**Comment on egusphere-2022-1475, RC1**

**Manuscript Title:**
**Structural framework and timing of the Pahtohavare Cu ± Au deposits, Kiruna mining district, Sweden**

**Referee's comments in black**
**Author comments in red**

**General comments**

The topic is interesting and relevant for understanding the relationships between different deposits types and their regional structural framework, which eventually, will aid in exploration of new deposits. The paper fits well the scope of the journal. There is new data, but it is unclear how representative it is (see P2 and comments to Fig. 3 below). The manuscript is written in a clear and understandable way.

However, the manuscript has several major shortcomings associated with i) defining the key questions, ii) presentation of the data and iii) subsequent structural interpretation (see points P1 to P5 below). As such, the new structural interpretations may not be verified from the presented evidence, and their correlation with regional geology, and further utilization in solving the relationships of the diverse mineralization of the study area are not justified. For the above reasons, the paper needs substantial improvement, and another round of review.

- **P1:** The study is not motivated as no specific research questions have been stated: The overall global IOA vs. IOCG problematics is described, but the manuscript does not state which are the key questions or hypotheses in applying or testing the concept to the area of the present study.

  Thank you for pointing this out and we agree that the key questions need to be clear to the reader. The main purpose of this study was to determine the relative timing of the formation of the Pahtohavare Cu ± Au deposits (which are currently unknown) by investigating the structural relationships of the ore and contextualizing them within the regional tectonic evolution. This is significant to the broader scientific community because there are currently no studies from the Kiruna mining district that assess the IOA and IOCG mineralization together from a mineral systems perspective and the respective tectonic settings. While the timing of the Kiirunavaara IOA deposit is well-constrained within the context of the Svecokarelian orogeny, the Pahtohavare deposits are not. The introduction section has been modified to clarify the purpose of the study.

- **P2:** The required geological background to justify the research questions (P1) is not provided.
  - In particular, the regional alteration-structure-mineralization features are mentioned (lines 22-23. 24-26, and later in Section 2.1), but their mutual relationships and role in formulating the research questions is not explained. Information such as that on lines 302-305 should be included in the introduction.

    Thank you for this comment. We have clarified the research question in the introduction which we believe provides better structure for the readers to understand the relationship between the alteration-structure-mineralization described in the introduction and background sections. Additional details have been added both to the introduction and to the background sections to improve upon this point.

We have also moved lines 302-305 to the introduction.

  - The structural description only characterizes bulk shortening directions of the main orogenic phases, but largely lacks information about the structural geometry and the character of the faults (trends, dips, kinematics, timing) and their relationship with alteration and stratigraphy. This information is required to justify the presented crustal evolution models (Fig. 6), as the model heavily leans on the presence of an extensional fault networks and reactivations along the included faults (which is justified as such!)

    Unfortunately, trends, dips, and kinematics of the extensional faults formed during the back-arc extension phase of the Svecokarelian (and possibly the early Paleoproterozoic rifting) have not been described in literature because of reactivation and overprinting of these structures from the later deformation events. However, we have added more information on the orientation of the early Paleoproterozoic rift structures, known kinematics of the shear zones for the different Svecokarelian deformation events, and added a new sub-section that describes local structures and the structural framework of Kiruna.

- **P3:** The introduction is missing the statement of the main outcome of the work (claim); presently the phrasing is (l. 56) "… investigation was conducted…", which leaves the work unmotivated. Please state clearly the main outcome of the work and its local and global significance, with respect to both the overall geological understanding and applicability in exploration (if any)

  Thank you for this comment. We have added a motivation and significance statement to the introduction which greatly improves the structure and clarity of the manuscript.

- **P4:** Presentation of input data: The presented structural interpretation (Figs. 3, 5) is not backed up by the description of the used data, as the spatial location and coverage of the outcrop observations and the drill-hole data is missing. No geophysics or other supporting information is provided either. There is a significant mismatch between that presented on maps and stereograms (see comments for Fig. 3 in particular). The location and largely also the orientation of the field and microscopic photos are missing. Introduction of structural data is not systematic (see e.g. comments regardings lines 156-167)

