Dear editor, dear reviewers,

We thank the reviewers for the careful inspection of our manuscript and providing useful comments and recommendations that helped to improve our paper. We made effort to address all the reviewer's comments. Beside numerous corrections and further text, we added new Figures (Fig. 1E, F), a new table (Table 3), and another nine references. You find our answers in blue color. We highlighted the changes in the text by yellow background.

Anonymous Referee #1

General comments:

The analysis of pore space geometry in rocks is of great relevance to many areas of earth sciences. In this study, the authors propose to compare the results obtained from different pore space characterization techniques in two sandstones, the Bentheimer and the Rotthbacher.

Though I think this is a great topic to investigate, I find that the work itself does not bring significant value in its present form. A lot of research has already been conducted in this domain and it is difficult to see what new element the paper provides, aside perhaps from the spectral induced polarization part which I unfortunately had a very hard time following. Maybe the work could be augmented with a better review of previous findings and a more thorough extraction of information from the microCT images. In the abstract, the authors announce that they are going to characterize the pore space geometry, although nothing is done beyond acquiring and tracing various cumulative curves. In the abstract again, the concept of fractals is used but it is unclear (1) whether it is warranted to compute a fractal number from these curves as it is not demonstrated that they represent distributions of objects and (2) what the authors recommend what one should do with that value.

We thank for the critical remarks. We agree that a lot of research has been done in the domain of pore space characterization regarding µCT, MICP, and NMR. The main aim of our paper is to integrate an electrical method in this study. The spectral induced polarization (SIP) method provides a relaxation time distribution. It is assumed that the relaxation times are related to geometric length in the pore space. In order to verify this approach, a comparison with other methods providing insight into the distribution of pore sizes is necessary. The curves representing the cumulative volume as a function of pore radius provide the chance to compare the curves resulting from different methods. Additionally, the cumulative curves are used to assess the fractal behavior of the pores volume distribution. The fractal dimension is a useful number for up-and downscaling of geometrical quantities. Additionally, the fractal dimension is used in methods of permeability prediction.

Regarding the work that is done on images and the comparison between different data sets, I wish the authors had provided more information and figures on the image segmentation result as well as the result of the maximum inscribed sphere (MIS) computation. Also, the authors may be aware that such computation (MIS) can be used as a starting point for performing a digital equivalent to MIP which becomes then valuable to compare with the experimental mercury injection curve. In fact, a comparison between experimental MIP and digital MIP on one hand, and between MIS and NMR on the other would have made more sense.

Because the reader does not have access to the state of the images prior to the tracing of the cumulative ’pore size’ curve (MIS), it is very difficult to check whether the result is consistent. I have a doubt regarding the offsets observed in Figures 2 and 6 and I am wondering if what is plotted for the MIS is really the radius or rather a diameter. Please check. Also I am surprised to see that virtually no ’objects’ with dimension smaller than 20 microns was detected in either sandstone considering the image resolution of 1.75 microns per voxel and 1.5 microns per voxel for the Bentheimer and the Rothbacher, respectively.

As shown within figures 2 and 6, in fact pores in range of the image resolution have been detected and segmented. Nevertheless, these pores with small radii almost provide no significantly volume contribution concerning the results of the digital image analysis. We assume that this has a couple of reasons: first, the pore segmentation is greatly influenced by the density contrast between each individual phase (void and solid minerals), as well as by typical X-ray artifacts such as partial volume effects, which cannot be quantified in detail with conventional µ-CT. Additionally, the watershed algorithm will be sensitive towards the previously mentioned reasons and hence will lead to under-estimated volumes especially for small pores. We have addressed these effects within the revised manuscript.

Our study shows how other methods can be used to extend the resolution to smaller pores. We confirm that the pore radii are presented in Figures 2 and 6. The MIS data contains over 10000 points and it is a huge table so we only show the figures here. The data points of several voxels were eliminated because these data may either be pores or noise. We added a new Table 3 that compiles the minima, maxima and mean values of different pore sizes derived from µ-CT data of the two samples.

I don’t think that I can speak at length to the SIP part because I am not familiar with it. I would like to see a more intuitive explanation as to why it is appropriate to compare SIP data with a drainage (MIP) curve. Also I don’t understand how the data of Figure 5 on frequency-dependent complex conductivity is converted into relaxation times (assuming this is what is being done).

We recognize that SIP is a novel method in the field of pore size distribution. We added a paragraph to explain the Debye decomposition approach that is used to transform the spectra of complex conductivity into a relaxation time distribution.

In terms the organization of the paper, I found the figures confusing in the fact that they convey more information than is being discussed at first, forcing the authors to go back and forth when describing their results.

We have reconstructed the Results and the Discussion.

I am convinced the authors have at they disposal a great starting point to a valuable study. The sandstones picked are definitely materials of interest to the community and the high resolution microCT images can certainly be exploited further.

We recognize that the reviewer is most interested in the µCT images. It would have been possible to write an additional paper with special focus on the data processing and interpretation of the µCT data of the investigated samples. But the reviewer should consider that the µCT yields information, which is limited by the above described effects. The other methods are quite important to get insight into the pore space at the sub-micrometer scale. We investigated in our study how NMR, MIP, and SIP data can be used to get insight into the structure of pore size over a wide range of pore radii.

Other comments:

*I think the English could probably be improved (grammar and choice of words mostly)

We made some corrections highlighted in yellow color in the text.

*In the conclusion, an image resolution of 3.5 microns per voxel is quoted – please decide.

Correction done.

*I did not see the benefit of plotting the curves starting from the smallest injection radii - it puts an emphasis on the fraction where there is less data and also that likely contributes nearly nothing to flow, while dwarfing most of the important information.

We plotted the curves starting from the smallest resolved radii to show the different pore ranges detected from the different methods. The fractal nature of pore size can only be recognized if a wide range of pore radii is resolved.

*How were the injection steps chosen for the MIP curves? It seems nearly random, and also very sparse in the case of the Rothbacher.

The injection steps were automatically recorded by the equipment. In Figures 2 and 6 the MIP curves were plotted with step values of 10 (only every tenth value is shown) and 4 (only every forth value is shown), respectively, in order to show the data points clearly.

*Table 2 would be easier to look at if some mineral names were added to it.

We changed the term mineral phase to chemical components, and we add a reference describing the minerals of the Bentheimer sandstone.

*The resolution of the microCT images is great, the authors should be able to show much more detail at the grain scale. Have the authors attempted to determine whether the voxel dimension was a true image resolution?

Thank you for the positive evaluation of the µCT images of the two investigated sandstone samples. Certainly, the image quality is good down to a resolution of roughly two voxels. But this resolution is not sufficient to characterize the small pore space of sandstone underneath a distinct radii threshold as previously described.