Evaluation of acquisition parameters in microtomography through of analysis of carbonatic rocks

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Abstract: X-ray computed microtomography is a powerful nondestructive technique for 2D and 3D structure analysis. However, parameters used in acquisition promote directs influence in qualitative and quantitative results in characterization of samples, due image resolution. The aim of this study is value the influence of theses parameters in results through of tests changing these parameters in different situations and scanner characterization. Results demonstrate that pixel size and detector matrix are the main parameters that influence in resolution and the necessity use additional filters for image quality. Microtomography was considered an excellent technique for characterization using the best image resolution possible.

Keywords: X ray computed microtomography, carbonatics rocks, Indiana limestone.

1. INTRODUCTION

Carbonatic rocks are sedimentary rocks widely studied due the importance in petroleum extraction after pre-salt discovery. This type of rock represent half of the petroleum extraction in Brazil [1].

X-ray Computed microtomography (MicroCT) is a important non-destructive technique for analysis of inner structures with high resolution in the order of micrometer. This technique has been used to characterize carbonatic rocks in relation to porosity and porous size distribution in this work [2].

However, the choice of acquisition parameters are essential to get the best resolution and image quality, ensuring the most accurate results [3].

The aim of this study is evaluate the influence of these acquisition parameters in image quality and through of gotten results.

2. MATERIALS AND METHODS

2.1. MicroCT

The scanner used was SKYSCAN/BRUKER High Energy model 1173, installed in nuclear instrumentation laboratory (UFRJ). A scan on center of the specimen was acquired changing the acquisition parameters like pixel size, detector matrix, additional filters and frames number (case 01 – case 07). Finally, the whole specimen was scanned to compare the same information(case I). These cases can be visualized in table 1.

The reference case was using detector matrix 2240 x 2240 pixels, pixel size of 18.16 µm, 130 kV and 61 µA of voltage and current, additional filter of Copper of 0.5 mm, 5 frames and rotation of 360°, represented in table 1 like case 01. These parameters was chosen according many references of works in this area [3].

After the acquisition, the projections were reconstructed in the software NRecon with the best corrections parameters. The next step was segmentation that was realized in Avizo Fire 9.01 with the method of watershed [4].

After that was possible, calculate porosity and get a distribution of porous size in Avizo Fire 9.01. Porosity can be represented by equation 1.

$$Porosity = \frac{Pore's\,Volume}{Total\,Volume} \qquad (1)$$

3. RESULTS AND DISCUSSION

3.1. Characterization of Scanner

In order to characterize the scanner in relation the influence of detector matrix, pixel size and spatial resolution, it was realized a test of modular transfer function (MTF), where is possible calculate the resolution by the equation 2.

$$Resoltion = \frac{1}{2x(MTF_{20\%})} \qquad (2)$$

With the results, it was possible generate a graphic of resolution vs pixel size and detector matrix and a graphic of resolution vs magnification and detector matrix, figure 1 and 2. Observe that for different detector matrix the same magnification is gotten with different pixel size, for instance, when you use detector matrix of 2240 x 2240 pixels you use a pixel size two times less than when you use detector matrix of 1120 x 1120 pixels.

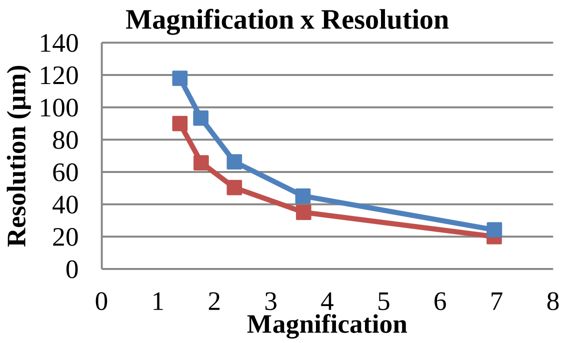


Figure 1 – Graphic of Resolution vs Magnification for detector 1120² pixel in blue and 2240² pixel in red.

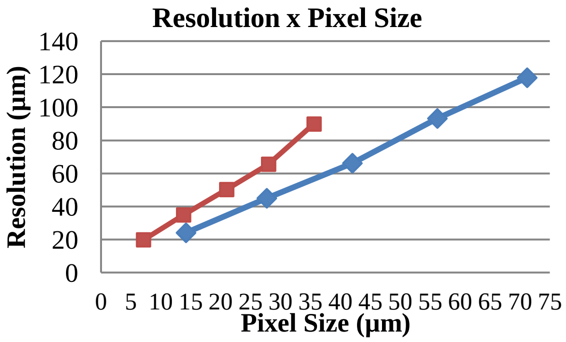


Figure 2 –Graphic of Resolution vs pixel size for detector matrix 1120² pixel in blue and 2240² pixel in red.

