E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 03 No 02 2018

Estimation Microporosity Value of Fontanebleau Sandstone Using Digital Rock Physics Approach

Reza Rizki[1,*], Handoyo[1]
[1] Geophysical Engineering, Institut Teknologi Sumatera, South Lampung, Indonesia.

* Corresponding author : rezarizki07@yahoo.com
Tel.: +6285220243152
Received: 27 Apr, 2018. Revised : 24 May, 2018, Accepted: 30 May, 2018, Published: 1 June 2018
DOI 10.24273/jgeet.2018.3.2.1544

Abstract

The technology of digital rock physics (DRP) allowed to predict the physical properties in core data sample, for example to predict value of porosity of data sample. This research applied the digital rock physics technique to predict the microporosity in sandstone sample: Fontainebleau Sandstone. The data are digital images from Fontainebleau Sandstone with high resolution scanned from micro tomography CT-Scan processing. The result of image processing shown in 2D and 3D image. From the data, the value of microporosity Fontainebleau Sandstone are between 6% - 7%. This result confirmed by the quartz cemented sample of Fontainebleau Sandstone. The scale and sub-cube give the different value of microporosity which is indicated the scale influence to value of porosity value. So the simplest and best way is to average the all result from sub-cubes.

Keywords: Digital Rock Physics, Image Sample, Microporosity

1. Introduction

The application of digital rock physics (DRP) has been widely used in some examples of sandstone sample data analysis. Applications are performed to predict the physical parameters of rocks such as porosity, permeability, and elastic properties of rocks (Handoyo et al. 2014; Arns et al. 2004; Wiegman et al., 2012). Digital image (3D image) rock can be obtained by scanning using the CT-Scan and combined with digital simulation software. In addition, the digital image has been applied to visualize of rocks and predict physical parameters.

Many research have done in Fontainebleau sandstone data sample using digital rock physics approach. For example by Saxena et al., 2017 and Fourier et al., 2014. This paper discusses the digital simulation to visualize complex pore and predict value of microporosity from Fontainebleau sandstone (Fb).

2. Data and Method

2.1 Data

The study of sandstone sample: Fontainebleau sandstone (Fb) are well analyzed with laboratory measurements from Han, 1986; Gomez, 2009; and Saxena et al., 2017. The value of porosity varying <10% in cemented sample and >20% in clean sample. Fontainebleau sandstone is well-sorted consist of almost quartz and small fragment of feldspar. The resume of Fontainebleau sandstone illustrated in Table 1 and Fig. 1.

2.2 Method

A rock sample (sandstone) generally consists of two main parts: pores and rock solid matrix (Fig. 2). Quantity of rock pore is expressed by the value of porosity. Porosity (ϕ) is the ratio between the pore volume (V_{pore}) of the total volume of rock (V_{total}) which is mathematically written as the bounds as (Mavko et al., 2009):

$$\phi = \frac{V_{pore}}{V_{total}} = 1 - \frac{V_{matriks}}{V_{total}} \quad (1)$$

The process of DRP (Digital Rock Physics) begins with an image of a large Fb sample at a relatively high resolution to cover a large field of view (cube). At this stage, rock fabrics larger than the image resolution are resolved while smaller ones are unresolved (sub-cube). Information concerning the unresolved rock fabrics is analyzed from additional images acquired at a finer resolution and smaller area of view. The porosity calculated from grayscale image of Fb data sample. In general, the stage of the DRP analysis shown in Fig. 3.

Table 1. Data of porosity and mineral description Fontainebleau sandstone (Gomez, 2009)

Data Sample	Porosity	Mineral Description
Clean Fontainebleau	> 20 %	Quartz with minimal rock fragments and feldspar presents
Cemented Fontainebleau	< 10 %	

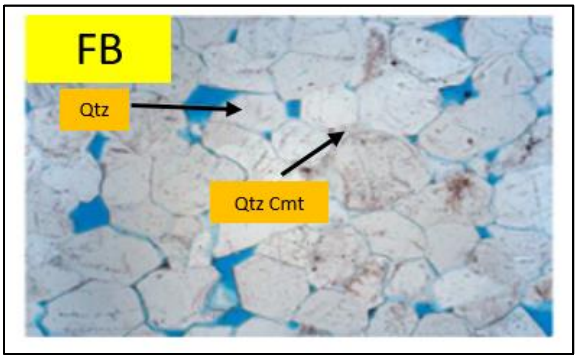

Fig. 1. Mineral description from thin slice SEM from Fontainebleau Sandstone (Saxena et al., 2017)

