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Interactive comment on "Basin inversion and structural architecture as constraints on fluid flow and Pb-Zn mineralisation in the Paleo-Mesoproterozoic sedimentary sequences of northern Australia" *by* George M. Gibson and Sally Edwards

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This paper represents an interesting and important contribution to our understanding of Pb-Zn mineralisation, the tectonostratigraphic evolution in the Lawn Hill platform – South Nicholson Basin region, and provides key insights on exploration for Pb-Zn ore-bodies. The evidence for syn-inversion deposition of the host rocks presented here calls into question the syn-extension models for Pb-Zn mineralisation and highlights

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Discussion paper

the importance of understanding the structures controlling inversion as well as the extensional architecture. I recommend this paper for publication after minor edits. My comments largely relate to a request for clarification or additional information on specific topics. In addition, I highlighted a couple areas in which a short discussion on both the evidence and uncertainty within some of the interpretations presented would benefit the paper. The authors have an extensive background and experience with the outcrop geology and interpretation of the seismic data in this region and have published widely. Although I have a difference of opinion on the interpretation of some of the regional correlations and some aspects of these seismic lines (mainly the deeper sections), I greatly appreciate the opportunity to review this interpretation. It has provoked me to review and reassess my interpretations and consider the correlations presented here. The lack of outcrop and the thickness of the cover basins means that there will always be a range of interpretations for this region, and we may never have a definitive answer on some of the questions. Interaction and discussion on the various interpretations will help the geological community to at least narrow down the range of options on some of the key questions. I have thoroughly enjoyed the opportunity to review and discuss this contribution to our understanding of the region. Regards Karen Connors

Figures

Several figures require better resolution as noted by Alan Collins, and I note that the authors have already addressed this. I would add a few additional suggestions. Seismic images âĂć If possible, it's good to provide Interpreted and uninterpreted images (especially where these have not been published previously), but I understand that this may not be possible. âĂć Please indicate the location of all features discussed in the text on each figure. It is difficult in some cases to be certain which features are being discussed in the text. âĂć The timing of inversion is based on the interpreted onlap relationship. A detailed image of the key examples from figure 6 a, 6b, and 8a, would provide better support for the interpretation. I suspect that even the proposed higher resolution image will not provide sufficient detail to clearly demonstrate the observed

onlap relationship for the reader.

Paper

I have uploaded a pdf copy of the paper with comments, but I have provided a little more detail on a few topics below.

Evidence for spatial and temporal overlap of mineral and petroleum systems

I seem to have missed something in your argument, as I don't understand the emphasis on the strikingly similar structural architecture reported for much younger inverted sedimentary basins. As a result, I find that it tends to distract the reader, or even detract from the argument / evidence. The interpretation of the structural geometry presented in the paper based on the seismic data and geological mapping speaks for itself. It is not surprising that it is similar to other inverted basins. Regardless of how striking, this similarity does not suggest a spatial or temporal overlap in the mineral and petroleum systems as suggested by the current wording of the abstract.

The presence of bituminous material or high TOC in the units that host the Pb-Zn mineralisation provide clear evidence for spatial overlap for mineral and petroleum systems, but this requires clarification and it does not indicate a temporal overlap or any relationship to inversion. In order to use the presence of bituminous material to indicate hydrocarbon migration through the same rocks that host the Pb-Zn orebodies, then I think it is important to indicate the locations where this is documented and to clearly distinguish those from the numerous Pb-Zn orebodies that are hosted in rocks with high TOC (total organic carbon) resulting directly from the depositional environment of these units, and not from hydrocarbon migration. This is an important distinction. The addition of this data would benefit the paper. In cases where Pb-Zn mineralisation is localised in a unit with bituminous material that represents migrated hydrocarbons then this provides a timing constraint for Pb-Zn (post migration at Century as noted in the text). But if the high TOC formed during deposition then it does not support a spatial or temporal link to hydrocarbon migration.

Although it is certainly possible that there was a temporal overlap in mineral and petroleum systems, the data or argument to support this is not clear to me. Thermal maturity, migration and trapping of hydrocarbons in an inverted basin does not have to occur during inversion, it may occur after inversion during later burial, or even before (although in the latter case there is a high potential for breaching of traps during inversion). I am no expert on hydrocarbon migration, but my understanding is that the key factor in migration is the thermal maturity of the source rock rather than a tectonic event to trigger or facilitate fluid migration. While it is possible that the source rocks in the Isa Superbasin moved into the generation window due to further burial during inversion, this is not discussed in paper.