3.2. Porosity and porous' size distribution

The porosity gotten in each case is also represented in table 1. It is possible to observe through of the results a strong influence of pixel size (case 3) and detector matrix (case 2) in resolution compared to reference case (case 1).

Also was possible get the pore's size distribution and, to observe that in case 2 the resolution is about 60 µm and pores smaller than 60 µm is not detected. Even as in case 3 that the resolution is about 70 µm, like in figure 3.

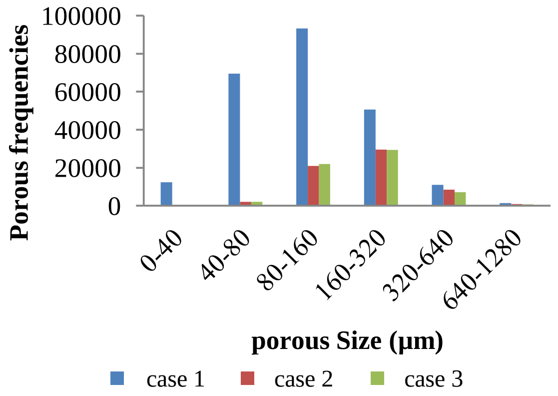


Figure 3- Graphic comparative of Porous frequencies VS porous size of cases 1, 2 and 3.

The comparison between case 1 and case 5, 6 and 7, where parameter additional filter was modified, showed the importance of use additional filters in acquisition. It is believe that aluminum filter is responsible by filter photons of low energy, that increase beam hardening

Table 1- Parameters used in each case, results of porosity and time acquisition.

Case	Detector matrix	Voltage and current	Pixel size	Frames	Add Filter	Rotation	Acquisition duration	Porosity (%)
1	2240 x2240	130kV e 61µA	18.16 µm	5	Cu 0.5 mm	360°	1:38:26	6.99
2	1120 x 1120	130kV e 61µA	36.32 µm	5	Cu 0.5 mm	360°	0:31:59	2.97
3	2240 x 2240	130kV e 61µA	29.91 µm	5	Cu 0.5 mm	360°	1:38:28	2.20
4	2240 x 2240	130kV e 61µA	18.16 µm	15	Cu 0.5 mm	360°	4:18:07	5.83
5	2240 x 2240	130kV e 61µA	18.16 µm	5	Without Filter	360°	1:19:09	4.16
6	2240 x 2240	130kV e 61µA	18.16 µm	5	Al 1.0 mm	360°	1:19:23	3.62
7	2240 x 2240	130kV e 61µA	18.16 µm	5	Cu 0.5 mm + Al 1.0	360°	1:07:35	7.60
I	2240 x 2240	130kV e 61µA	18.16 µm	5	Cu 0.5 mm	360°	8:07:35	6.29

effects. However, the average energy necessary to pass through of sample is larger, being required use of copper filter in these acquisitions.

On figure 6, it can observe that case 1 and 7 have porous size distribution very similar, even as case 5 and 6, but on figure of the slices it is possible to observe more details with the use of copper filter.

It was realized a test to evaluate the sign-noise relation (equation 3) for different frames number, where N is photon's number and σ is standard deviation or noise. Through of the results was possible to generate a graphic of SNR vs frames number, figure 4, and evaluate the best or approximated frames number ideal for the best image quality.

$$SNR = \frac{N}{\sigma} = \frac{N}{\sqrt{N}} = \sqrt{N} \quad (3)$$

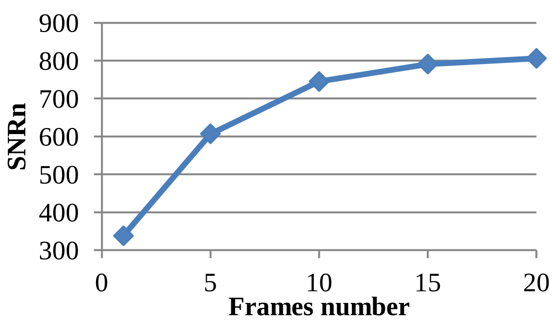
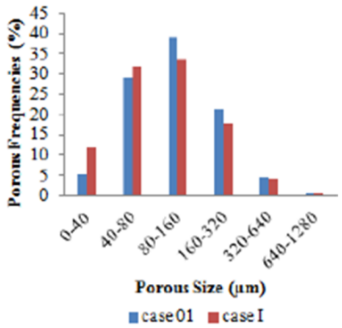


Figure 4 - Graphic of SNR vs frames number

It is possible to observe in graphic on figure 5 that the curve begin to have a constant behavior from 15 frames. However, comparing the acquisition time of the case 1 and 4, when the frames number is 15, it is observed that the acquisition time in case 4 is three times great than case 1. It is necessary to balance the gain and the time acquisition to choice this parameter.

