Porosity Characterisation of Reservoir Rocks from Brazilian Pre-salt through SEM and Image Analysis

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The carbonate reservoir rocks of Brazilian pre-salt are characterized by the dominance of stromatolitic limestones, grainstones and microbial laminites with simple mineralogy and a huge heterogeneity of pore systems. This systems can be extremely complex, depending on the desposition textures of the rocks, whitch is later modified by diagnetic process. The quantitative and morphological knowledge of this different types of porosity is impactful much research that involves appropriate evaluation of the petrophysical properties and pores formation processes.

The goal of the present study is to extract petrophysical parameters as total porosity percent, size distribution and geometry information through 2D images of carbonate rocks acquired by SEM. Therefore, a group of polished thin sections of carbonate rocks from a pre-salt reservoir, with average size of 20 mm X 29 mm (area to be analyzed), was selected. The automated acquisition of 170 backscattered electron images of each sample was carried out covering the thin section area, which were combined to create a large mosaic image (20000 X 29000 pixels) that represents the entire sample. To execute the stitching, the images were acquired with 10% of overlap. Image analysis was performed using Fiji/ImageJ software and the automated routine proposed in this study is divided into three steps. The first was the filtering using Non-Local Means Denoising algorithm [sigma 5, smoothing factor 1] to obtain a better definition of small pores, where noise has been substantially reduced. Pores were segmented by thresholding. As sensitivity analysis showed the necessity of two thresholds to an appropriated segmentation of large and small pores, the process was executed two times to obtain a final image integrating the two groups of pores (Figure 1). The last step of the image analysis was the measurement of area and shape description parameters (circularity, aspect ratio, roundness, solidity) of both groups of pores.

The results show that the proposed methodology can be an additional tool for 2D porosity characterization, contributing to elucidate the high heterogeneity of pore geometries in carbonate rocks. This technique features the following advantages: it is a nondestructive way to extract more information from the same sample used for optical petrography, with higher resolution; it allows the integration of petrophysical and lithological data, that can add valuable information to reservoir knowledge; after establishing the parameters as resolution and thresholds, image acquisition and analysis were executed automatically, providing the possibility of analyzing samples in batches; the methodology is efficient to resolve different sizes of pores in the same sample; finally, the proposed methodology can be integrated into the routine of mineralogical analyzes carried out on thin sections of reservoir rocks, giving fast estimative of petrophysical parameters.

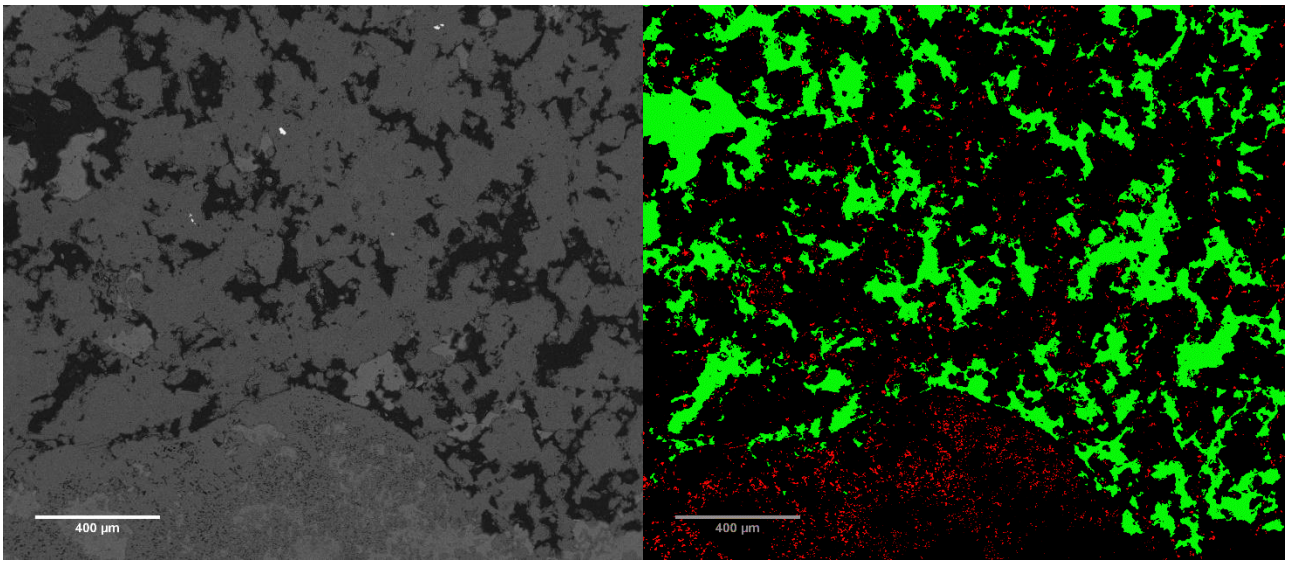

Fig 1: (a) Part of a SEM image of a carbonate rock showing two different groups of pores; (b) Resulting image after the segmentation using two thresholds, showing large pores (green) and small pores (red).