Comments to the author:
The manuscript has been reviewed by 4 reviewers, where all of them found the topic Significant for the research community. Three of the four recommended a second revision process, while the other did not provide enough feedback for the manuscript. Following reviewers R1, R3 and R4, there are several questions from the previous revisions that are still unanswered. Some of the figures are difficult to read and/or their figure captions are still ambiguous.

As pointed out by R1, it is not clear what the author refers to "that human interpretation is bound to the experience of the interpret in a way that would significantly alter the results". This should be properly explained in the manuscript. Also, their question "does that difference is significant enough to change the statistical distribution of a large population such as the one used as an example in this study?" is still not well resolved. This will need to be explained further in the response letter and in the manuscript, as R3 has pointed out.

As R4 mentioned in their report, the manuscript is still difficult to follow, especially the method section. Considering that this is Method Article, this section should be clear for all readers, as is the key of this manuscript.

Although R1 and R3 recommend a minor revision, we consider that the author will need more time to resolve some of the issues mentioned by the reviewers. Therefore, we consider that a medium-major revision should be appropriated.

We thank the editor for giving us the opportunity to address the reviewer's comments in an appropriate amount of time. We added a file highlighting all the changes we made to the manuscript since the last iteration. We believe that the number of changes we made demonstrate our attempt to comply with all the suggestions and comments. Detailed responses to the reviewers are uploaded and we hope that with the revised manuscript can be considered for publication.

Kind regards,

Ulrich Kelka

Submitted on 03 Aug 2021
Anonymous Referee #1

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

The revised version of the manuscript by Kelka et al answers most of the remarks and questionings that I had given previously. The only remark I still have is that I don't understand why authors repeat several times in the manuscript that human interpretation is bound to the experience of the interpret in a way that would significantly alter the results (they refer to as "human bias"). The variability of structural interpretation is a fascinating topic which have been studied elsewhere, especially when it comes to cross sections (see the corpus of work by Clare Bond and Ian Butler), so there is no doubt that different geologists (with a proper training and background) picking up the lineation on a map will results in different results. Yet the question arising is: does that difference is significant enough to change the statistical distribution of a large population such as the one used as an example in this study? Authors suggest that it does, but I don't see any points in the study that support that statement: no comparison of human interpretation results made by different geologists. Without that, it is not really convincing to interpret results by the scope of the human bias as authors do in the discussion. As I believe this question of human bias is beyond the scope of the paper that here present a good comparison of different more-or-less automated methodologies and provide with convincing coupled solution to reduce variability in interpretation, I would suggest reworking the wording used in the several occurrence relative to the experience of the user.

*Thank you for the comment. We agree that the question and a thorough treatment of human bias is beyond the scope of this paper. Our work included only two expert interpretations and we agree that this is not enough to provide measured insight into bias nor is that our intention. Our aim was to compare the automated methods (which provide a single lineament set) to the lineament sets of the expert interpretations. As suggested, we have amended and removed language to make the concept of human bias in the manual interpretations less prominent. In the discussion, we have emphasised this by adding "*We do not seek to explore these aspects but do note that interpretation bias may be playing a role in the creation of the manual lineament datasets used. *"We further removed our statement* "which is likely to be a result of human bias" from the statement "Lineaments obtained by manual mapping in this study scatter around a particular length". *Based on our discussions about the manual mapping, we do conclude that this is the result of technical expertise that has knowingly (i.e., biasedly) looked for specific trends associated with geologic understanding of the area however we agree with the reviewer comments and do not want to detract from the aims of the paper with our inference on human interpretations.*

Prior to publication, I would like to draw the attention of authors to the English grammar and syntax, which is surprisingly complicated in this manuscript when considering the origin of the authoring team. Mainly in part 2, the numerous typo and complicated organization make this part very hard to read. I suggest to rework this part and to have the manuscript proof read once more before it can be published. Here after are reported some of those in the part 2:

Thank you. In addition to making changes as suggested below we have proof-read and streamlined the text of Section 2.

l. 70-72: please rephrase. Replace prevailed by remained, what is the subject of comprise, and represent? If it is structures, I don't think comprise is adapted.
If a surface expression of such structures exists, this may be indicative that the crustal structures remained active for a long time resulting in a high amount of deformation or strong lithological contrasts.
L. 72 indicate must be indicates.

- *In the framework of the central <u>Gawler</u> mineral-systems, the vicinity of such structures indicates potential exploration targets.*

L. 73: What is the meaning of "crustal formation", do you mean the formation of the crustal rocks, or the formation of the crust?

- *Three major orogenic events, corresponding to crustal deformation and tectono-thermal alterations, are recorded by the crystalline basement of the Gawler Craton: the Sleaford Orogeny (Paleoproterozoic, 2440~Ma), the Kimban Orogeny (Paleoproterozoic, 1845–1700~Ma), and the Kararan Orogeny (Mesoproterozoic, 1650–1540~Ma)*

l. 87 : replace mayor by major

- *The region around Tarcoola includes four major provinces of the central Galwer Cratons: the Christie, Wilgena, and Nuyts subdomains, and the Harris Greenstone belt*

l. 94: replace elongate by elongated

- *The interpreted Precambrian basement geology of the Harris Greenstone Belt comprises east-northeast-trending linear magnetic highs that often correlate with broad gravity signatures and are flanked by ovoid to elongated magnetic lows and highs*

L. 97: large plutons of what? In that sentence, you imply pluton is a type of rock, which is not the case. This paragraph and the following one shouldn't be put together?
We have combined this with the following paragraph on the same topic of Hiltaba Suite and plutons, as well as rephrased.L. 98: I don't understand "the predominantly northwest-trending Gairdner Dyke Swarm", either you speak about the dykes that trend predominantly NW, either about the Gairdner Dyke Swarm (which does not trend).

