


<p><b>instituto madrileño de estudios avanzados</b></p> <p>C/ Eric Kandel, 2 – 28906, Getafe – Madrid - Spain</p> <p>Telephone: +34 91 549 34 22; fax +34 91 550 30 47</p>		<p><b>Nº REPORT: 1/1</b></p> <p><b>ISSUE / DATE: 19-MAY 2014</b></p>
<p><b>Title:</b></p>		
<p style="text-align: center;">Study of the microstructure of samples "Utrillas-65.45m" pre(M1) and post(M2) injection by XCT.</p>		
<p><b>Summary:</b></p>		
<p>Two samples were measured by XCT (pre- and post- CO<sub>2</sub> injection). The samples investigated were "Utrillas-62.45m". The acquired volumes have been delivered to CIEMAT for their evaluation. The different phases are visible in XCT experiments and the differences from the two states are going to be evaluated by CIEMAT.</p>		
<p><b>Keywords:</b></p>		
<p> </p>		
<p><b>Written by:</b></p>	<p><b>Approved by:</b></p>	<p><b>Concurred by:</b></p>
<p>AUTHOR Federico Sket</p>	<p>SUPERVISOR</p>	<p>MANAGER</p>

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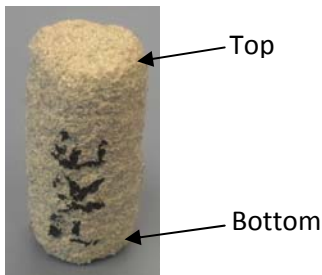
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## 1 Introduction

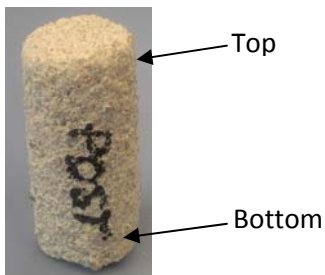
This report summarizes the results of X-ray computed tomography for microstructure characterization. The samples were measured in the as-received state, i.e. no sample preparation was necessary.

The samples were named as follows:

- 1) M1\_PRE\_CO2\_62-45: The indications on the sample show the sample type. Top and bottom indicates the measurement position.



- 2) M2\_POST\_CO2\_62-45: The indications on the sample show the sample type. Top and bottom indicates the measurement position.



The files delivered to CIEMAT together with this report are:

- 1) This report: "Report\_Tomography\_Utrillas-62.45m\_v01.pdf"
- 2) Two tomographic volumes:
  - "M1\_PRE-CO2\_62-45\_vol1912x1872x1794\_BH9.1\_8b.raw"
  - "M2\_POST-CO2\_62-45\_vol1980x1940x1800\_BH9.0\_8b.raw"
- 3) Samples were returned to CIEMAT

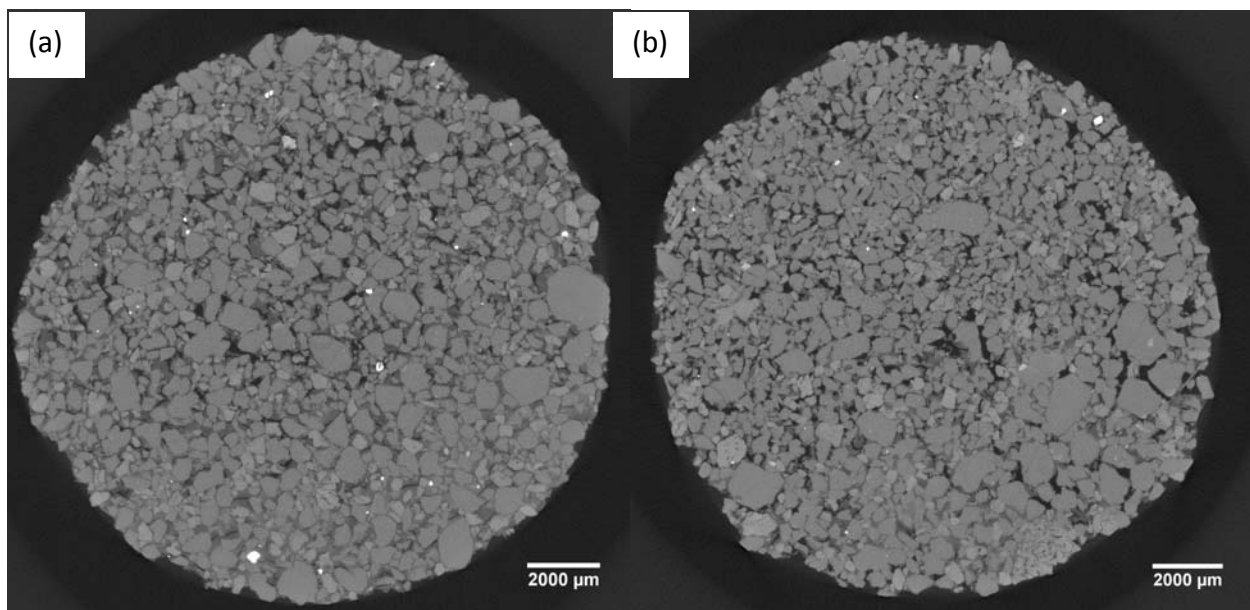
Obs: The raw data of both measurements were not required by CIEMAT. However, they will be stored at IMDEA for two month before deletion.