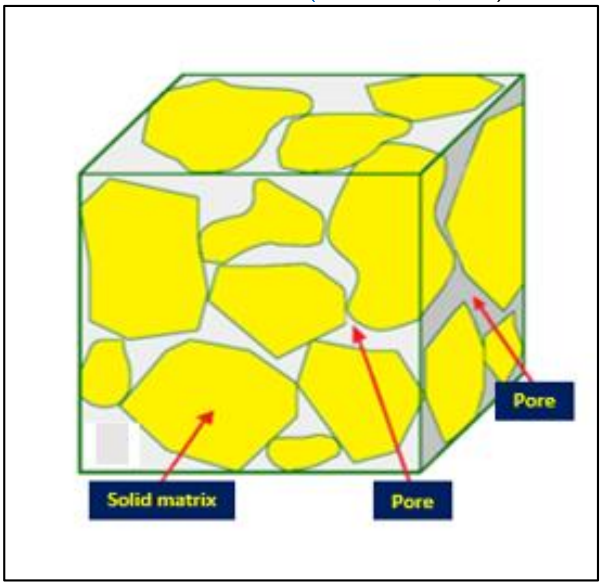

Fig. 2. A Visualization is shown by the pore spaces between rock-solid matrix (modified from Mavko and Nur, 2009)

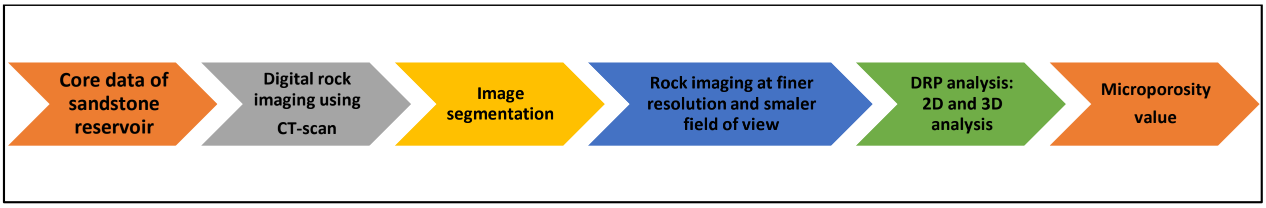

Fig. 3. DRP data processing stages on sandstone sample. Stage begins with digital image processing to the calculation of microporosity

3. Result and Discussion

3.1 Result

The result of image processing of Fontainebleau sandstone shown in Fig. 4, which shown the natural scale of 2D image data with dimension 800 × 800 pixels, (b) the region of interest with dimension 400 × 400 pixels, and (c) the 3D model of Fb sample with dimension 800 × 800 × 400 pixels. The result of 2D image already visualized the pore and solid matrix (Fig. 4a). The geometry of pore generally well visualized as an angular type.

To calculate the value of porosity. The image must separate in pore and grain image purely. This way to make sure the image only consists of pore and solid grain matrix of sample data. The image is shown in Fig. 5. The white color is representing of solid matrix and the black color is representing of pore image. Also visualized the noise in image result.

Next step, the result of microporosity value shown in Table 2. The main cube with dimension 800 × 800 × 400 pixels breaks down to small cube with dimension 400 × 400 × 400 pixels. This way to simplify of the process calculating in digital simulation. The value of microporosity from Fb sample approximately between 6% - 7%.