- *The northeastern part of the study area was affected by the Gairdner Dyke Swarm at 827 Ma that comprises predominantly northwest-trending dykes*

L. 108: the distribution of what ? The distribution of the thickness, the geographical distribution?

- *However, the spatial distribution of each sedimentary sequence is poorly understood*

L. 109: replace is the by comprises of
L.110 and elsewhere: I am not comfortable with the "NW corner of figure 2", I don't think it is proper English, it should be upper left hand of figure 2 or NW corner of the study area.

- *The oldest preserved cover is composed of Late Carboniferous to Early Permian post-glacial sediments within the Mulgathing Trough in the north-western corner of the study are*

L.110-111: I don't get this sentence about the depth, why do you use "could", provide a depth, and then state we just don't know?

- Magnetic source depth analysis suggests that the trough locally more than 600 metres deep, with the maximum depths likely not detected

L.112: undulating. Should it be undulated?

- The terrain across most of the study area is relatively flat to moderately undulated

l.114: 'or saline' should be 'or by saline"

- Prominent topographic highs are localised around dissected rocky outcrops. The surface is characterised either by aeolian sand covering variably weathered bedrock, mostly in elevated parts of the landscape, or by saline playa lakes and drainage tracing topographic lows

l. 116: "over several kilometers in length and dune crest mainly trending W-E" is hard to understand, "individual plurikilometric-long dunes with W-E trending crests".

- One distinct feature is the longitudinal dunefield that occupies an extensive area in the south-western and southern part (Figure 3) with plurikilometric-long dunes with W-E trending crests.

L. 118: what is a “solid geology interpretation”, do you mean “solid geological interpretation” or an interpretation of the solid part of the ground? If the former, I suggest to remove solid, because it means some of the other regional studies were simply not good.

- *An interpretation of the solid geology was undertaken around Tarcoola in the central Gawler Craton. Please see https://www.ga.gov.au/eftf/minerals/nawa/solid-geology for further details.*

l. 120: the use of the verb recognize suggest you can distinguish between faults and shear zones, if so, how do you do?
L. 121-124: I suggest to remove these sentences, because they are geologically incomplete and are confusing. Also I don’t think you need to define fault zones and shear zones.
The dominant linear structures that can be identified in the aeromagnetic data are shear zones and faults. Identified faults and shears tend to be relatively discrete zones whose magnetic signature was altered by circulating fluids, or by the juxtapostion of two blocks of rock with different magnetic character.L. 130: misplaced parenthesis
Corrected parenthesis

L. 138: What is “a Hiltaba Suite pluton”? do you mean a pluton from the Hiltaba Suite?

- In the central Nuyts Domain, a pluton from the Hiltaba Suite has a long, straight northwest-trending margin that is bound by the Kooniba Shear Zone.

L. 139: replace “occur” by “are observed”

- The granite pluton adjacent to the shear is cut by abundant faults that are observed in several orientations and looks like a fracture zone. None of these faults extend across the Kooniba Shear Zone into the rocks of the St Peter Suite.

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

The authors took into consideration most comments to the original version of the manuscript. This resulted in the improved quality of the manuscript. However, no response is provided to some comments of referees. In some cases, the authors provide a response in the Rebuttal letter without adding any text of their response in the manuscript. Authors should not only provide answers to the comments of referees, but make appropriate changes in the manuscript, otherwise some parts of the manuscript remain unclear.

I provide below, in specific comments, the comments of the previous round that were either not responded or those for which no changes in the text were done. Technical comments contain suggestions of some text improvements that should be done. The comments refer to the line numbers of the revised manuscript given in the form Lxxx. After taking into consideration these comments, a decision on the acceptance of the manuscript for publication can be made.

Specific comments

1. The authors assume that they added the following text in the introduction text, however, I couldn't find it in the revised manuscript:

"Datasets such as lidar, digital elevation models, or radiometrics data represent only the change in surface properties such as elevation or surface geology. These lineaments may or may not represent structures that extend into the subsurface. By using datasets that represent the subsurface (i.e. gravity and magnetics) lineaments extracted are directly representative of changes in the subsurface. The challenge is (1) identifying if the lineaments from any dataset are geologically meaningful and (2) if lineaments from surface and subsurface datasets represent the same structure (e.g. fault, lithologic boundary)."

We apologise for the oversight as we indeed did not add the sentences mentioned above. We now include in the introductions fourth paragraph:

"In this study, we use the above-mentioned new GCAS datasets to identify surface and subsurface lineament features and design a workflow to automatically extract and analyse these features. We assume that elevation and radiometric data relates to surficial features, while gravity and magnetics data represent structures below the cover. This study is part of a broader effort to geologically link basement architecture with surface linear features, landforms, and landscape variability in the central Gawler Craton (Gonzales-Alvarez et al., 2020). It is important to note that datasets such as lidar, digital elevation models, or radiometrics data represent only the change in surface properties such as elevation or surface geology. These lineaments may or may not represent structures that extend into the subsurface. By using datasets that represent the subsurface (i.e., gravity and magnetics) lineaments extracted are directly representative of changes in the subsurface. The challenge is (1) identifying if the lineaments from any dataset are geologically meaningful and (2) if lineaments from surface and subsurface datasets represent the same structure (e.g. fault, lithological boundary)"

2. Nothing from the answer to the following question of referee #1 has been added in the manuscript still keeping the question unanswered for a manuscript reader:

"The area of study has a long and complex geological history. So how do you know that the lineaments are indeed from the same long-term tectonic history which would be relevant to the fluid flow and related ore deposit?"