  Thank you for this point. The authors originally decided to present only the main structural results (i.e.  reducing the number structural measurements reported on the map) because of the crowded result of reporting all the data on the map. However, we agree that this leads to nontransparent presentation of the data. We have adjusted the figure to include more surface mapping measurements, outcrop coverage, and locations of the microscopic images. We added the drill hole localities to the 3D model in Fig. 5 (now Fig. 7) as well as a full data map as a supplementary figure (S1). We also provided an aeromagnetic anomaly map (now Fig. 3) to support the interpretation. Additionally, co-author O. Martinsson has provided a new mine level map from the Southern Pahtohavare deposit and a surface map showing the ore location with additional structural data at the Southeastern Pahtohavare deposit (Fig. 6, new manuscript). This work was conducted from the 1990s but has not previously been published. It adds significantly to the manuscript and the new surface structural measurements from Southeastern open pit have been added to the stereoplots in Fig. 3

(now Fig. 4C-E). Furthermore, we have rewritten the structural results section to improve the presentation of the data according to your general and specific comments.

- **P5:** Structural interpretation: The lack of spatial data for the used input points (P4) makes it impossible to evaluate the validity of the structural interpretation. There are inconsistencies regarding the geometry of interpreted cross-sections, modelled anticline (antiform) and the orientation distribution of the bedding data. Reasoning behind the presented kinematic interpretations of the shear zones are not given in adequate detail (e.g. lines 191, 268)

  We have modified Fig. 3 (now Fig. 4) to be more transparent with the presentation of spatial data and have clarified the geometry of the fold and distribution of bedding data in the text. We have also rewritten and expanded our presentation of data from the shear zones to improve clarity and help with evaluation of our interpretations. The discussion section 5.1 has been rewritten to improve the connection between the presented data and the interpreted results.

**Specific and technical comments:**

***Comments on Introduction***

Line 21: Start the introduction with i) the global IOA-IOCG problematics, then proceed to ii) Kiruna deposits and geology, and based on these, develop research questions that can be a) used to improve the understanding about the IOA vs. IOCG in the Kiruna area (relevant questions are stated on lines 305-309, and should be included in the introduction; see P1), and b) solved with the available dataset and methods.

Thank you for this comment. We have rearranged the introduction section according to your points and have added more information about the purpose of the study.

Lines 34-37: These relate to the implementation >>> move to lines 55-59 (original line numbering)

We have rearranged this sentence to improve the structure of the introduction. Thanks.

***Comments on Background***

Line 112: change “direction” to “orientation”

This has been revised in text.

Line 113: Please indicate the trend of the conjugate faults.

We have added this to the text.

Line 115: A word appears to be missing in the title

We have revised the title for section 2.1.4.

Lines 116-117; 127-128: Please go directly to the point/subject in the first sentence of the section (applies to other sections as well). Now the first sentences are “empty”, which reduces the effectivity of the writing.

We have modified the text to improve the effectivity of the writing.

Line 118: “Rektor” is not shown on map. Please make sure all the locations cited in the text are visible on the figures.

Thank you for this comment. We have added an additional annotation for this location to the figure and cross checked that localities are properly cited in the figures or described in the manuscript to improve clarity.

Line 121: “formation” of what? Please explain!

We have reworded this sentence to improve clarity.

Line 133: unclear, please rephrase!

We have rephrased this sentence.

Line 142: Include “Kiirunavaara Group” in the legend of Fig. 3.

Thank you for this comment however we think that adding this subheading to the legend will be inconsistent with the current format which separates the rock sequences by relative age. Additionally, the Kiirunavaara Group is also too long to include after each of the names for Hopukka and Luossavaara formations. We prefer to keep the legend in its current format however have added the Hopukka or Luossavaara formations in parentheses when we refer to the Kiirunavaara group to help the reader refer to the geologic map.

Line 144,149, 252 + others): “Above the Luossavaara formation are a series….”. This is not good English, please rephrase to e.g. “ The Luossavaara Fm is overlain by ….”

We have done some revising, however, some text has been left with its current format to reduce unnecessary repetition of the same phrasing.

Line 146: Move the reference to the structural character of the unit in a new Section (2.2.2) explaining the local structure

We have moved this information to the new section (2.2.2.) to explain local structures.

Lines 156-167: Include this in a new section, which should include, in the following order: i) the relevant structural geometry of the area, with particular emphasis on the faults, ii) the known kinematics of the faults, iii) the known ages of the faults (and other deformation)

We have added a new section (2.2.2.) explaining the local structures and emphasized the previous knowledge on the faults in the district.

