Referee comments in red italics.
Author response in black.

Referee #2

This paper presents a workflow to firstly identify lineaments (faults and shear zones) by different techniques and later on plot their intersections in an effort to create density maps that can be used as exploration tool in areas with a 'thick' sedimentary cover.

In my opinion, the paper is very poorly written, especially the geological part. The text is very often redundant. Some parts are repeated constantly throughout the text (e.g., relationship between mineralization and faults). There are millions of commas missing. The expression 'the study area' is constantly repeated (I have counted up to 36 times). Figures 13 and 14 are not discussed in the text and only referred to in table 1 or in figure 15. They should be at least minimally discussed.

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.

In relation with the technical part, the work has a sound mathematical basis used with little geological/rational support. The datasets have different resolution, implying that identified features have different length and are going to be plotted in different positions (something that is key to make intersection maps).

> The potential to have different lengths are not only a function of the resolution in each dataset but also a function of the specific lineament extraction algorithm steps. For example, the automated PCI algorithm applies a sequence of mathematical operations - one of which is a maximum allowable angle on the length of edge segments extracted from gradient maps that contribute to a single overall lineament. The lineaments shown here are the result of a user specified parameter set that when adjusted may result in a differing set of lineament lengths.

Upward continuation uses values that are not explained (why 2000 m or 900 m and what does it imply). Why not using vertical derivatives to picture gradients and boundaries/lineaments? These are good at spotting gradients, which in potential field data are evidence of lithological boundaries (by fault, shear zones or purely compositional). And last but no least, the places that authors point as potentially interesting areas for mineral prospecting (Fig. 15), very seldom coincide with mineral occurrences, so we have a problem.

> We agree and this is one of the main reasons we distinguish between 'surface' and 'subsurface' datasets – subsurface lithological boundaries are manifested in the potential-field datasets. It is also worth noting that the automated lineament extraction techniques discussed in the text, and further below are existing techniques that we make use of (but have not developed ourselves). Where practical, we refer the readers to existing literature.

While the lineaments are plotted on the original datasets in figures, the automatic lineament extraction techniques (i.e. PCI and worms) actually do use derivative/gradients with thresholds to identify boundaries (e.g. edges) in the datasets that ultimately yield the lineaments. The PCI Geomatica algorithm operates on the gradient of the data to identify edges (second paragraph of section 3.5, Geomatics(2005)). 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. 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). Calculating depths of causative sources is not done here, as more assumptions would need to be made in order to do so and is outside the scope of this work. For our purposes, the knowledge that lineament features present in upward continued data are likely from changes in subsurface geology is sufficient in order to demonstrate our workflow. While we are unable to guarantee that lineaments in the selected upward continuation heights of the gravity and magnetic data represent the same depths, we are confident that the lineaments represent geologic changes at depth as opposed to geologic changes at the surface (represented in our workflow through elevation and radiometrics).

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*."

In summary, although mathematically the paper is correct, it lacks a good geological background. Processes are applied over datasets that might not be useful for the purpose of the paper. And in case it was going to be published, it needs to be rewritten, mostly the geological part. Also, datasets need to be further discussed and errors and limitations considered. So in my opinion, the paper has to be rejected in its present form although resubmission of a new MS could be an option given the goal and background of the paper

Ahead there are some comments that I made before I realized it was better to make annotations in the MS. So use both, this text and the annotated MS for review.

Some comments.

Line 39: compare with vertical derivatives. Gravity and magnetics depend on 1/r2 at least so depth diminishes the potential field signature

We changed the sentence to: "We assume that elevation and radiometric data relates to surficial features, while gravity and magnetics data represent structures below the cover."

We address the damping of the magnetics and gravity in the detailed response above and added more detailed discussion on this in the manuscript. We also clarified that the edge enhancement filtering applied is based in obtaining derivatives.

Please see response to main comment above, derivatives are at the core of the lineament extraction techniques used.

Line 81: The key geological features should be enough….

We changed the sentence

Line 87: What does Lake Harries Greeenstone Belt (figure 1 and 2b) have to do with the lithologies? You haven't cited this belt before. Cite figure 1 so we know what you refer to.