This is a crucial question, and we thank the reviewer for bringing this up. In the area we investigated the timing of the mineralization is relatively well constrained and so are the formation/activity of major shear zones. Our approach is based on linking lineaments extracted from datasets representing features at depth to surficial lineaments. We have added the following sentence to the geologic discussion explicitly addressing this point:

"Given the mineralization is linked to the youngest orogeny in the area (Kararan Orogon) and only minor tectonic activity is evident in the area after this event, we can assume that links between surficial and subsurface features point to areas of high defomation and/or neotectonics activity."

Further, the latter would also point towards areas that remained active over a long time or were reactivated. In the framework of the central Gawler craton, these areas represent favourable targets for exploration. In other areas of the world the timing and geological history has to be factored in to a larger extend and as the Gawler craton represents a special case, we now mention in the discussion that the timing and mineralization in relation to the activity of structures has to factored in during the interpretation of lineament maps and have included the following paragraph:
"For a reliable interpretation of the obtained lineament maps the geological history of the respective area must be considered. This means that differently oriented lineament sets could correspond to different tectonic and fluid flow events. In areas comprising multiphase deformation extracted lineaments might therefore not be of relevance for the targeted mineral system and for instance directional constrains on the utilized lineaments would need to be applied. In the case study presented here, the youngest orogenic event (Kararan Orogeny) is thought to be linked to the mineralization (Bockmann et al., 2019; Fraser et al., 2007) and to the reactivation of pre-existing structures (Dir, 2005; Reid and Dutch, 2015). In this special case there is no need for applying strict constrains on the extracted lineament sets but this might be necessary for other regions.

3. The same refers to the following question of the same referee:"Is there any way to interpolate between the large gaps by giving the machine a specific regional trend?"

While simple topological correction such as merging lineaments based, for instance, on segment orientations and a critical distance would be possible as a postprocessing step, this is not within the scope of this contribution. Also the software we used does not provide this functionality.

4. 4. It is still not explained in the manuscript what a targeting map is.
   We used the term targeting map as opposed to for instance mineral potential map. The reasons is that we do not include any information about known mineralization and our output identifies areas that targets for further exploration. We have added the description of targeting maps as follows:
   *"*Towards that end, we further explore the use of targeting maps (i.e. a map generated to highlight areas with specific features) based on surface and subsurface lineaments. Targeting maps derived from lineament analysis are often based on the density of lineaments per unit area."

5. The following comment of referee #2 have not been answered: "From a geological perspective, the Geological Overview is not well organized, and it is almost impossible to get an image of the geology of the area. Structures and zones cited in the text are often missing in figures, so it is impossible to follow the description. The differentiation between shear zones and faults the authors make is meaningless. And the paper lacks a description about the age of faults/shear zones and that of mineralization. If the latter is older than most of the structures, what is the point of doing this work. Contrarily, if mineralization is younger,it could use any pathway. That needs to be described in the introduction. And if this is not known, you need to say it and use it as support for your work."

We thank the reviewer for pointing out this shortcoming. Please find below a short summary of the currently know time constrains of fault- and shear zones formation/activity and their temporal relation to Au-mineralization, which is now included in the Geological Overview

- *The NW- and NE-trending faults across large areas of the 9A area cut the c. 1585 Ma Hiltaba Suite plutons. This means the faults formed at or after c. 1585 Ma, likely during the c. 1570-1540 Ma Kararan Orogeny (Hand et al., 2007). Other authors have the Kararan Orogeny as 1600-1570 Ma (Reid et al., 2017).*
- *The offsets of the pluton contacts by the NW- and NE-trending faults suggest apparent NS-directed shortening at this time.*
- *Mineralisation at Tarcoola has been constrained at 1564 Ma (Bockmann et al., 2019). Mineralisation at Tunkillia has been constrained at 1590-1570 Ma (Fraser, 2004). This indicates that mineralisation in the study area likely occurred during the Kararan Orogeny, when the central Gawler Craton was undergoing NS-directed shortening.*

- *As well as forming new structures, older NE-trending crustal-scale structures, e.g. the Bulgunnia, Muckanippie and Coorabie shear zones were reactivated during the Kararan Orogeny (Direen et al., 2005; Reid and Dutch, 2015-RB 2015/29)*

In the manuscript we added a paragraph at the end of the Geological overview:
The NW- and NE-trending faults across large range of the study area cut the _ 1585 Ma Hiltaba Suite plutons. Therefore, the faults formed at or after _ 1585 Ma, likely during Kararan Orogeny that occurred either at 1570 Ma (Hand et al., 2007) or 1600-1570 Ma (Reid et al., 2017, and references therein). There is evidence that pre-existing structures (i.e. Gulgunnia, Muckanippie, and Coorabie shear zones (see figure2) were reactivated during the Kararan Orogeny (Dir, 2005; Reid and Dutch, 2015). In conclusion, most of the large-scale fault zones could have provided pathways for mineralizing fluids. Based on the observable offsets of pluton contacts a N-S directed shortening can be assumed during the formation of the Au-deposit mentioned above.

6. An answer to the following comment of referee #2 still should be provided: "Line 125: Are those in any magnetic map? Shouldn't you show the magnetic map with the interpretation instead of just the interpretation? Is it possible to find the reference you include? Later on you use North-West, or North-west or even NW. Revise and be consistent".

We added a reference to the magnetic dataset utilized during the interpretation (figure 4c). The report related to the structural interpretation is referenced in the main text. The line data and other datasets are freely available through the SARIG: https://map.sarig.sa.gov.au/

7. An answer to the following comment of referee #2 should be provided instead of providing general words "Please see responses above.": "Line 171: Intensity or anomaly? I'd say it is anomaly, considerend the scale. To be confident with RTP datasets you need to be sure that there is no remanence are you? Otherwise, you are moving anomalies in the wrong direction."

