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Comparison of pore space features by thin sections and X-ray microtomography

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HIGHLIGHTS

- μCT can identify connected and non-connected pores, a feature TS does not possess.
- Quantification of porosity by μCT gives porosity distribution in the whole sample.
- μCT and TS when paired together are able to complement one another.

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ABSTRACT

Microtomographic (μCT) and thin section (TS) images were analyzed and compared regarding porosity and its distribution along the samples. The results show that μCT, although limited by its resolution, shows relevant information about the distribution of porosity and quantification of connected and non-connected pores. TS have no limitations concerning resolution, but are limited by the experimental data and can only give information about connected pores. These two methods have their own advantages but when paired together they are able to make for a more complete analysis.

1. Introduction

In the field of geosciences, there is a large interest in analysis of the pore space and its characteristics, such as void space and pore dimension. Porosity is usually referred to as the amount of void space on which fossil fuels, such as petroleum, gas and water, might be found. Some traditional techniques are often applied for evaluation and quantification, such as, thin sections or mercury intrusion porosimetry (Elliot and Heck, 2007; Armitage et al., 2010; Desbois et al., 2011). Although commonly used, these procedures are destructive and prevent future investigation, not allowing further comparisons in such objects because they have already been chemically or physically changed. Moreover, they also require intensive and tiresome study since these procedures are not automated and might be limited by the operator, especially in the case of point counting, which is a means of describing rocks and their void space in a quantitative way by thin sections.

Thin sections (TS) for microscopic material investigation in transmitted and reflected light remain one of the most classic mineralogical methods of analysis in petrophysical research. Thin sections provide an approach to identifying substances with relatively high spatial resolution. It allows an estimate of chemical compositions and provides clues for understanding the history of the rock formation (Terry and Moxon, 2009).

X-ray microtomography (μCT) is a technique already established for industrial use and its applications reach several different areas, like biology, orthodontics (De-Deus et al., 2014) and geology. It has been expanded to investigate pore network of potential reservoir rocks and sedimentary rocks (Van Geet et al., 2000, 2003), where differences in attenuation of the radiation from the effects of density and effective atomic number allow characterization of the rock and pores (Alves et al., 2014). Although μCT still has some issues concerning the spatial and density resolutions, which are not present with thin sections and mercury porosimetry techniques, which results in the appearance of artifacts and noise

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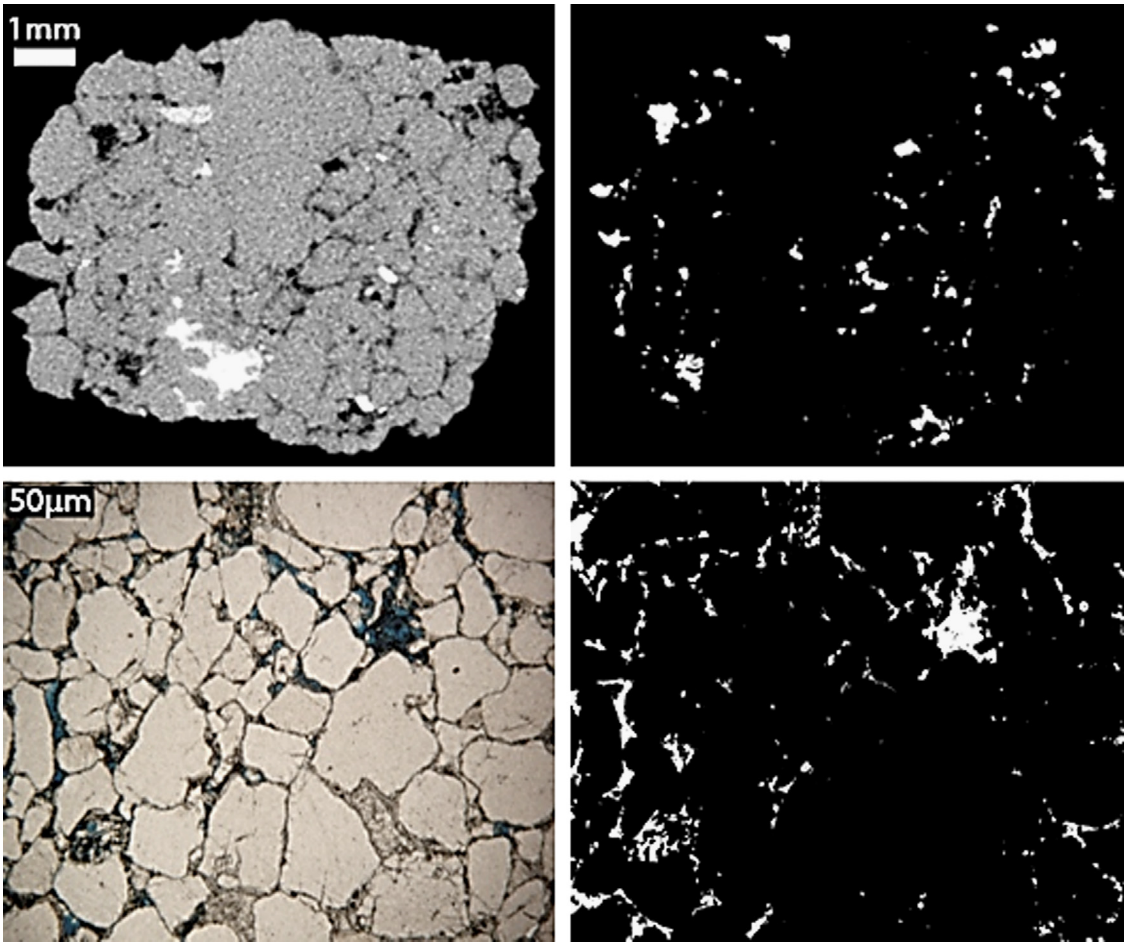

