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Solid Earth Discussions

Interactive comment on "Large-scale electrical resistivity tomography in the Cheb Basin (Eger Rift) at an ICDP monitoring drill site to image fluid-related structures" *by* Tobias Nickschick et al.

Anonymous Referee #2

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General comments:

The paper describes an application of electrical resistivity tomography to image structural features in the Cheb Basin, targeted to identify fluid-related structures. Its application of a large-scale survey in itself is quite novel, and the results agree well with borehole logs. Although the authors state that the main target is to image fluid-related structures, the paper really describes a more structural characterization of the Cheb basin by integrating large-scale resistivity, gravity, borehole, and geological information. While the geophysical data agrees well with the borehole logs, the contribution

of the geophysics to the development of the geological model remains unclear, as the added benefit of the geophysical investigation is not clear.

What also remains somewhat unclear is why the authors actually choose to use ERT? There are other, i.e. EM methods, that may be more suited for this kind of deep investigation of resistivity structures.

More generally, the logic of the paper should be improved. This is clear when considering the Figure ordering, referencing, and placing, where, e.g., Fig. 2 is referenced before Fig. 3, and Fig. 1 is about 5 pages after it has been referenced first.

Specific comments:

One of the reasons for the limited benefit of the geophysics may perhaps be the large regularization factor that was applied to the resistivity inversion. This, in turn, led to a rather smooth resistivity model, which agrees well with the already existing borehole logs, but other than hinting to a basaltic intrusion, adds only limited new information. Perhaps more or an adapted data filtering may be required to help to achieve an acceptable Chiˆ2, while having a lower regularization factor. The authors are not providing any information on the sensitivity distribution or DOI index (e.g. Oldenburg & Li, 1999), which would allow to judge the reliability of the resistivity models particularly in depth. Providing a more thorough analysis and description of the resistivity models may help to improve the value of the geophysical data to the geological model development.

Regarding the title, the authors state that they are investigating "fluid-related structures". As resistivity depends on several factors, this relation from the resistivity model to fluids remains questionable. Especially given the geology of the study site, where the clay-rich Cyprus formation may well show the same response as a hydro-thermally altered rock formation.

Technical comments:

P1, Line 6: This is somewhat confusing. Why do you require a deep drilling program to

study near-surface structures? Near-surface is perhaps a subjective phrase depending on the audience.

P2, Lines 11-12: This sentence interrupts the flow here, as in the following sentence you provide more detail on the activities described before. Also, it might be worth adding what the open questions are.

P3, Lines 6-7: Why is a dipole-dipole array a "special investigation strategy"? I would describe this as a standard ERT array.

P3, Lines 28-30: You should reference to Figure 3 here.

Section “Geology and geodynamic activity”: This section is very detailed and can be shortened by focusing on the main processes that are causing the swarms and CO2 release.

P6, Lines 21 – 26: Since you refer to the results here, it would be good to also show them.

Figure 1: Dashed line (i.e., country border) should be included in the legend

P8, Line 8: You refer to Fig. 3 before Fig. 2. Please revise your order of figures, which doesn’t seem very logical at the moment.

P8, Line 13: These are good examples, but since you are referring to novel techniques, this list isn’t exhaustive.

P8, Line 20: Although the practical reason is obvious to me, i.e. electrodes of the injection dipole need to be connected to each other, the theoretical reasoning is not as other arrays may achieve deeper penetration or higher resolution.

P12, Line 7: Do you mean that you assume that the signal is not distorted, hence has a very high signal-to-noise ratio?

P12, Line 10: What is alpha?

P14, Lines 1-2: Please clarify, what do you mean by this? Do you mean that you distinguished bad data points by their corresponding reciprocal error? Or do you mean that most of the bad data points have a good quality reciprocal measurement?

P14, Line 8: How do you deal with measurements that don’t have a reciprocal measurement? Are you estimating an error model from the reciprocal data or are you assigning measurement errors otherwise?

P15, Line 9-10: If no error estimate is available I would suggest not including error weights in your inversion. Adding the BERT default is likely not your actual error model, and will have an impact on your inversion result.

P15, Line 14: This is quite a large regularization parameter and will likely result in very smooth models. Did smaller values result in much higher misfits? Did you do a L-curve analysis?

P15, Line 19: This is only true if the outlier also has a high error, otherwise the high regularization factor is likely causing the smooth response.

P17, Line 10: This would be more obvious if you add the sensitivity distribution, e.g. as shading.

P17, Line 11: Although most of them are not exactly on the line, could you add simplified logs to Fig. 9?

Figure 10: As for Figure 9, I suggest adding either the sensitivity distribution or calculating a depth-of-investigation index to quantify a "reliable" depth of your ERT models.

P 20, Line 11: Since you are referring to the gradient here, it might be worth plotting it as well.

Figure 11: Other than the possible basaltic intrusion, what is the contribution of the ERT and gravity measurements to this model? Especially the PPZ doesn’t seem to show an expression in the data.

P23, Lines 11-13: I don't think this conclusion is obvious from your data. Why couldn't it be related to a thickening of the Cyprus formation?

References: Oldenburg, D. W., & Li, Y. (1999). Estimating depth of investigation in dc resistivity and IP surveys. GEOPHYSICS, 64(2), 403–416. https://doi.org/10.1190/1.1444545

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