Apologies for referring to previous responses. The magnetic data is the total magnetic intensity reduced to pole, so intensity is correct. We have also added text to discuss the issue of remanence on the RTP data used in the context of lineament extraction in the discussion as follows: " We note that, the presence of magnetic remanence may alter the field anomaly, rendering the reduction-to-pole data we used less useful, however for our purposes of extracting lineaments from multiple datasets, the uncertainty in the degree of magnetic remanence is of less concern than the uncertainty associated with the different automated and manual techniques in extracting lineaments."

8. The author write a few times in their responses to the comments "See comments above". It is not clear, where. The answer "Please see comment above and modified discussion." is not clear.

Thank you for the opportunity to clarify these specific references. We have copied below where the use of "See comments above" where used in response to Referee #2, which are all related to gravity and magnetic data which was identified as a major comment in the opening remarks of Referree #2. Rather than repeat responses to the same comment, we opted for referring to the comment above, which we now see was confusing rather than helpful and we have now individually addressed these comments below. Please accept our apologies for the confusion.

Figure 8: why at 2070 m? Have you tried other altitudes? Have you calculated the approximate depth your are seeing with this upward continuation?
RPT might be misleading when there is magnetic remanence.....Are you sure there is none? At least you should discuss it
Why a different upward continuation? You need to discuss the values you choose

> We agree that the presence of magnetic remanence may alter the field anomaly, rendering the reduction-to-pole data less useful, however for our purposes of extracting lineaments from multiple datasets, the uncertainty in the degree of magnetic remanence is of less concern than the uncertainty associated with the different automated and manual techniques in extracting lineaments, which is the focus of this manuscript and our workflow.

We have added the following text to explain the selection of the upward continued values of Figure 8. "*Upward continuation heights of the gravity and magnetic data were selected such that the lineaments represent similar detail*."

Line 291: You still need to discuss the effects of:
using RPT data that might have magnetic remanence and upward continuation values that you have chosen

We added to the discussion:" We note that the presence of magnetic remanence may alter the field anomaly, rendering the reduction-to-pole data less useful, however for our purposes of extracting lineaments from multiple datasets, the uncertainty in the degree of magnetic remanence is of less concern than the uncertainty associated with the different automated and manual techniques in extracting lineaments."

Line 318: Gradients decrease with upward continuation. I still don't know why using those upward continuation values. Working with vertical derivatives will easily give you lineaments

The worms, or automatic gradient extraction, method is based in potential-field theory where upward continuation, derivatives, and the wavelet transform are used to identify edges in the data that we use here as lineaments (see Hornby et. al. (1999) for full method description). Upward continuation/derivatives are an integral part of the automated technique being used (see Hornby et. Al. (1999) and Foss et. Al. (2019).
The upward continuation heights for the gravity and magnetic were selected to show a similar level of detail. The difference in heights is related to the fact that the fields decay at different rates (1/r^3 vs 1/r^2). Foss et. al (2019) have performed upward continuation of both potential-field datasets to multiple heights with worms extracted for each dataset. Here, we use only one of the many worm-sets available (freely downloadable through on-line data portal SARIG) as the focus here is on development of a workflow. Upward continuation acts as a filter and is commonly used to supress shallow source bodies and emphasize deeper sources, however associating depths with those features associated with a specific upward continued height is not trivial and requires further assumptions about the source body (e.g. sphere, cylinder, dyke). Upward continuation is described in the second paragraph of section 3.4 and is an integral part of the automatic gradient extraction algorithm (see Hornby et. al. (1999)). The resolution of the gravity and magnetic data do differ and is related to both differences in data density and the decay of each field away from subsurface sources. The worms shown here are a single example set from a range of upward continuation heights (see Foss et al. (2019)) that were identified as having similar detail when considering the above differences. We have added the following text to explain the selection of the upward continued values of Figure 8. "*Upward continuation heights of the gravity and magnetic data were selected such that the lineaments represent similar detail*."

Line 321: And even so, are results realiable? What do you get if you use different values of upward continuation? Or no upward continuation? Gravity data has less resolution too
Line 325: Again, magnetic data probably has remanence and then, RTP might be giving you wrong positions. The Earth magnetic field has had different orientations....and of course, intensities. And gravity data has little resolution

We address both above comments together. Upward continuation is an integral part of the automated technique being used (see Hornby et. Al. (1999) and Foss et. Al. (2019). The worms shown here are a single example set from a range of upward continuation heights (see Foss et al. (2019)) that were identified as having similar detail when considering the above differences. Different values would likely result in a somewhat different lineament dataset; however we have selected upward continuation heights for each dataset in order to carry out our study. A full exploration of all upward continuation heights would be interesting, but beyond the scope

of this study. We have added the following text to explain the selection of the upward continued values of Figure 8. "*Upward continuation heights of the gravity and magnetic data were selected such that the lineaments represent similar detail*." We further included text in the Discussion addressing the issue of gravity resolution, which is not uniform: "We note that the magnetic and gravity datasets are of different resolution and in particular the resolution of the gravity dataset is non-uniform. As the upward continuation acts similar to a low-pass filter the difference in resolution becomes negligible."

Line 369: uses different datasets (upward continued vs original data?), doesn't it? So difficult to compare

> The dataset is not strictly the 'upward continued' dataset, and upward continuation is simply one step in the data processing required to perform the multi-scale analysis. The worms, or automatic gradient extraction, method is based in potential-field theory where upward continuation, derivatives, and the wavelet transform are used to identify edges in the data that we use here as lineaments (see Hornby et. al. (1999) for full method description).
>
> The upward continuation heights for the gravity and magnetic were selected to show a similar level of detail. The difference in heights is related to the fact that the fields decay at different rates (1/r^3 vs 1/r^2). Foss et. al (2019) have performed upward continuation of both potential-field datasets to multiple heights with worms extracted for each dataset. Here, we use only one of the many worm-sets available (freely downloadable through on-line data portal SARIG) as the focus here is on development of a workflow.