Line 163: “central Kiruna” >>> please be more specific and refer to a feature annotated on the map

We have added an annotation to the map and more description to the text.

Line 165: “… kinematics…” but along which structure, please explain!

We have added more information to the text.

Line 180: “… coeval with syn-volcanic faulting…” >>> Is this 1.90 or 1.89 Ga; please add an age.

We have added an age to the text.

Line 191: What is the dip and kinematics of this shear zone? (If known from earlier work)

The kinematics of the shear zone have not previously been reported with structural data and is presented in the results and discussion sections of this paper.

Line 194: Please explain in adequate detail which is the structural and lithological control. Later on (lines 198-200) there is some reference to hot lithology, but this is too far away from the statement on line 194 to be followed, and the type of structural control is not described. This is highly relevant for this investigation, as your work needs to either confirm or disprove the earlier interpretations, which can then be further used in confirming the working hypotheses (or questions) presented in the introduction.

We have rewritten the description of the deposits and included two new figures of the deposits (Fig. 6, new manuscript) to better present the structural context of the ore deposits.

***Comments on Methods***

Line 206: What are these localities? How are the input data distributed with respect to the mapped structure? This is a crucial issue to show as the reliability/uncertainty of the map is largely dependent on the input data; is the fold structure (hinge, both limbs) and all/some of the faults covered by field observations (or drill hole data (see line 218).

Thank you for this comment. Additional data has been added to Fig. 3 (now Fig. 4) to show where these mapping localities are and how they are distributed. Additionally, we have added a supplementary figure (S1) that shows the distribution of all of the measurement and observation points.

Line 211: What is the purpose of the sampling, how many samples were taken in total? Are (all) the samples oriented (many of the sections in Fig. 4 show no orientations)?

The purpose of the sampling was to study structural controls on mineralization, and this has been added to the text. Unfortunately, none of the drill cores from the Pahtohavare area are oriented, so oriented samples were only possible from field samples.

Line 218: From where are the drill holes? Show on a map/sections!

We have added the collar locations of the drill holes to the 3D model and have added a supplementary table with the drill hole names and locations (Table S1).

***Comments on Results***

Lines 232-233: Remove the first line; this is already told.

This has been edited in the manuscript.

Lines 237 + 238: See comments for Fig. 3 regarding the geometry of the antiform. Parasitic folding should follow the overall geometry of the fold, and as such does not explain the scatter in bedding orientations. Please also be more specific in the description: e.g. Do not use "somewhat irregular" but instead describe the style of scatter or clustering on the stereograms, and link that specifically to the limbs and the hinge domain of the fold.

We agree that this phrasing was unclear. We have changed the phrasing as well as added a subfigure to Fig. 3 (now Fig. 4A) to clarify. We also agree that parasitic folding should follow the overall geometry of the fold, but structural deflections and transposition can cause parasitic fold orientations to vary. We argue that one parasitic fold measurement alone does not give the full picture, but unfortunately this was the only measurable outcrop in the field area. However, the stereoplot from the northern limb (now Fig. 4A) better illustrates the strength of plotting many bedding planes with varying orientations together because the geometry of the fold (visualized in the aeromagnetic anomaly map, now Fig. 3) is maintained.

Line 239 + 245: Location of the Pahtohavare open pit + Saarijärvi is not shown on the maps. Please add this information.

We have added the labels of the Pahtohavare deposits to the map and have added a better description of the Saarijärvi locality to the text. We also put a figure reference in Fig. 2.

Lines 255-259: These belong to the discussion (normally no references allowed in the results). What is non-coaxiality of strain based on? I can't see the evidence.

The sentences with the reference have been removed from the results section. The non-coaxiality of strain is based on the shearing textures such as the S-C fabric and asymmetric porphyroclasts observed in thin section. The section has been rewritten to improve clarity.

Line 263: Where is this shear zone, please indivcate!

We have added a figure reference to (now) Fig. 4B to show the locality of the shear zone.

Line 264: "mineral lineation … shows a moderate oblique-reverse movement…" >>> not true as it only shows the relationship between the horizontal and vertical slip, NOT the shear sense, which needs to be derived from shear-sense criteria

The mineral lineation occurs on a near vertical foliation plane and can either be interpreted as oblique reverse or oblique-normal with a dominantly reverse/normal movement. We interpret oblique-reverse as the most probable geological explanation for forming the anticline bound by the NW-SE trending Pahtohavare shear zone.