## 2 Results

### 2.1 X-Ray Computed Tomography measurements

Tomographic inspection was performed on samples M1\_PRE\_CO2\_62-45 and M2\_POST\_CO2\_62-45. The tomograms were acquired at 100 kV and 90  $\mu$ Amp without any filter. The exposure time was set to 500 msec. In total, 1800 radiographies were acquired for each tomogram. The pixel size was set to 8.95  $\mu$ m.

The reconstructed volumes can be visualized using different softwares, like ImageJ (freeware software) or VGStudio max (commercial software). The full dataset for each sample are provided in raw data files. For instance, Figure 1 shows a cross section of both specimens M1\_PRE\_CO2\_62-45 and M2\_POST\_CO2\_62-45.



**Figure 1.** (a) Cross section M1\_PRE\_CO2\_62-45. (b) Cross section M2\_POST\_CO2\_62-45.

The raw data files can be opened using the ImageJ freeware software. All the information required to generate the reconstructed volumes is included in the filename. For example, the name of the file that corresponds to sample SD-1\_Utrillas\_M1 is:

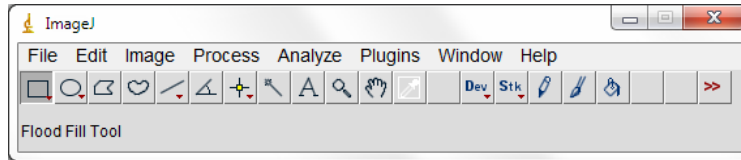
M1\_PRE-CO2\_62-45\_vol1912x1872x1794\_BH9.1\_8b.raw

Where:

- The numbers “1912x1872x1794” indicate the dimensions in “x”, “y” and “z” respectively.
- The volumes were saved in an 8bit format

- The last slice of the volume (1794 for M1 and 1800 for M2) is close to the bottom part of the sample that was named as “bottom”.

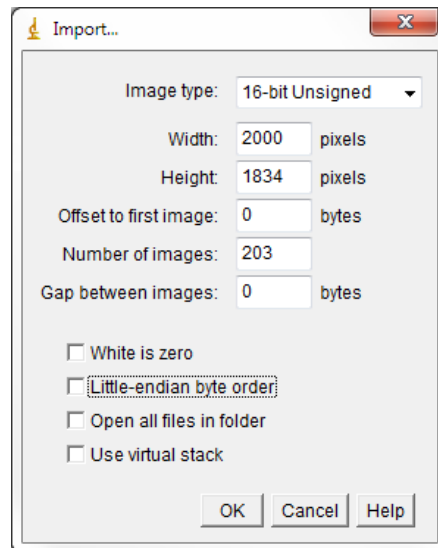
Figure 2 shows a screenshot of the ImageJ software:



**Figure 2.** Screenshot of the ImageJ software.

Please note that due to the large size of the files (approximately 5.6 GB each file), you probably need to check the memory & threads variable of ImageJ under Edit\options. Please refer to the ImageJ webpage (<http://rsbweb.nih.gov/ij/>) for more information.

In order to open the file, go to file, import, raw...The following window will pop up and, for the example, the parameters to be filled are:



**Figure 3.** Screenshot of the ImageJ software

### 3 Conclusions

- The microstructure of both samples could be revealed by X-ray tomography. The quantitative analysis and the usefulness of this measurements will be determined by CIEMAT.
- Higher resolution (up to approximately 2  $\mu\text{m}$ ) can be achieved, however in smaller sample volumes (diameter of 4mm maximum). These measurements could provide a better insight of the smaller features in the specimens. In this case it is important to evaluate if such small volume is representative enough.