Technical comments

L8-11: this part of the abstract provides a content of your study. Please, replace it by the results obtained.

- *We modified this part of the abstract.*

L37: a comma is missing after "(Wilson et al., 2018)".

- *Added comma*

L52: a comma is missing after the words "In hydrocarbon exploration".

- *Added comma*

L62: a space should be added between the number "200" and "km".

- *Added space*

L77: a space should be added between "1570" and "Ma".

- *Added space*

L77: a comma should be added after "Hand et al. (2007)".

- *Added comma*

L97: the words "see legend Figure 2" should read "see legend of Figure 2".

- *Added "of"*

L107: a space should be added between "600" and "m" in "600m".

- *Changed sentence to: "Overlying the crystalline basement of the Gawler Craton in the analysed area are Palaeozoic, Mesozoic and Cenozoic sedimentary sequences that combined form significant but variably thick cover ranging in thickness from 0 to more than 600 m."*

L115: a space should be added between "part" and "(Figure 3)" in "part(Figure 3)".

- *Added space*

L135: "(Figure(2)" should read "(Figure 2)".

- *Removed parenthesis*

L152: a space should be added between “200” and “m” inside of “200m”.

- *Added space*

L155, L179: the abbreviation “DEM” is explained already in L24 and L154.

- *We now use the abbreviation “DEM”*

L157: a space should be added before “(Figure 4b)”.

- *Added space*

L157: a space should be added between “100” and “m” inside of “100m”.

- *Added space*

L158: a space should be added between “50” and “m” inside of “50m” and between “50,000” and “m” inside of “50,000m”.

- *Added space*

L200: a comma is missing after the words “In compensation”.

- *Added space*

L221: the abbreviation PCI should be explained at the first use.

- *PCI is the name of the company*

L223: “Pandey and Sharma, 2019, e.g.” should read “e.g., Pandey and Sharma, 2019”.

- *Updated citation to display correctly*

L239: “yield” should read “yields”.

- *Corrected typo*

L269: the text “2kmx2km” should read “2 km x 2 km”.
L272, 273, 276: a space should be added between a number and “km” or “m” in 6 cases in the lines.

- *Added missing spaces before units*

L350-351: the sentence starting with “Especially in areas that comprise thick cover...” is not clear. Is a comma missing?

- *A comma was missing in this sentence it now reads: “Especially in areas that comprise thick cover, narrowing down potential exploration areas with an automatic or semi-automatic method can significantly reduce cost for exploration”*

L363: “mineralization are” should read “mineralization is”.

- *Changed “are” to “is”*

L364: “this seems in-line” should read “this seems to be in-line”.

- *Added “to be”*

L381: I think, to be specify the words “Gawler Craton in South Australia” should be added after the words “subsurface and surface lineaments”.

- *Changed sentence to: “In this study we pointed out the differences between subsurface and surface lineaments in the Gawler Craton in South Australia mapped/extracted with different methods and from a variety of remotely sensed and geophysical data”*

L397: a comma is missing after “On one hand”. The words “On the other hand” are missing in the rest of the section.

- *Added comma*

L403: I suggest to explicitly add the web link for “South Australian Resources Information Gateway” to be visible, when the paper is printed. The same refers to “FracG” in L404.

- *We changed the layout of the “code data availability” section:*
  Code and data availability. Datasets and the code for automatic lineament analysis are freely available:
  South Australian Resources Information Gateway - https://map.sarig.sa.gov.au/ (Data).

FracG - https://bitbucket.csiro.au/scm/fracg/fracg.git (Code).

L408: the text “wrote parts the manuscript” should read “wrote parts of the manuscript”.

- *Corrected this typo*

L421: “fro” should read “for”.

- *Corrected this typo*

L423: the name “hirotugu akaike” should be written with capital letters: “Hirotugu Akaike”.

- *Changed to capital letters*

L445-446: what is the reason to provide two web links for the same paper?
L501: what is the reason to provide two web links for the same paper?
L521-522: what is the reason to provide two web links for the same paper?
L538: the same web link is given twice.

- *We now removed any url in favour of the doi to avoid duplicate entries in the reference list*

Figures

Figure 1: the order of the descriptions of 3 sub-plots in the capture of the figure should be changed. First should be “Outline of the workflow...”, followed by “Large mineral occurrences in the Gawler Craton...” and finally “Overview map of the Australian continent...”. Additionally, please check for missing commas in the text “Cu, Au Fe, Ag, Pb, Zn, Co, Ni, Cr, Mn Ti”.

- *As another reviewer also pointed out shortcomings of this figure we rearranged the figure and corrected the caption.*

Capture of Figure 5: “Rose diagram showing the distribution of strike directions of the data...”. Which data? Please explain. “Gaussian distributions fitted to the probability density function...” Gaussian distributions of which parameter? Please, specify.

- *We changed the caption to: “Directional analysis of structural interpretation (Figure 2a).* ***a*** *Rose diagram showing the distribution of strike directions of the structural interpretation with a bin size of 10 degrees.* ***b*** *Gaussian distributions fitted to the probability density function of the strike directions obtained via kernel density estimation.”*

Capture of Figure 6: “bin size of 10”. Please provide a unit of the bin size.

- *Added the unit “degrees”*

Capture of Figure 7: a space should be added between “2070” and “m” inside of “2070m” and between “930” and “m” inside of “930m”.

- *Added missing spaces*

Capture of Figure 8: “the radiometric (total dose rate)” should read “the radiometric data (total dose rate)”. Please, specify the unit of the bin size in the text “bin size of 10”.