Line 268: "sinistral oblique-reverse" >>> With respect to what deformation zone? What is the evidence? To me the NNW-SSE carbonate veins in Fig. 3D indicate vein-opening due to dextral slip along the bounding NW-SE fault/shear zone.

We have added that this movement is with respect to the NW-SE trending Pahtohavare shear zone. The data we have on shear sense indicators is unfortunately not conclusive enough (it could be that the shear zone has been reactivated as well) and we would like to highlight that the steep dip of the shear zone given by the local shear zone measurements (~80°) would indicate a dominantly reverse or normal movement compared to sinistral or dextral.

Line 271: Where are the tension gashes documented?

We have made the text more specific.

Lines 273-274: This is background information which needs to be moved to the Geological setting (see main comment P2b)

Thank you. This has been moved to the background section.

Lines 276-280…: This can't be linked to the figures nor evaluated as no spatial reference to the DHs is given in this manuscript (see P4).

The drill holes used for the 3D model have been added as collar locations to provide spatial reference.

***Comments on Discussion***

Lines 292- …: The discussion is quite unfocused and repetitive with earlier parts of the manuscript as the research questions are not adequately defined (P1)

We have rewritten large parts of the discussion section to provide a better focused discussion.

Lines 333-335: The relationship between the vein orientations and the derived kinematic interpretations or the kinematically linked faults/shear zones is either vague or not given at all (see also line 268).

Thank you for this comment. We have rewritten the discussion section and expanded on the vein orientations and derived kinematic interpretations in the text.

Line 341: What actually are the Pahtohavare deposits like? Now the geometric style of the deposits are just very roughly indicated in Fig. 7, whereas other figures only show their location.

We have included two new deposit maps based on your comments in this peer review (See response to Point 4). The deposits geometries are now described in more detail in the background, results, and discussion sections.

Lines 349-358: This information needs to be used in defining the research questions in the introduction, and the essential details needs to be included. For example, earlier considerations about the crustal level vs. the style of deformation need to be included as they are required in correlating the results of this investigation with the regional geology.

This information is not the motivation behind why the study was conducted but rather it is provided to give background for discussing a result from this study that conflicts with previous structural interpretations from the geology around Kiruna town. We have modified the opening sentence to better structure the discussion.

Line 384: Add the name of the SZ on the map.

We have added the Pahtohavare shear zone (PhSZ) onto the map (now Fig. 4) and Figs. 2, 6, and 7 (now Figs. 2, 8, 9).

***Comments to figures (many of which are linked to general comments P1-P5)***

**Fig. 2:**

- Please provide a cross-section to illustrate the relationship between the stratigraphy and the structure e.g. across the Luossavaara deposit. Annotate the Luossavaara deposit on this map (see Fig. 7)

  Thank you for this comment. However, the structural setting of the Luossavaara deposit is out of the scope of this study and is currently the subject of another ongoing research project at LTU. We have annotated the Luossavaara deposit onto the map.

- What is the character of the ENE-WSW trending fault which separates the Kiruna and Luossavaara deposits? Are the Kiruna and Luossavaara deposits initially part of the same lens/layer, and later split into pieces? Or is the fault syngenetic + later reactivated?

  This is a good question with important implications and is currently being studied by a colleague at LTU. We prefer to provide structural details on the main study area for this work which is outlined in Figure 3 (now Fig. 4).

- Legend: Loussavaara Fm >> Luossavaara Fm

  This has been edited.

**Fig. 3:**

- Is there some geophysics available to support the map, or is it solely based on mapping data?

  The current map is a modified version from Martinsson (1997), but in general the geology in the Kiruna area has utilized aeromagnetic anomaly maps to continue lithological contacts through unexposed areas and to highlight major structural lineaments (e.g. Offerberg, 1967, Geological Survey of Sweden). An aeromagnetic anomaly map has been added as a new figure (Fig. 3, new manuscript).

- What is the distribution of the structural data?
  - Please include the location of the input data points; both surface mapping and drill-hole (DH) data? This could also be presented as a separate "data map", but preferably included into the existing map; there should be space for it.