Syn-inversion deposition of host rocks vs syn-inversion mineralisation

The abstract states that all mineralisation is hosted by the syn-inversion fraction, but this is not documented in the figures or clarified in the text. Although most of the information is there, it is scattered throughout the text and a summary would be helpful. Which stratigraphic units host Pb-Zn mineralisation (e.g. show as thin lines within the supersequences on Figure 3; or add a more detailed figure as 3b), and what are the age constraints on the orebodies? The seismic examples in the paper nicely highlight the syn-inversion deposition of units that host some of the Pb-Zn ore bodies (or will with higher resolution images). This draws into question the syn-extension model as indicated in the text, but does not clarify the timing of Pb-Zn mineralisation. As pointed out in the text, Century orebody is dated at 1575 Ma indicating that it developed later during the Isan Orogeny well after deposition of its syn-inversion host rock. Other Pb-Zn orebodies such as Mt Isa / Hilton are much closer in age to that of their host rocks (part of Gun Supersequence). Could these orebodies be syn-inversion? There are age data for a few other Pb-Zn orebodies (Walford Ck, Lady Loretta, Grevillea, and Dugald River even if they only provide an age range). It would be helpful to add them the time-space chart in Figure 3 and be more specific about which orebodies you relate to which inversion events, and whether these are the same inversion events active during

deposition of the orebody host rocks.

Age of River Supersequence relative to Riversleigh inversion

Please see notes in text and on Figure 3. The age for River as post ~1642 or 1641 on Figure 3 differs from published age dates ranging up to 1647-1648 Ma. This requires clarification in the text and on Figure 3 as it has implications for timing of River relative to inversion and extension.

Age of Carrara Range Group and Mitchiebo Volcanics

I recognise that the age of the Carrara Range Gp is a minor point relative to the title and main conclusion that the Pb-Zn bodies are hosted in syn-inversion sediments and formed during inversion events. One option is to consider limiting the focus of the paper and to not discuss all the lines to the west. However, if these seismic lines are included then it is important to more fully discuss the evidence behind interpretations for which there is some uncertainty.

I note that the Carson et al. (2020) extended abstract which provides a more detailed interpretation around the data in Kositcin and Carson (2019) was not available when this paper was written. Regardless, the Carrara Range Group and Mitchiebo Volcanics have been correlated with the Peters Creek – Fiery Creek units of the Calvert Superbasin as well as older units of the Leichhardt Superbasin as indicated on page 5. Kositcin and Carson (2019) provide new constraints from detrital zircon data that revise the Carrara Range Gp to include the Surprise Ck and Drummond formations in the Carrara Range area (Carson et al., 2020). Given the occurrence of these units overlying the Murphy Metamorphics it is not surprising that many of the max depositional ages are ca 1850 Ma, however the Drummond and Surprise Ck samples include max dep ages of 1743 and 1715 Ma as well as the older ages (Kositcin and Carson, 2019). This combined with the remarkably similar zircon profiles in these units and the Gator Sst, favours interpretation of the interlayered sediments and volcanics of the expanded Carrara Range Gp as a single package deposited at ca 1725 Ma and therefore of Calvert

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age (Carson et al., 2020). The Mitchiebo Volcanics and Don Creek Sst, the oldest units in this package remain undated, but the contact with the overlying Gator Sandstone is conformable (Rawlings et al., 2008) and the lower units are generally considered part of this group (e.g. Carson et al., 2020; Australian Stratigraphic Database).

If the undated Mitchiebo is part of Carrara Range Gp then the Leichhardt is absent in the Carrara Range area, and only a thin early Calvert sequence is preserved on the Carrara Range basement high. Alternatively thin Calvert and thin Leichhardt may both be present. Given that the Leichhardt Superbasin is absent on the Kamarga Dome to the east of the South Nicholson Basin (SNB), and on the southern margin of the Murphy Inlier (if Buddawadda is part of Peters Creek) or very thin, and is likely to be absent (or very thin) on the Carrara Range, it is easy to argue that the Leichhardt Superbasin is largely or completely absent beneath the SNB (Frogtech Geoscience, 2018).

The interpretation of a largely absent Calvert Superbasin west of the Riversleigh Fault as presented in this paper, or perhaps very thin, is a reasonable proposition, but it warrants a brief discussion of the age of the Carrara Range Gp, as well as the regional observations to support the absence of the Calvert and the merits of non-deposition vs erosion relative to the regional tectonics.

Carson et al., 2020; https://geoscience.nt.gov.au/gemis/ntgsjspui/handle/1/90009
Other references cited are included in the reference list of the paper.

Please also note the supplement to this comment:
https://www.solid-earth-discuss.net/se-2020-31/se-2020-31-RC2-supplement.pdf

Interactive comment on Solid Earth Discuss., https://doi.org/10.5194/se-2020-31, 2020.