- *Added “data” and “degrees”*

Figure 6, 7, 8, 9: the text and numbers in two right subplots of each (upper and bottom) panel of these figures are too small. I suggest to arrange all three subplots of each panel in one line and increase the font size, as it is done in Figure 5, to make the text and numbers better visible.

- *We rearranged the subfigures of all four figures.*

Figure 14: the abbreviation “SA” in the text “Significant to SA” should be explained.

- *Changed caption to: “Yellow and red diamonds indicate state-wide (SA: South Australia) and locally significant mineral occurrences that were detected in drill cores.”*

Capture of Figure 14: “that are divide” should read “that are divided”.

- *Changed to “divided”*

Review: Establishing an integrated workflow identifying and linking surface and subsurface lineaments for mineral exploration under cover: Example from the Gawler Craton, South Australia

General:

- the title of the manuscript is "Establishing an integrated workflow...". Please provide a chart of this "integrated workflow" and also mention, what do you mean with "integrated" somewhat earlier than in the conclusion. During reading in section 5 I got really confused when are you combining and merging which datasets of extracted lineaments and why. I could follow until table 1, but how and why you choose the combinations for Fig. 11, 12 and 13 I missed and got lost (I think, I got the reasoning much later when I contemplated about Fig. 14 a while). Please make sure that this chart also helps the reader with your terms you are using for the various datasets, extraction methods, merged extraction-datasets and stacked merge-extraction-datasets with other datasets. All this 'manual', 'semi-manual', 'semi-automatic', 'auto', 'worms' and so on and so forth gets a bit challenging to follow in the course of reading.

- why do you propose to use stacked information of lineament density and intersection density? You only write in l. 343 ff. why you think/assume this combination is necessary. Please explain this way earlier, because in the introduction from l. 46 - l. 53 you only mention publications which used either of the two methods, and there is no publication which showed that a combination of both density information will provide better targeting. And I was wondering the whole long manuscript why you would be doing that until I found the one paragraph in the discussion. That makes the reading and following of your manuscript really hard.

- *We combined our response to the points raised above as we think the issues raised are closely linked. We thank the reviewer for pointing this out. We added a column to the table 1 to make it easier to distinguish which dataset is obtained from which data and what method was used to generate the data. Furthermore, we modified section 5: "The targeting maps are derived 290 by overlaying the P20 maps with contours of the I20 maps (Figures 11,12, and 13). Considering not only the overall lineament density but also the intersection density allows to further constrain potential targeting areas. High intersection densities in a single dataset can indicate structural complex zone that are either indicative for enhanced faulting in the subsurface (gravity and magnetic) or could point towards neotectonic activity (DEM or radiometrics). By obtaining intersection densities of subsurface and surficial lineaments, cross-strike features can be identified that are thought to represent zones of enhanced permeability (Wheeler, 1980; Southworth, 1985). Areas of enhanced structural complexity or numbers of cross-strike discontinuities could therefore represent zones for preferential up-welling of mineralizing fluids, and we suggest that the adjacent areas that comprise an overall high density of lineaments represent preferential exploration targets.*
  For identifying these mineral potential zones, we set a threshold of 9 intersections per 500 m by 500 m pixel size and then visually identified the areas of overall high densities in the vicinity of these specific points as favourable targeting areas. The threshold is kept constant across datasets in this study to ensure a better comparability but would need to be adjusted depending on the underlying data for more reliable targeting."

- the manuscript is partly comparing which lineament extraction methods yields best targeting. In these parts it is unclear what is compared with what, because different methods are applied on different types of datasets. E.g. the geophysical data sets could also be interpretated by the human eye, and that could be compared to the worming. Instead, each type of dataset - which naturally contains different type of information - is also treated with a different algorithm. In the sections and paragraphs concerned with the comparison please be clear about if you are trying to compare the approaches of extracting the methods or if you are targeting at comparing different types of data and their inherent information.

- *We agree that this needed to be addressed in more detail to avoid any confusion. Overall aim of out study was comparing the fully automated approach implemented in PCI Geomatica with the manual segmentation and the worming and compare the geometrical differences of the datasets in terms of length and orientation. We added to section4: "We note that the different techniques will yield variable results and different information can therefore be obtained from the same dataset by applying for instance the worming (figure 7) or automatic segmentation (figure 9). We do not seek to compare the geological or physical information inherent to each dataset but rather perform a statistical analysis to point out the most striking geometrical differences (e.g., length and orientation). An in-depth evaluation of which extraction methods yields more reliable or realistic geological information is beyond the scope of this study."*

- there are several small grammar mistakes (e.g., missing commata) and small typos, e.g. missing or additional spaces. Please carefully re-read or use grammar tool of microsoft word.

We worked though the manuscript to correct all typos. Please see also detailed responses below.

1 Introduction:

Generally good, but in some paragraphs "unorganized":

- paragraphs from l. 30 - 35 and l. 41- 45 are basically saying the same, but the reader gets confused what is already knowledge, respectively already studied/confirmed hypothesis, and what is the working hypothesis for this study? Please unify and clear up these two paragraphs.

We modified the paragraphs in the introduction so that we do not repeat information.

- paragraph l. 46 - 53: what do you want to say with it at this place? It rather reads like a list of other studies, but you already started with saying what you would like to do. Please clean up, and streamline this (maybe together with next paragraph) to what is the aim of your study and how you want to do it.

We made changes to the 4th and 5th paragraph of the introduction to make it clearer on what this study wants to achive and how we aim at doing it.

2 Geological Overview:

- l. 59, last word: major, not mayor. Please correct in whole document, there are several instances of mayors...

- *Corrected these typos*

- Could you please change IOGC to IOCG in the whole document? It reads so weird, and could be confused with the Indian Oil and Gas Canada company...