Table 2. The result of microporosity calculation in 8 cubes of Fontainebleau Sandstone

No of cube	Porosity
Fb 1	7.2 %
Fb 2	7.2 %
Fb 3	6.2 %
Fb 4	6.6 %
Fb 5	6.8 %
Fb 6	7.4 %
Fb 7	7.0 %
Fb 8	6.4 %

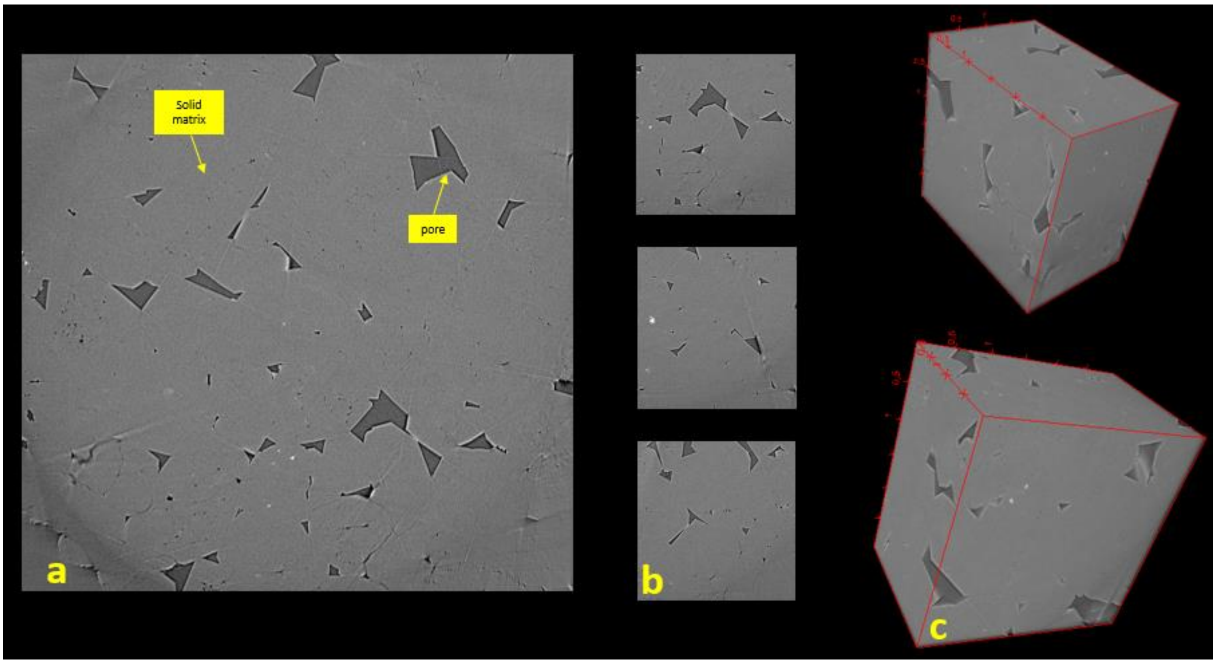

Fig. 4. The result of image processing in 2D and 3D natural image of Fb sample

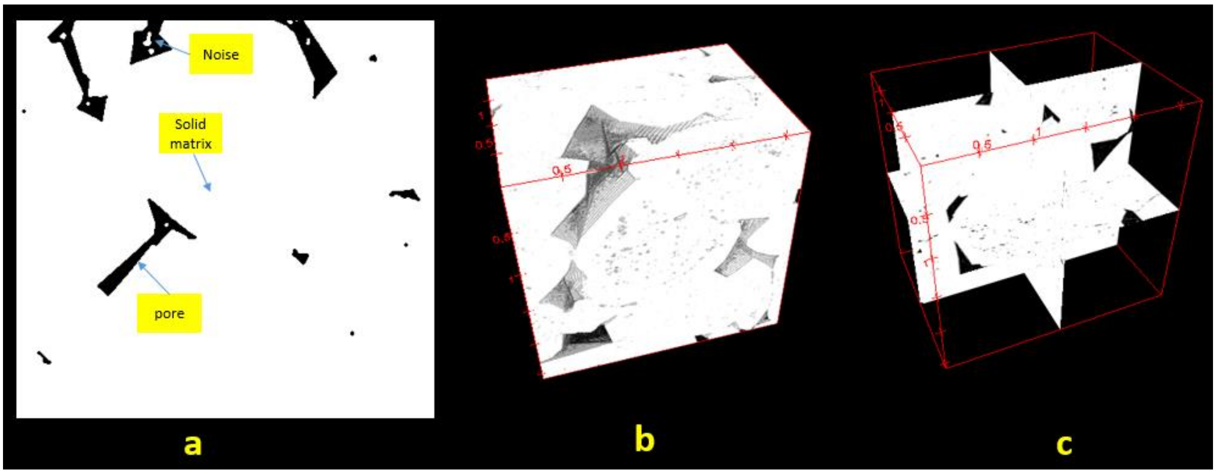

Fig. 5. The result of image processing in 2D and 3D grayscale image of Fb sample

3.2 Discussion

From the data, the value of microporosity Fb sandstone are between 6% - 7%. This result confirms by the quartz cemented sample of Fb sandstone. The resulting deal with the data from Gomez, 2009. The scale and sub-cube give the different value of microporosity which is indicated the scale influence to value of porosity value. So the simplest and best way is to average all result from sub-cubes.

4. Conclusions

Digital rock physics application successfully applied in Fontainebleau (Fb) sandstone sample. From the digital simulation to prediction elastic properties of Fontainebleau Sandstone sample, it indicates the value of porosity is generally homogenous in 6% - 7%. The result indicates the quartz cemented is influence to decreasing the value of porosity. Quartz cement present and identified in SEM visualization. The 3D scale of sub-cube also contributes to making the different of porosity value of data sample.

Acknowledgments

Thanks to Saxena et al., 2017 to open data in the publication entitled “Effect of image segmentation & voxel size on micro-CT computed effective transport & elastic properties”, USA. Thanks also for The Rock Physics Network ETH Zurich for the open source data of Fontainebleau sandstone images.

References

Andrä, H., Combaret, N., Dvorkin, J., Glatt, E., Han, J., Kabel, M., Keehm, Y., Krzikalla, F., 376 Lee, M., Madonna, C., Marsh, M., Mukerji, T., Saenger, E.H., Sain, R., Saxena, N., Ricker, 377 S., Wiegmann, A., Zhan, X., 2013a. Digital rock physics benchmarks—Part I: imaging and 378 segmentation. Comp. Geosci. 50, 25–32.

