TOMODENSITOMETRY APPLIED TO CHARACTERIZE ROCK PROPERTIES OF A CONVENTIONAL HETEROGENOUS CARBONATE RESERVOIR IN EASTERN CANADA

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Keywords: core analysis, carbonate, medical CT-scan, porosity matrix

Summary: This project is part of a new Industry-Academy research partnership assessing the reservoir potential of a lower silurian carbonate formation within a prospective play, the Massé structure. Tomodensitometry was applied to characterize the distribution of internal structures and calculate porosity.

1. INTRODUCTION

Little is known about this specific sector of the St. Lawrence River area but Oil and gas operators have drilled over 6000 meters of wells in the past ten years building an unprecedented subsurface dataset. Several wells revealed oil or gas shows associated with naturally fractured zones notably within the carbonate Sayabec Formation (Fm). Carbonate reservoirs are genetically complex and spatially heterogeneous due to their bioclastic content, the presence of fractures and their complex diagenetic history responsible either for creation or occlusion of porosity. Tomodensitometry has been commonly applied to core analyses within the Oil and Gas sector in order to analyse permeability, fractures patterns, or assess fluid flow in porous rocks [1-3]. However the methodology is mainly applied to clastic reservoir rocks or relatively homogenous carbonate reservoir [4, 5]. In the Massé structure area, the Sayabec Fm is 300 meters thick in average. The upper part of the Sayabec Fm displays a wide range of carbonate facies, from well sorted peloidal packstone to poorly sorted packstone with crinoids, bioturbated mudstone and locally bryozoans and/or stromatopores boundstones. These carbonate facies are interbedded with plurimetric layers of siltstones. Industry partner needs a rapid and efficient tool to optimize their drilled wells in order to locate the most porous and permeable intervals and help planning future drilling.

2. METHODHOLOGY

CT measurements were performed using a Siemens SOMATOM Definition AS+ 128 at INRS-ETE. Images were recorded in DICOM and visualization was made Fiji. For this project, we had access to a continuous 40m thick interval from the Sayabec Fm. In addition, five isolated samples were made available for scanning in a dry state and then flooded with water. For comparison, independent porosity measurements performed using a gas porosimeter were available. Coreflooding was conducted at room temperature using an in-house coreflooding system. The method involves scanning of the core samples under vacuum and then at different times when it is progressively saturated with water. An image substraction of final and initial stage (saturated and dry) was performed using Matlab software allowing a visualization of macropores network and calculation of porosity.

3. MAINS RESULTS

X-ray tomography images showed a good contrast between pores, grains/matrix and dense mineral phases

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(Fig.1A-B). This allowed us to generate 3D images of the macropores network documenting their geometry, connectivity and distribution (Fig.1C). The method delivers qualitative data about the spatial distribution of porosity within a sample. These informations cannot be obtained with conventional gas porosimeter analyses. In addition, the mathematical comparison of the two density matrices (saturated and dry) documents the ease to saturate one sample. In few cases, saturation is documented whereas macropores are not macroscopically connected. This revealed the role played by microporosity. By segmenting the macropores, the method gives also the minimal porosity value of the specimen (Fig.1C).

4. CONCLUSION

Tomodensitometry is a very valuable tool for quantitative characterization of heterogeneous carbonate reservoir facies in 3D. It provides a large set of 3D data regarding the porosity such as macropores dimensions and geometry, or macropores distribution. With a simple coreflooding system, the comparison between a dry and saturated states can revealed the role played by microporosity. Future works intend to optimize the coreflooding system to perform multiple core sections simultaneously. Another important step forward is the calibration of the method using standard rock samples commonly used in the Oil and Gas sector, such as the Indiana Limestone or the Berea Sandstone.

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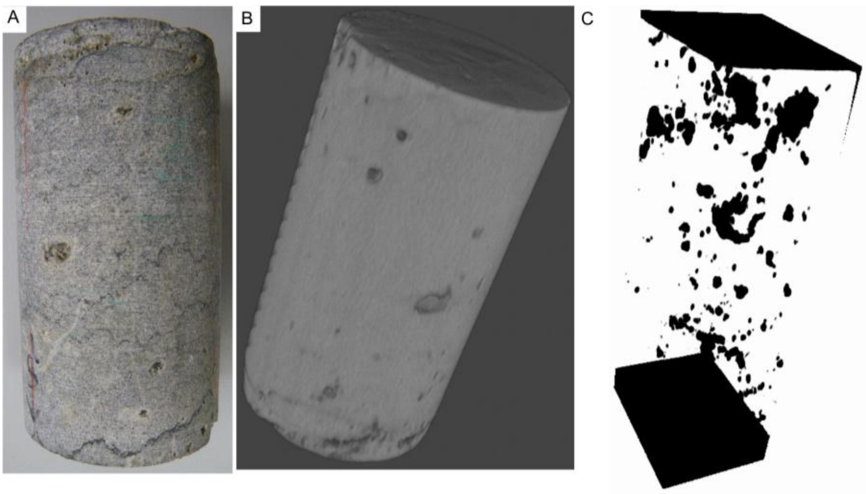

Figure 1: (A) Photograph of the core sample 3-145, a fine-grained, well sorted limestone. Open pores (moldic porosity) and thin pseudo-horizontal stylolithes (underlined by opaque minerals) are visible at the surface. (B) 3D CT image of the sample. (C) 3D MinIP projection. The porosity calculation performed on density matrices gave a value of 1.75% of the total sample volume. In comparison, helium gas porosimeter gave a value of 1.3% for the same sample which would correspond to a porosity underestimation of approximately 35%.