To evaluate the representativeness of one scan compared with the whole sample, it was scanned with the same parameters of case 01, reference parameters, and it was possible to generate a graphic comparative of porous frequencies (%) vs porous size. Besides that, the porosity was calculated in 5 parts of the sample to observe the porosity during the sample, figure 5.



Porosity (%)	
Part 1	7.28
Part 2	6.95
Part 3	6.95
Part 4	5.24
Part 5	4.99

Figure 5 – Graphic of Porous frequencies VS porous size on the left and the porosity in parts during the whole sample (case I).

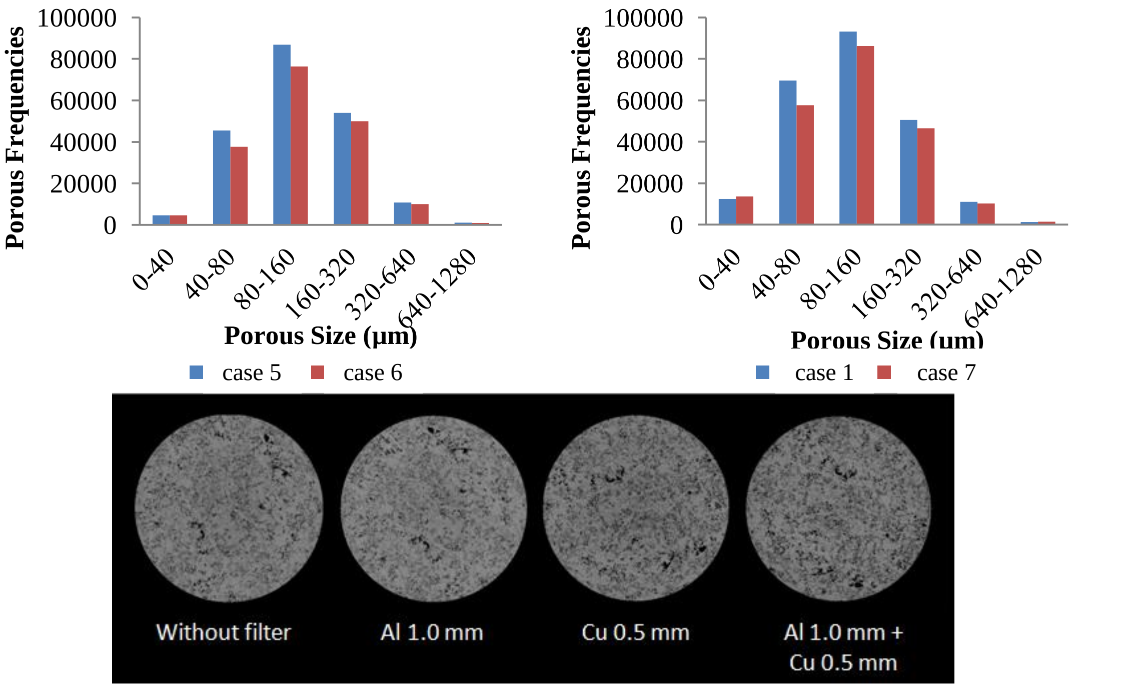


Figure 6 – Graphics comparatives of Porous frequencies VS porous size of cases 6 and 7 on the left, and cases 1 and 9 on the right. The figure below represent the same slice in different situations changing the additional filter.

4. CONCLUSION

It is possible to conclude that all parameters influence in image quality with different intensity and it is necessary to optimize these parameters correctly to get the best image quality on the best acquisition time.

Detector matrix and pixel size were the main influencing parameters in relation to spatial resolution, and for this scanner and this type of sample the best matrix detector is 2240^2 pixels and the best pixel size is the smallest offered for scanner. However also is necessary to balance the pixel size with the time and the gain gotten with this improvement.

Additional filter in this study was obligatory, and the use of copper filter is essential for improvement of contrast and image quality. Then, the use of copper filter or the combination of copper and aluminum filter were acceptable for this work.

Comparing case 1 with case I, it is difficult to say about the representativeness of an scan because the specimen present variation of porosity during the length. However, the mean porosity present a value very similar what was found with a scan on center.

5. REFERENCES

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