    Thank you for this comment. We have added detail-subfigures to Fig. 3 (now Fig. 4) to better show the distribution of surface mapping data. The drill hole collar locations used in the 3D model have been added both to Fig. 5 (now Fig. 7) and to supplementary figure S1.

  - What explains the presence of sub-vertcal NE-SW and ESE-WNW foliation planes? They are not compatible with the distribution of the bedding data (and hence indicative of the presence of bedding-parallel foliation); are they spatially associated with the faults?

    We first want to note that the foliation depicted in Fig. 3 (now Fig. 4) most likely consists of both S1 and S2 foliation directions and therefore, may contain foliation directions that are not compatible with the distribution of the bedding. Without clear overprinting field relationships, the authors chose to not separate these generations based on the stereonets alone.

For the NE-SW sub-vertical foliation: The localities that have steeply dipping NE-SW foliation planes on the stereonet are not associated with the faults. However, the character of the foliation measurements are of high strain. It is common in the Kiruna area that the foliation locally overturns in areas. If this is the case, then we would argue that the foliation is still compatible with the distribution of the bedding data and overall geometry of the fold.

For the ESE-WNW sub-vertical foliation: The orientation for these foliation planes may be related to the second deformation event and represent axial planar S2 fabric to the Pahtohavare F2 fold. However, as mentioned above, we chose not to separate the generations of fabric due to the lack of clear S1 and S2 cross cutting field relations. Of the data with this subvertical orientation, three localities can be suggested to represent a foliation direction compatible with the NW-SE trending Pahtohavare shear zone due either a) a close spatial proximity of the outcrop to the shear zone (foliation measurement 80/214, seen on Fig. 3 original manuscript near the NW-SE trending Pahtohavare shear zone), and b) being a measurement from a small-scale shear zone in Pahtohavare Southern open pit. These spatial mapping measurements can be seen in the new subfigure Fig. 4B in the new manuscript.

- Structural interpretation and correlation between the structural data shown on the map and the stereograms (plots hereafter):
  - Very few tectonic symbols (bedding, foliation) are shown on the map. Together with the missing information about the input data used in compiling the map (structural point data, geophysics, level maps from the mine etc…), it is impossible to judge the reliability of the structural interpretation.

    We thank you for this comment and have added more structural symbols to the map and included two new subfigures that summarize the structural data in more detail (Fig. 4A-B, new manuscript). We have also included an aeromagnetic anomaly map (Fig. 3, new manuscript) to illustrate the geometry of the fold and local structures. Additionally, co-author O. Martinsson has provided a level map from the Southern Pahtohavare deposit and a surface map showing the ore location and additional structural data at Southeastern Pahtohavare deposit from work done in the 1990s (Fig. 6, new manuscript). This work adds significantly to the manuscript and the additional surface structural measurements have been added to the stereoplots in Fig. 3 (now Fig. 4).

  - No sub-horizontal bedding data is shown on the map (min dip value on the map is 40), but the plot shows a cluster with ~9 reading with a mean 180-190/30 (dipdir/dip) orientation. These data should locate on the southern limb of the fault, but the bedding dips in Section A-A´ of Fig. 5 show that all the dips on the southern limb of the anticline are steep.

    We have added more spatial mapping data to Fig. 3 by adding subfigures (now Fig. 4A and 4B) for specific high density mapping areas to account for this comment. However, we would like to note that the outcrop exposure in Pahtohavare does not allow for a perfect transect across the limbs of the fold and reconstruction of the bedding directions. For our case, the stereonets are important in showing the overall geometry of the fold that can be seen in the aeromagnetic anomaly map, despite that the ground spatial mapping data is limited (due to the approximately 5% outcrop exposure). For example, the cluster of bedding points that show a mean 180-190/30 are associated to a series of outcrops on the northern limb where there are multiple bedding directions in a relatively small area (approximately 200m x

300 m, see Fig. 4A, new manuscript), and is interpreted to represent parasitic folding.

While the stereonet shows that the fold is slightly overturned, previous mapping results (Martinsson 1997) has shown the southern limb is only locally overturned. The data collected in this project from the Southern Pahtohavare open pit shows bedding locally has a dip direction steeply towards the SE. Therefore, we have chosen to depict the geometry of the fold with steeply dipping bedding in the southern limb with a subvertical to inclined axial plane.