We changed figure 1 and only introduce the provinces that are of relevance to our study in figure 2. We tried to reduce the geological description to the elements that are necessary for the reader to understand the local geology as need to follow the presented work.

We now only refer to the Harris Greenstone Gelt that is visible in figure 2a

Line 91: Rocks of the Hiltaba Suite (figure 2).

Added reference to figure 2b

Lines 91 to 95: No need to mention four times 'study area'

Changed the text to avoid repetition of 'study area'

Line 96: Granitic gneisses are orthogneisses?

Yes

Line 97: What is a low magnetic signature? Low amplitude?

Changed to low amplitude magnetic signatures to be more concise

Line 98: Comma missing after Suite.

Added missing comma

Lines 117-120: How can you distinguish the magnetic signature of shear zones and faults? That paragraph responds to your own work or there references missing. Fluid flow also demagnetizes or remagnetizes shear zones. Also, shear zones also juxtaposes blocks of rocks with different magnetic character.

Line 123: I don't see, as such, a NW trending Mulgathing Trough in figure 2a. In general, there is little relationship between geology as described in the text and shown in the maps. This needs to me highly improved.

We thank reviewer#2 for pointing this out. We modified figure 2 so that figure 2a shows the broad overview of the region including the large shear zones. We then present the more detailed view in figure 2b and highlighted the Mulgathing Through in a brighter colour to make this younger element better distinguishable from the bulk.

Fig. 1: Add a rectangle in the Australia map in figure 1b delimiting the area shown in the bigger figure 1a. Maybe figure 1a should be figure 1b and viceversa.

We changed figure 1 and only show the initial figure 4a now. The investigated area is merged in this figure and we increased the thickness of the rectangle to ensure better visibility.

Additional comment from se-2021-42-RC2

Line 80: Disorganized. Is it described geographically??? By age??? You should follow a criteria and mention it in the text

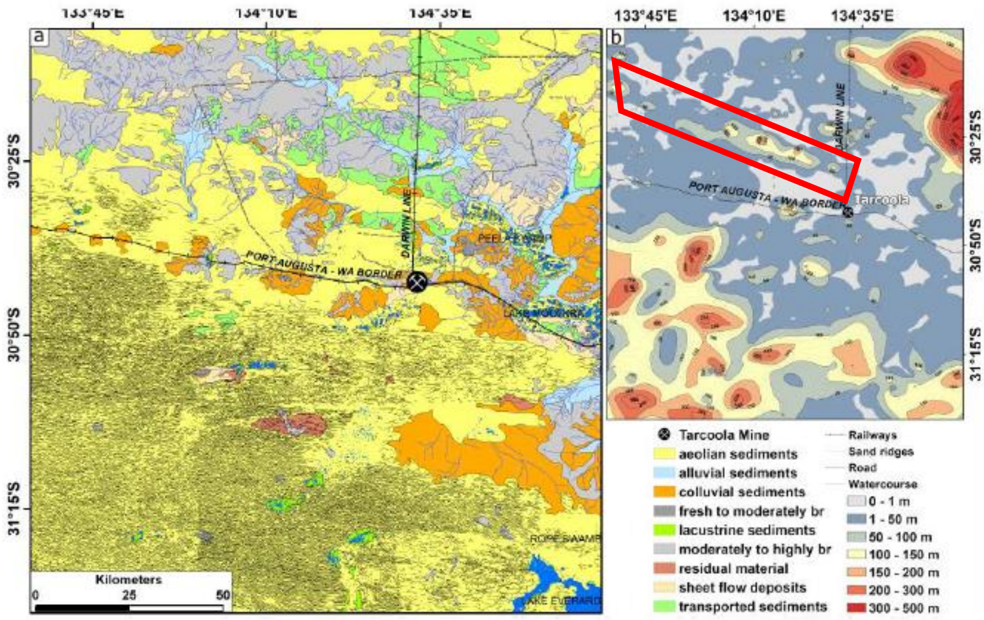
We restructured the introduction and geological description. We tried to omit any unnecessary details to clearly indicate that the focus is set on the structural framework and only to a lesser extent on the generic framework of the Gawler Craton or the lithological units.