- *Changed to IOCG*

2.1. Good.

2.2 :

- "a solid geological interpretation was undertaken ... using aeromagnetic data.." - uhh, a very risky phrase among some hard core geologists. They would argue that "solid" geology can only be done with drill core backup. Did the interpretation use drill core/outcrop information as well? If yes, please write so. If no, please re-formulate so that it becomes clear why this interpretation is so "solid".

- *The "solid geology interpretation" refers to the interpretations of the solidified lithologies and structural elements. As the reviewer rightfully pointed out this could be understood as a "solid" interpretation of the geology which is not what this is referring to. We therefore changed this sentence to: An interpretation of the geological framework"*

- l. 121 - 124: This is geological journal; we expect the reader to know the difference between shear zone and fault. But you may keep this explanation, but then please unify with paragraph from l. 141 - 145.

- *We restructured the section "Structural Framework" according to the reviewers' suggestion. We now begin the section with a short introduction of the aeromagnetic survey followed by a description of the structures signature in the aeromagnetic data. We then progress to a short description of the fault pattern in structural domains and conclude with how cross-cutting relationship allow for obtaining relative timing of fault/shear zone development in relation to the Au-mineralization.*
  We be that this strongly enhanced the clarity of this section and thank the reviewer for his suggestion.

3 Methodology:

General: I'm missing a table containing summarising which method was applied on which surface or subsurface data set

- *We added a column "segmentation method" to table 1. We further added a second table summarizing which datasets were combined for creating the targeting maps, which method was used for the segmentation and the name convention used in figure 14.*

- 3.1 OK, but phrases are bit convoluted. If you have the patience, please rephrase in structurally easier phrases

3.2 A clear section - if the reader knows what all these tools are you are mentioning here. For me with a certain statistical background it is just fine, I understand perfectly how you automatize the main lineament extraction. But SE is geology-based journal, and you'll lose more geology-oriented readers here completely. Please add few more, very simple sentences, how kde works and why you chose to use these tools.

- *We added a few sentences to section3.2 and slightly restructured it to enhance the clarity. We further added a reference to a publication presenting a tutorial on kde for any reader further interested in the underlying concept.*

3.3 l. 183: Phrase is unclear, especially what is the "edge detection filter" - do you mean the manual picking of lineaments?

- *The edge detection filter refers to the sobel filter that enhances the edges in the image. We applied this to the DEM data as a pre-processing step prior to the manual fitting. This aimed at highlighting the bias of the manual segmentation as the underlying dataset is the same but due to the processing the human operator picks different lineaments.*
  We agree with the reviewer that the particular sentence they highlight and changed the sentence and slightly restructured the section.

3.4. Good. l. 193: please use past tense for what you did with the data, here change "is" to "was".

- *Changed this typo.*

3.5. Good.

4 Comparison of lineament datasets:

- l. 234: Where did you explain how you used the kde for the lineament length distribution? If that was in 3.2 then I missed it, because in section 3.2 I thought that was only referring to kde of orientation. Please introduce/mention the kde for length somewhere, e.g. in 3.2., with a phrase.

- *As the reviewer correctly pointed out we only described the kde and subsequent fitting og Gaussians for the orientation distributions. The visualization of the length kde was performed using the python matplotlib violin plot functionality. We now mention this in the caption of figure 10 to avoid any confusion.*

5 Lineament density maps as exploration tool:

- please be consistent with usage of capital letters in section titles, e.g. in this section title. (Or is "exploration tool" a specific technical term?)

- *We changed to non-capitalised letters*

- l. 261: the title of the section mentions only lineament density, but in the first sentence you mention two types of density. This is confusing. Is this section only about one type of density, then please explain why you are going to introduce two methods here, or is it about two types of density, then please change section title, or naming of density methods.

- *As the title is" Lineament density maps as an exploration tool" we are referring to the plural. We believe changing the title would potential be more confusing. We refer to lineament density maps and lineament intersection maps which are both lineament maps. We hope that the reviewer agrees and apologise in case they feel their comment not rightfully addressed.*

- l. 266: "Datasets that are obtained" is not clear which obtaining is ment: the original datasets, e.g. TMI, gravity, etc. or the datasets of extracted lineaments. Please clarify.

- *We thank the reviewer for pointing this out. Indeed, this might lead to confusion and we change to "Lineament dataset were obtained"*

- l. 266: Please give an example, what you are merging, or directly refer to table 1. I had to read the sentence several times, an example would facilitate the understanding.

- *We added reference to the two tables in the manuscript which hopefully makes it more understandable.*

- l. 269/l. 272: please be consistent in area size representation, either "by" or "x"

- *We now use "by" for the size representation throughout the manuscript.*

- l. 275: It is absolutely crucial for the following understanding, that here you explain why you are combining which datasets for the figures. I only understood way later, when I read the caption of Fig. 14 what you are intending to do here. Please move explanation of Fig. 14 somewhere here and also introduce the names of the methods mentioned in the legend of Fig. 14 here, so that later on the reader knows what she/he is seeing in Fig. 14.

- *We again thank the reviewer for pointing out this shortcoming. We modified the section and added additional information and references to the modified tables: "The targeting maps are derived by overlaying the P20 maps with contours of the I20 maps (Figures 11,12, and 13). We used combined lineament dataset that represent either surface or subsurface signals (see table 1). In cases where we utilized the structural interpretation (figure 2) as the subsurface datasets the density maps comprise three individual lineament datasets (figures 11 and 12 a) whereas the other targeting maps comprise of four lineaments sets (figures 12 d, 13). The reason behind this is that the remotely sensed data sets comprise two datasets for the surface (DEM and radiometrics) and two datasets representing subsurface (TMI and gravity) respectively that might detect features at different scales or are based on data of different resolution. We merged the lineament sets to obtain comprehensive datasets comprising surface and subsurface*

features. Which datasets are used for obtaining the respective targeting map and which extraction methods were used for obtaining the utilized lineaments is summarized in table 2. We further classified the targeting maps into "manual", "automatic", or "semiautomatic" indicating whether the underlying lineament sets were derived with purely manual segmentation, represent a combination of manually and automatically extraction or are obtained solely by automatic segmentation (see table 2)."