- Should the sub-horizontal cluster of bedding data (see previous point) be including in defining the statistical fold axis (β)? This question relates to understanding the geometry of the anticline:

  Yes, we argue that it should be included in the statistical fold axis. The geometry of the fold is best visualized with the aeromagnetic anomaly map (Fig. 3, new manuscript) and though the shallow bedding is located on the northern limb of the fold, the stereonet visualization of the structural measurements agrees with the geometry of the fold from Fig. 3 and from previously published description of the fold (Martinsson 1997).

  - The southern limb of the anticline appears to be separated from the hinge and northern limb by a fault. Should the geometry of these domains be treated separately instead plotting a common β -axis for all the bedding data?

    The brittle fault separating the limbs of the fold seen on the map has only local offset of the stratigraphy in the field (Fig. 3, now Fig. 4), however, it does not propagate past the upper greenstone units. Therefore, we argue the two limbs can both be used for constructing the statistical fold axis.

  - What causes the) is "flat-topped" character of the anticline (Section A-A´ in Fig. 5)? Flattening of the fold hinge along Section A-A´from SE to NW is not justified as shown above.

    The flat-topped character of the anticline was drawn to represent the curvilinear nature of the fold axis. We know that the fold axis plunges to the SE (~35°, now ~50° with the 1990s data from Southeastern open pit) from the stereoplot data, but we also measured a fold from the Southern Pahtohavare open pit that shows the fold axis dips near horizontally (03/090). Furthermore, a new subfigure from the northern limb of the anticline (now Fig. 4A) shows the plunge in this area is ~20°. We have redrawn the cross section to better illustrate our interpretation of the geometry based on the stereoplot data.

- Is there sedimentary way-up data? Should the "anticline" be "antiform"?

    There has been sedimentary way-up data reported in Martinsson (1997) including graded bedding and pillow lava orientations. However, the main evidence making this structure an anticline is that the older stratigraphy is found in the core and the younger stratigraphy at the rims.

**Fig. 4:**

- Orientations and sampling sites are largely missing and should be included.

Thank you for this comment. We have added orientations and sampling sites to (now) Figures 2 and 4.

- The figures are jumping back and forth from topic to another; please restructure to explain the geometries of the structural elements and their (cross-cutting) relationships, then proceed to the evidence about localized deformation (shearing, faulting), including the shear sense criteria

  We have rewritten the results section to have better flow and continuity.

- The character of the highlighted clasts in Fig. d are not discernible from the figure

  We have replaced Fig. 4D with a higher magnification image to better highlight the porphyroclasts (now Fig. 5F). Furthermore, full thin section microphotographs of the sample has been added as supplementary figures (S2-S3) to the manuscript.

- Add reference to the orientation of the thin section, and the interpreted sense of shear for figs. e) + f). Moreover, show the spatial context of section by indicating their occurrence on a map / cross-section. Within these, the microphotographs are not useful.

  The thin section depicted in Figure 4E-F is not oriented. Unfortunately, it is a limitation of the field area that none of the drill cores are oriented and therefore this reference cannot be given. However, we have revised to show the interpreted sense of shear and added the drill hole locality to the Fig. 3 (now Fig. 4).

**Fig. 5:**

- This is a nice 3D-illustration

  Thank you for this comment.

- The moderately SE-dipping fault in Section A-A′ doesn't intersect the section in the 3D-model. Please revise /extend.

  The moderately SE dipping fault is currently shown in the 3D model in the upper part of the greenstones (where it cross cuts the present day topography, and not the extrapolated topography). However, we have slightly modified the 3D model to improve clarity.

- What is the character of the discordant bottom contact of the pillow basalt; tectonic or depositional unconformity? Please explain and annotate in the figure accordingly.

  The character of the bottom contact of the pillow basalt is depositional and was accidentally drawn discordantly. We have updated the cross section according to the comments from this peer review to improve the figure.

**Fig. 6:**

- This tectonic sketch should cover the same area as Fig. 7 as the latter encloses also the major IOA deposits, which are not presented here. For this reason, this figure is not motivated in providing improved understanding about the relationship between the different deposits types (Pahtohavare & IOAs), which in the beginning of the abstract is stated to be one of the major unknowns of the area, and as such, main aims of the study.