Line 99: Above you mentioned that the youngest tectonic activity dates back to ~1400 Ma, and here we have dykes at 827 Ma and a through in the Permian?

We change the sentence above in lines 73-75 to: "The last large-scale deformation in the Gawler Craton was the reactivation of shear zones…". The formation of the Gairner dykes is a more local scale phenomena in contrast to the large-scale deformation (orogeneses) described before that did not affect the entire Gawler Craton.
We hope that by explicitly referring to large-scale phenomena we are able make the description clearer.

Line 103: What is in figure 3??? The Mulgathing through???? Or the post-glacial sediments? I cannot see either!
Line 105: what through? the basement to the SW? Or Mulgathing Through? which is, according to you in the NW? In the map in figure 3b the deepest basement is found at 500 m according to your scale, and it is in the SW or NE, and Mulgathing through is in the NW? I'm lost
Line 105: your scale in figure 3b goes down to just 500 m

The reference to figure 3 is wrong in this place of the manuscript. As reviewer#2 points out correctly, the through is not visible in the cover map (figure 3a).



Caption figure 2: Many of the features that you describe in the text are missing in maps

By changing the geological introduction and the description of basement and cover we hope that all features described in the text are now easily found in the maps.

Line 119: What do you mean? You don't demagnetize things in nature. Rocks lose one magnetization and gain another. Explain/rephrase.
Line 120: shear zones are not discrete zones but can do the same thing (remagnetize). Not a criteria to differentiate between fault and shears

We agree with the reviewer that the wording needs to be improved and changed the sentence to: “Faults and shears can be recognised as relatively discrete zones whose magnetic signature was altered by circulating fluids, or by the juxtaposition of two blocks of rock with different magnetic character.”
We did not intendent to describe criteria to differentiate between fault and shear zones

Line 123: Not in Figure 2a, at least you refer to the legend, which does not refer to a Trough but a complex

We highlighted the younger Mulgathing Though in figure 2a and omitted the description of the Mulgathing Complex that is a large Archean- to Mesoproterozoic province of the Gawler Craton as this does not contribute to the understanding of the local geology.

Line 125: Are those in any magnetic map? Shouldn´tt 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 Nort-West, ot Nort-west or even NW......revise and be consistent

Line129: Tarcola Fault is to the N of Finke shear, not to the south?

We changed the sentence to:” An exception to this trend is the north-northeast-trending Tarcoola Fault that appears to propagate from the southern Finke Shear Zone.”

Line 130: THis domain is shown in figure 2b not 3b.

We corrected the figure reference.

Line 132: Where is the Kooniba shear zone?
Line 133: *I see the Yerda shear zone but not the Kooniba shear zone*

We added reference to a larger-scale map found in Gonzales-Alvarez et al., 2020 and specified that the Kooniba shear zone is indeed outside of the domain investigated here.

Line 136: Show them in an aeromagnetic map figure

We referenced figure 4c that we be believe show clearly the types of magnetic anomalies associated with the structural elements, and pointed out appropriate literature for further details in the text: *For details on the signature of fault in aeromagnetic data we refer to Grauch et al. (2007).*

Line 138: what is a demagnetized feature? Something that has no magnetic response? Demagnetized and lack of magnetic response are too different things.

We changed the sentence to: "Faults often form shorter, narrow features with changing magnetic expressions that can be difficult to recognise in rocks with low magnetic response."

Line 140: From here on, the text does not belong to structural framework but introduction or such
Line 146: Again? This is introduction. No need to remind us what you want to do. You are describing here the structural framework
Line 153: How thick? This is an interesting point and, up to now, no word of it (just a map where it seems to be between 1-50m? It hat correct? Specify it.

We cleaned up the paragraphs and moved it into the introduction.

We added reference to the cover thickness that is shown in figure 3b (up to 500m)

Caption figure 4: There is no Ag in the legend, despite you mention it in the figure caption?

Corrected the figure which is now figure 1b

Line 155: You don't need this paragraph! It has been said many times by now
Line 159-161: Again? Remove it

We removed both paragraphs from the manuscript

Line 166: I haven't been able to read it

The report can be obtained here: https://products.sarig.sa.gov.au/Products
We can certainly provide a copy if needed.