Arns, C.H., Knackstedt, M.A., Pinczewski, W.V., Garboczi, E. G., 2002. Computation of linear elastic properties from microtomographic images: methodology and agreement between theory and experiment. Geophysics, 67, 1396-1405.

Bourbié, T., Coussy, O., and Zinszner, B., 1987, Acoustics of Porous Media. Houston, TX: Gulf Publishing Co.

Dvorkin, J., Nur, A., and Yin, H., 1994, Effective Properties of Cemented Granular Materials, Mechanics of Materials, 18, 351-366. Dvorkin, J., and Nur, A., 1996, Elasticity of high porosity Sandstones: Theory for Two North Sea Datasets, Geophysics, 61, 1363-1370.

Fourier, D.E.L., 2014. Analysis of Permeability and Tortuosity of Fontainebleau Sandstone and its Models Using Digital Rock Physics Approach. Physics of Earth and Complex System, Faculty of Mathematics and Natural Sciences, Bandung Institute of Technology, Indonesia.

Gomez, C., 2009, Reservoir characterization combining elastic velocities and electrical resistivity measurements. Ph.D. dissertation, Stanford University.

Han, D., 1986, Effects of porosity and clay content on acoustic properties of sandstones and unconsolidated sediments: Ph.D. dissertation, Stanford University.

Handoyo., Fatkhan., Fourier, D.E.L., 2014. Digital Rock Physics Application: Structure Parameters Characterization, Materials Identification, Fluid Modeling, and Elastic Properties Estimation of Saturated Sandstones, HAGI Proceeding 2014 Solo, Bandung Institute of Technology, Indonesia.

Mavko, G., and Nur, A., 2009, The Rock Physics Handbook, Second Edition Tools for Seismic Analysis of Porous Media. Cambridge University Press The Edinburgh Building, Cambridge CB2 8RU, UK

Saxena, Nishank, Day-Stirrat, Ruari J., 2017. Effect of image segmentation & voxel size on micro-CT computed effective transport & elastic properties. Marine and Petroleum Geology Article. USA.

Wiegman, et all. 2012. Predicting Effective Elastic Properties with Elastodict. Fraunhofer ITW. Germany.