Thank you for this comment. We would first like to note that this sketch is not drawn to be a 1:1 depiction of the Kiruna mining district and is meant to be purely a conceptional hypothesis of how structural features could have developed in the area. However, we have added a label to depict the approximate location of the Kiirunavaara deposit.

The same scale problem applies to correlation with Fig. 1: Which of the WNW-ESE faults in Fig. 1 corresponds to the northern WNE-ESE fault in Fig. 7?

We have added labels to the figures 2, 3, 4, 8 and 9 (new manuscript) for the Pahtohavare shear zone (PhSZ), Kiruna-Naimakka deformation zone (KNDZ), and Svappavaara deformation zone (SDZ) to improve correlation between the figures. We would like to note that WNW-ESE SDZ in Fig 2 is cut off in Fig 7 (now Fig. 9).

>>> This is in fact a critical point for understanding the primary (syn-depositional) fault network and their potential control over the deposition of the supracrustal rocks:

1. The northern WNW-ESE fault constrains the lateral extent of the Hauki, Matojärvi and Luossavaara FMs so that they occur only to the north of the fault

   Since this figure is of conceptual nature, not all the possible basins have been drawn, so these units are not necessarily controlled by the single basin depicted in the concept.

2. By contrast, the depositional basin defined by the two opposingly dipping, WNW-ESE trending normal faults in Fig. 6a would suggest that the above FMs should have been deposited to the south of the northern WNW-ESE fault in Fig. 6. Northerly dip for both WNW-ESES trending normal faults in Fig. 6a could be more compatible with respect to the spatial distribution and thickness of the presented stratigraphic units.

   We agree that having a northerly dip for both normal faults could occur, but we would like to illustrate a simplified basin model with this concept. We also agree that the normal faults in Fig. 6a would suggest the formations should have been deposited to the south of the northern WNW-ESE fault, but the figure is meant to emphasize how the structures could have developed. The basin itself is much bigger and probably composed of several sub-basins.

- a): The age should be max. 1.89 Ga = age of the oldest supracrustals

The age has been modified in the figure.

- Please clarify the timing relationship between the 1.87 Ga deformation event (Gig. 6b) and the deposition of the 1.89-1.85 Ga rocks; is there ongoing deposition at the time of this deformation event? In particular one would expect deposition of syn-faulting (1.87Ga) strata into the releasing bend of the N-S strike-slip fault (presently just teh Rakkurijärvi deposit is localized into this site).

The deposition of the mid-Orosirian rocks is interpreted to have occurred during basin development (Andersson et al., 2021) between ca. 1.89 Ga and 1.87 Ga before the onset of crustal shortening phase depicted in Fig. 6B (now Fig. 8B). The exact depositional ages are difficult to know, however the Rektorn ore body yielded a zircon U-Pb age of 1.874 Ga (Westhues et al., 2016), which constrains a minimum age of the hosting Luossavaara formation. The timing of the deformation event is constrained approximately by pre- to syn- orogenic intrusions which suggest it took place between ca. 1.90-1.87 Ga (e.g. Cliff et al., 1990, Romer et al., 1994, Westhues et al., 2016, Andersson et al., 2021, Logan et al., 2022).

The releasing bend drawn near the Rakkurijärvi deposit is purely conceptual and drawn to loosely correlate with the geologic map. The deposit has been described to be hosted both in the Kurravaara conglomerate and the Kiirunavaara group volcanics. Further investigation of overlying rocks in the Rakkurijärvi area has not been conducted and is beyond the scope of this study.

Please replace symbols for the deposits so that the symbol better illustrates the location, shape and orientation of each deposit, as far as possible, in the given scale. This needs to be in line with the information presented in Fig. 7.

Thank you for your comment. The conceptual nature of Fig. 6 (now Fig. 8) is meant to show the general areas where the Pahtohavare and Rakkurijärvi ore deposits occur. Adding detail for the individual sub-deposits (total = 8 between Pahtohavare and Rakkurijärvi) that would match the respective shape and orientation is not possible within the space available. For example, Eastern Pahtohavare occurs as a horizon that would be difficult to draw as a plane (pre-tilting) in Fig. 6a-b. The Rakkurijärvi deposit geometry is known to a lesser extent, and is also beyond the scope of this study. However, we have modified the symbols to add Pahtohavare Early ($Pah\text{-}_E$) and Pahtohavare late ($Pah\text{-}_L$) to improve clarity for the figure.