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.

Please see responses above.

Figure 5: Make these maps bigger. Also, you should mark the most important interpreted lineaments in the magnetic map

We increased the figure size in the draft.

Line 202: Do you later discuss if your results agree with those of these authors?

We added a brief reference to the findings of Foss et al. (2019) to the discussion:
While the edge vector's orientation and length distributions differer significantly, a reasonable correlation considering their locations is observable (figure 8}). In line with Foss et al. (2019), this suggests that the mapping of gravity and magnetic contrasts with worms allows for correlating the magnetic and gravity field anomalies. It must pointed out that the mapped edges only act as approximate markers of the horizontal contrasts in density or magnetisation (Foss et al, 2019).

Line 222: Maybe the resolution of the datasets play an important role here. You'll need to discuss it

Addressing concerns about the upward continuation and the difference in resolution of the potential field data we added the following to the discussion: *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. 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 235: What parameters have you used?

We added a citation to a report in which we utilized the same parameter combinations: "For detailed description of the parameters used in this study we refer to Gonzalez-Alvarez et al.,2020."

Line 237: Surprisingly, here surface data gives you the same directions as upward continuations (indluenced by deep sources) and different to those of shallow datasets (figure 7)

This clearly shows the difference between manually segmented and automatically extracted lineaments. We believe this is one important finding that would need further evaluation with field data.

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

For further discussion on upward continuation, please see the response to general comment above. 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.

Line 241: Quite surprising results and different to those on figure 8 over the same datasets? However, similar results to those in figure 7 over surface datasets

As the edge enhancements correlated better with known structures such as plutons or shear zones, we think the difference shows which method is suited better.

Line 252: Not always. See figures 6 and 7b

We now point this out in the text

Caption figure 12: Does any of them coincide with known mineralized areas?

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

See comments above.
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."

Figure 14: Nowhere in the text you refer to this figure

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

See comments above. Upward continuation/derivatives are an integral part of the automated technique being used (see Hornby et. Al. (1999) and Foss et. Al. (2019)

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

Please see comment above and modified discussion.

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

Please see comments above and in the discussion. The chosen upward continuations should allow comparability and also dispel concerns about the difference in resolution.

Line 360: The amount of identified mineral occurrences that do not coincide with a combination of lineaments is huge. Does it reduce credibility to your study?
Line 383: Up to know, your results do not localize existing known mineralizations

We are now pointing out the poor correlation between know mineral occurrences and identified targeting areas in the discussion. We changed the discussion of figure 14 that presenting all the targeting areas:

Figure 14 shows the target areas identified by the different methods. At the current stage the areas identified as potential targets by different methods represent the most promising regions for follow up hydrogeochemical sampling for identifying mineral footprints in the cover. These are probably North-east of the Tarcoola mining site at the margins of a large intrusive body, the Northwestern part of the study area where the edge of Permian graben is cross-cutting the Muckamippie Shear Zone, the region in the Southeast of the study area close to the Yarlbrinda Shear zone, and the area in the Northeast where mineral occurrences are reported along the Bulgunnia Shear Zone. Most of the targeting areas are located along the shear zones that form the borders of the geotectonic provinces. Giving that the area is part of the Central Gawler Au Province where mineralization are mainly shear-hosted Au (Hand et al,2007) this seems in-line with the exiting knowledge of the region. In addition, the targeting areas are often associated with the margins of the Hitaba Suite (in particular in the southern part of figure 14). Here it is important to note that the gold deposits in the Central Gawler Craton exhibit some similar characteristics considering the mineralization style, as the gold is dominantly hosted in sulphide-poor structurally controlled quartz veins that seem to be spatially related to the Hiltaba Suite (Daly et al.,1993). We do not directly identify the deposit exploited at the Tarcoola mine but an area to the northeast that is situated along the margin of the Tarcoola formation (know host-rock Pawley, 2016) that includes two known mineral occurrences of local significance.

We note that relatively few know mineralization coincides with the targets identified by the lineament analysis (figure 14) and further research is needed to validate the reliability of the presented workflow. Geological knowledge of the area might help to reduce the number of false positives obtained by lineament-based exploration targeting.