Solid Earth Discuss., 7, C1792–C1796, 2016
www.solid-earth-discuss.net/7/C1792/2016/

Solid Earth Discussions

SED

7, C1792–C1796, 2016

Interactive Comment

Interactive comment on "Calculating structural and geometrical parameters by laboratory experiments and X-Ray microtomography: a comparative study applied to a limestone sample" *by* L. Luquot et al.

L. Luquot et al.

linda.luquot@idaea.csic.es

Received and published: 6 January 2016

Dear Reviewer 1,

We would like to thank the anonymous reviewer for his/her thorough and constructive review of this manuscript. We found his/her comments very useful in improving the content of the MS. Below, please find reply to the comments which he/she had raised during the review of the MS.

Specific comments

1. As suggested by the anonymous referee, in order to specify the two rock sample steps (before and after dissolution processes), we changed the title as follows: "Calculating structural and geometrical parameters by laboratory measurements and X-Ray microtomography: a comparative study applied to a limestone sample before and after a dissolution experiment".

2. We approve the referee's comment. Indeed, in our laboratory methodology, the use of the triple weighing method was relevant. However, we agree that helium pycnometry is faster and certainly more accurate, but requires additional hardware setup. Nevertheless, we mention this technique in the revised version as an alternative to measure the porosity (pp. 21).

3. The referee's comment makes sense, as the main limit of the X-Ray microtomography is clearly the voxel size. However, we think that this approach is relevant for other types of rock than the one presented here. One of the objectives of the present study was to investigate a representative elementary volume of rock and compare measurements from laboratory and from images. To this condition, the voxel size is limited by the acquisition technique and the rock sample size. We used a synchrotron energy source to achieve the highest possible resolution. Yet, under this condition subresolved porosity is still present, as would be the case for any natural or synthetic porous material. Nonetheless, we developed a methodology that tackles this limitation. Consequently, we think that the framework adopted for this study is relevant and can be easily adapted to any type of rocks. Thus we added the following sentences in the conclusion part (p. 24): "Moreover, the studied sample presents both resolved and subresolved porosities, which would be the case for any other type of natural or synthetic porous material, whatever the acquisition technique. Thus, the framework developed in this work is relevant and can be easily applied in many contexts".

4. We totally agree with the referee's comment as the permeability measurement is not compared with any computing permeability from image processes. Consequently to avoid any misunderstanding, we removed the term permeability in the introduction from

the list of compared parameters. Nevertheless, although it was not compared to other results obtained by images, we leave the information about the permeability in order to notify the reader that the dissolution process heavily modifies the hydrodynamic properties during the wormhole formation. Contrary to what the referee writes, Peclet and Damkhoeler numbers are not sufficient to predict the dissolution features.

5. A. BET and S/V measurements are mentioned and briefly discussed in the Comparison and discussion section pp. 21. As BET measurement is a classic measurement, we did not explain it in the methodology, nevertheless, we explained how to compute the S/V ratio in the methodology section pp. 12. B. The tortuosity coefficient is mentioned several times throughout the paper and discussed in the Results section, in particular in §3.1.3. Yet we agree that tortuosity was not directly mentioned in the Comparison and discussion part. In both experimental and numerical cases, tortuosity is calculated from the diffusion coefficient, which was discussed in details pp. 23. Nevertheless, we added a new sentence in the aforementioned part in order to emphasize the tortuosity change. "Consequently, the tortuosity coefficient decreased after the dissolution experiment and both values for Bvl_be and Bvl_af are similar for laboratory measurements and image based computations. C. Skeleton extraction is an important step that enables to obtain a localization of the most significant pores, as shown on Figure 5 and mentioned pp. 23. Moreover, as mentioned by the referee, the skeleton is a great tool to simplify the 3D structure of the pore space into a 1D, which allows generating numerical models on complex systems, but this is far beyond the scope of this study.

6. We agree to change the title of Section 2.1.1 as suggested. As well understood by the referee, the porosity values cited in Section 2.1.1 come from general information provided by quarry mining companies. In order to make this precise, we added the following in pp. 5: "according to general information provided by quarry mining companies". No information is provided concerning the techniques used to obtain these values.

7. We agree with all the referee's suggestions in Section 2.2 Materials and methods. We added a Table stating all the analyzed properties, the methods and algorithms used (lab and/or XMT) to analyze them, and the characterized phases (new table 1). Then, in order to detail all the methods to measure the pore size distribution in that same section, we merged the pore size distribution section with the geometric parameters.

8. We agree with the referee's suggestion and changed the names of the subsections in the Results section as proposed.

9. As proposed by the referee, we mentioned that Equation 1 is the Young-Laplace equation with cylindrical approximation. No Hg porosimetry has been performed.

10. The effective porosity is the component of the porous phase connected to at least one face of the sample. Some connected components of the porous space (clusters) are not part of the effective porosity as they are not connected to at least one face of the sample. In order to avoid any confusion, we changed the subsection title "Connected porosity" into "Connected components of the pore space".

11. We agree with the comment and moved the calcite dissolution equation (R1) to Section 2.1.3.

12. We made clear that 4 measurements were performed on the same sample (pp. 6).

13. We removed any subjective terms, as all values are precisely quantified in Table 1.

14. As the aim of the paper is not to discuss pore clogging mechanism, we decided to simply remove the sentence mentioned by the referee.

15. In Table 2, we replaced the number of voxels in the resolved porous phase by its relative fraction. As the results of the 5 segmentations allowed us to validate our choice of parameters, we decided to skip this step for the subresolved porous phase, as it would have led to perform a total of 25 segmentations.

16. We think that the referee stressed an interesting point of the comparison between

SED

7, C1792–C1796, 2016

laboratory and imaging setups in terms of accessibility. It is true that it may not be easy to get synchrotron time, yet more and more institutions and industries have invested in microtomography hardware, making this technology more affordable. Moreover, concerning access to laboratory equipment, one should note that only a few institutions have access the entirety of the setups used in this study. We then concluded that the comparison was fair and decided not to discuss accessibility matters.

17. Concerning the paragraph discussing diffusion coefficients, we switched the two sentences in order to first present the results before mentioning the evolution of the parameters. We agree that the subresolved porosity can affect the diffusion coefficient but only if this phase is connected.

A new marked version of the manuscript is uploaded as supplementary file.

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/7/C1792/2016/sed-7-C1792-2016-supplement.pdf

---

Interactive comment on Solid Earth Discuss., 7, 3293, 2015.