphide saturation at depth and ore generation at the surface".

Line 428: If you can't "test the hypothesis in the present study" then it shouldn't be discussed as it is speculation. Please remove this paragraph and any subsequent discussion that is based on it.

Line 434: Replace "seems not necessary for any kind of for any kind of sulphide saturation" with "does not seem necessary for sulfide saturation".

Line 440: "In addition, ..." see Line 256 comment above.

Line 451: "There are four main conclusions: ..."

Line 456: "According to their occurrence and chemical composition, ..." Line 459: "Cu-rich" not "Cu-richer"

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Line 469: Delete “the”

Line 473: “which is used here”

Line 475: “an early mss-only or mss-rich and a late iss-only or iss-rich stage

General comments on style and English usage

The correct IUAPC spelling of “sulphides” is “sulfides” – see: <https://www.nature.com/articles/nchem.301>. Please amend throughout.

Check capitalisation of Fig, Figure etc. these are used inconsistently. Make sure that “figure” or “fig.” are in the correct format for the journal – usually they are capitalized and “fig.” always has a full stop to indicate an abbreviation. The same applies for the usage of “tab.” and “table”.

It would be useful in the methods section or supplementary material to state what the criteria for magmatic sulfides are, this is an open source publication and this type of information will be valuable for readers who wish to undertake similar studies.

In the text abbreviations for the sulfides are used e.g. pn, po etc – write out in full throughout. Think about having “Type X” being always capitalized – it makes it easier for the reader to see what is being written about – you have classified something so consider making it a proper noun – A proper noun is the name of a particular person, place, organization, or thing. Proper nouns begin with a capital letter. I realise this is a stylistic preference so not necessary to correct.

Abbreviations used inconsistently. Once defined they are sometimes used in full instead of using the abbreviation e.g. the Konya volcanic belt – I don’t think it is necessary to use abbreviations such as these, and using the full name helps the reader as they don’t have to refer backwards to see what the abbreviation refers to. The saving on space using abbreviations is minimal and use in full is preferred except for commonly understood abbreviations e.g. EPMA.

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The level of referencing is appropriate. However, I have not checked that all citations in the text are in the bibliography.

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Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2019-106>, 2019.

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