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Solid Earth
Discussions

Interactive comment on "Seismic imaging of dyke swarms within the Sorgenfrei Tornquist Zone (Sweden) and implications for thermal energy storage" *by* Alireza Malehmir et al.

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Anonymous Referee #2 The paper nicely illustrates the ability of the seismic method to contribute to the geological evaluation of the thermal energy storage site. The acquisition and processing methodic, parameters and the workflow described clearly in the text, although the actual delineation of the bedrock surface from the tomography is vague. Also, section 6.3 concerning the entire crust structure seems a bit detached from the main part and objectives of the paper. I would recommend the work for publication with some corrections.

(Authors) Please see also responses to reviewer #1. We made a mistake with the

orientation of the BABEL line. We wish to keep this, as it is major structure crossing the zone. The revised manuscript we hope have made this more connected.

(Anonymous Referee #2) Here are my comments and suggestions: Page 2: "The seismic survey had an initial objective of identifying depth to bedrock and if major bedrock undulations could be related to zones of weaknesses (fractured or/and altered) in bedrock." I did not see the comparison of the depth to the bedrock from seismic (diving wave tomography) to drilling results in the paper. You provided some of it in Fig. 9 but did not summarize the results and did not provide any errors bars or discrepancies. Can you clarify this part please?

(Authors) The interpreted bedrock depth and comparison with the boreholes are shown in the revised figure. Uncertainty is not a big issue although we could try to estimate this as we have done in our earlier results using match of the bedrock depth with the velocities observed in the tomograms and various scenarios. Here, only visual interpretation of the depressions is important, therefore no need really to expand this further.

(Anonymous Referee #2) Page 7, line 10: "that the wireless recorders and shooting on the northern side of the road 11 was necessary to enable their imaging" Shooting – yes, but recording did not provide much looking at the shot records in Figs 5 and 6. All the north-dipping reflections in the records are present in the cable part. Wireless part did not contribute much due to short offsets, unfavorable north dip and maybe due to greater noise as indicated in the stacked sections in Figs 7 and 11. To justify this statement you can show some shot gathers from the source locations in the southern ends of profiles 2 and 3. The wireless part did record very good first arrivals, though.

(Authors) This is a good point and we partly agree with this. Shooting was likely important, however with no recording no good shot statics can be obtained and this can complicate imaging due to bad static solution. We avoid showing more figures. We have already 17 figures. This would just distract the readers.

(Anonymous Referee #2) Page 9: “we used a constant velocity of 4000 ms-1 for both migration and time-to-depth conversion” and later “5000 ms-1 should have been used instead” Why 4000m/s velocity was used? According to Fig 9, tomography velocities are closer to 5000m/s at the bedrock (and deeper down) and might be even greater for amphibolite, gneiss and dolerite.

(Authors) Given the target depths are only 500 m or so, the top 10-50 m low velocity zones should also be taken into account. The average velocity was calculated from the tomograms to be on the order of 4000 m/s also our judgment of the first breaks. We accept that we have no control on this, hence also possibly some mismatch of the reflections with the log data.

(Anonymous Referee #2) Page 9, line 12: meant profile 4, not profile 5?

(Authors) Thanks for spotting this. Corrected.

(Anonymous Referee #2) Figure 8: Please indicate what do the colors mean?

(Authors) They represent data density. Added to the caption now.

(Anonymous Referee #2) Page 14: These include (1). . . (2) they have. . . (4) gneissic-amphibolitic (3) is missing

(Authors) Thanks for spotting this. Fixed.

(Anonymous Referee #2) Figure 13: The relations of the features in the 3D view are unclear and impossible to interpret – looks like a 2D image. Perhaps it would be better to plot X-Y-Z axes and connect reflection points by wired surfaces.

(Authors) Followed also as suggested by reviewer #1.

(Anonymous Referee #2) Section “6.3 Revisiting BABEL offshore seismic lines A-AA-AB” does not add much neither to “implications for thermal energy storage” nor to “imaging of dyke swarms within the Sorgenfrei Tornquist Zone”. It looks detached from the main part of the paper and speculates only on the near-vertical vs steeply dipping

dykes which is not of a great importance for the practical aspects of the energy storage site. You refer to Phillips et al. (2017) where they show that Paleozoic dykes can dip at 35_ - 50_, so there is no need to explain it here. I do not see value in this section.

(Authors) Please see the revised manuscript. We insist to keep this as the BABEL lines A-AA-AB provide a larger picture crossing the Tornqust zone. We also made a mistake with the orientation of the profile and now further speculations can be made.

(Anonymous Referee #2) Page 21: “if any evidence of dyke emplacement could be found in the Precambrian basement” Permian dykes in Precambrian basement or dykes of any age? What is the possible relevance of their presence or absence to the Permian dykes in the study area? Again, I do not see value in this section.

(Authors) The value would be a more confidence on their orientation and how deep they extend. Please see above and response to Reviewer #1.

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