Fig. 1. Images of μCT and thin sections, respectively, against its segmented image.

in the final image (Remeysen and Swennen, 2008), it is a reliable laboratory examination that has been frequently used in the petroleum and gas field. μCT does not need intervention of the operator and the image evaluation can be performed automatically by several image processing algorithms of reconstruction and segmentation, which diminishes the work and for the influence of the operator, therefore increasing comparison among samples, and reliability and reproducibility of the technique.

The objective of this study was to provide a comparison study between thin sections and μCT results of the void space of sediments by quantifying porosity, pore size and its distribution along the samples. The results show that μCT has several advantages over traditional methods and might become a standard method for geological analysis in the future. Even so, μCT shows the best efficiency when compared with others techniques.

2. Methodology

In this study, three groups of sediment samples were used and they were named as 2MC1SC, 7AR155BA and VF4SE. Those acronyms refer to the location of origin, specifically Brazilian basins, where the samples were taken. In total 12 sub-samples (1 cm³ of volume for each sub-sample) were extracted from the original samples as follow: 4 samples from 2MC1SC group, 4 samples from 7AR155BA group and 4 samples from VF4SE group. All of them were scanned and then four thin sections of each original sample were made and analyzed.

Table 1
Porosity values by μCT and TS.

Samples	μCT					TS
2mc1sc	2D		2Dm		3D	2D
	Porosity (%)	σ	Porosity (%)	σ	Porosity (%)	Porosity (%)
1	2.07	0.35	2.26	0.37	2.08	22.37
2	1.25	0.16	1.38	0.18	1.27	11.41
3	1.95	0.34	2.13	0.35	1.93	21.11
4	1.92	0.26	2.08	0.27	1.90	15.99
7ar155ba						
1	4.66	0.97	4.82	0.99	4.75	6.84
2	5.63	1.06	5.79	1.07	5.68	8.67
3	5.72	0.97	5.90	0.99	5.80	9.50
4	5.08	1.00	5.24	1.03	5.20	7.16
vf4se						
1	1.36	0.39	1.50	0.43	1.37	2.20
2	1.83	0.27	1.97	0.30	1.86	2.85
3	0.95	0.37	1.05	0.40	0.95	2.09
4	1.60	0.63	1.76	0.67	1.62	2.33

μCT of all samples were performed with a Skyscan/Bruker® apparatus, model 1173, which is a high-energy system equipment that operates up to 130 kV of energy and a minimum resolution of 5 μm. The detector is a flat panel type with a pixel size of 50 μm. The acquisitions were carried out with a pixel size of 9.91 μm, 90 kV of energy and 88 μA of current.