6 Discussion:

- l. 294-295: I disagree! The length of lineaments is not necessarily a bias by human eye, but lineaments can be of different length! Or, if you really think that the variability of lineament length is a result of human bias, then please give a reason for this assumption.

- *As pointed out by another reviewer, we do not have data to support this statement. It is likely that there is human bias involved when picking lineaments and the length distribution could be affected by this. Consequently, we removed the sentence on the human bias as quantifying the bias introduced by a human operator is beyond the scope of this study.*

- l. 295-297: similar issue here: please explain why and how you think the length (which has in my opinion a certain natural variability) is biased by algorithms, respectively how the natural variability of the length can be distinguished from the contribution of the bias on the variability.

- *The length distribution of the automatically extracted liniments certainly results from the parameter choices for the extraction. The threshold lo length defining the minimum length designated to a curve to be considered as a lineament, threshold to line fit error and the threshold to angel distance for merging two vectors will introduce a bias. To clarify this, we modified the paragraph: "Some input parameters of PCI Geomaticas LINE module will certainly introduce a bias towards certain length distribution of the extracted lineaments. The two most important parameter are the threshold to length and the threshold to angular difference that defines the maximum difference in orientations for uniting two segments (see table 7 in Kelka and Martinez (2019) for details on the parameters)."*

- l. 311: I guess, you meant the humans consciously detect trends, and not that trends are concious?

- *Corrected the typo*

- l. 322: typo "differ"

- *Corrected the typo*

- l. 326: please simplify and clean up this sentence.

- *We tried to simplify this sentence without altering the statement.*

- l. 350 - 356: this doesn't belong into the discussion section, please merge into introduction.

- *Merged paragraph intro introduction*

- l. 369: typo "know" -> "known"

- *Corrected the typo*

- l. 375: typo "uncertainly" -> "uncertainty"

- *Corrected the typo*

- l. 377: typo "know" -> "known"

- *Corrected the typo*

7 Conclusion:

Clear and concise.

Figures:

Fig 1:

- Figure caption doesn't fit the sub-figures right now. Please correct.

- The first figure mentioned is Fig. 1b, is this correct, i.e. is the sub-fig naming correct? If yes, why don't you switch the two sub-figures, so that the manuscripts starts with Fig. 1a)?

- please make legend larger and better readable. Also, please make a better distinction between the two legends and to which sub-figure each of them belongs.

- *We rearranged the figures so that we reference figure 1a first in the manuscript. We also added a frame around figure 1b to make the legends more distinguishable and we also increased the font size of the legend.*

Fig 2:

- please make legend larger and better readable.

- in sub-Fig 2b the geological units are extremely difficult to read based on the legend with all these similar colours. Please strongly simplify (which geological information of all these gabbros, basalts, gneises, etc. is really important for your message?), or use pattern and/or abbreviations in the figure clearly assign a field to one lithological unit.

- again: is the naming of the sub-figures correct?? If yes, the figure caption is atypical, e.g. for structural domain map I would less expect the geological map in sub-figure b but rather something like sub-figure a. I'm a bit confused by these maps in combination with the caption...

- *We changed the colouring of the lithology to make the different unit more distinguishable, increased the legends font size, and rearranged the subfigures according to the reviewer's suggestion.*
  We do not think that we can justify further simplify the figure. The geological framework is complex in this area and the lithological boundaries between different rock types might correlate with the location of extracted lineaments. We hop that our modifications will still satisfy the reviewer.

Fig 3:

- please make legend larger. Legend items for sand ridges and water courses didn't show up in my printer, please make better readable.

- also, legend is easier to follow if the two legends are seperate, especially because both legends contain colour information. It is possible to understand, but not so nice for the reader.

- Sub-figure a) is a mess. It is really difficult to read, and I totally failed to understand what are the sand ridges here? Please simplify, which information from this map do you feel is important for the understanding of your method? Emphasize those features and reduce visual impact of the unimportant information.

If you change the sub-figure naming, respectively the captions, please make sure the numbers are correct in the whole text afterwards!

- *As also another reviewer suggested to restructure this figure as well, we decided to split the subfigures into two separate figures. The font size of the legends is increased, and we also enhanced the visibility of roads and the sand ridges.*
  Because we are following the colour convention for regolith maps, we did not alter the colouring of the different units. Like the comment regarding figure 2, we do nt believe that we should simplify the map. Together with figure 2 and 4, the purpose of the maps in our contribution is to demonstrate the complexity of the bedrock and cover sequences. This complexity is the reason why our presented workflow is particularly useful in such regions. We hope that the reviewer can agree with this and that they are acknowledge our attempt of complying with their suggestions.

Fig 10:

- inconsistent naming: please unify y-labels, e.g. GRAV (auto) and Worms (GRAV) to GRAV (worms) and GRAV (auto) (which 'auto' btw?, worms is also 'auto', isn't it?), etc. , to match it to DEM, RAD, etc.

- *We completely overlooked this inconsistency. We thank the reviewer for pointing this out and corrected the labelling in the figure. In order to avoid confusion we changed "auto" to "PCI Line" so that it is more clear which segmentation method was used for which dataset.*

Fig 14:

- caption doesn't explain the legend items related to "Significant SA", "Significant locally", etc. Please make the figure + caption self-explanatory.

- *We added a description to in the caption. We also realised that the western part of the figure was accidently cropped. We now correct this.*