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Total Porosity Calculation by Using jPOR On The Carbonate Rocks of Taccipi Limestone

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ABSTRACT

One of an effective and quickly method has been established to measure total porosity of the rocks. Macro file (jPOR.txt) for ImageJ is an utilises, which can be used on digital photomicrographs. The method can be run entirely using free to download software because there is no specialized scientific equipment. Digital photomicrographs are acquired from MicroCT Image Scan (MIS). Images were processed using a newly developed custom 8-bit palette and analized for porosity in ImageJ using the simple to use jPOR macro. The method directly calculates total porosity for batches of images with or without the option of user adjustment. Results are showing some images and calculation of the total porosity. This method have been succeeded applying in the carbonate rock images of Taccipi Limestone, South Sulawesi.

Keywords: Total Porosity; jPOR; MicroCT Image Scan (MIS); Taccipi Limestone.

1. INTRODUCTION

The development of digital images and of computer software that can perform a variety of image analysis techniques has revitalized the way that we do of digital image [1,2]. Textures can be digitized and measurements, for example, size, shape, and sorting of constituent grains or crystals quickly acquired [3,4]. Computer models can be used to generate virtual textures with known 3D properties to be used as reference textures for image analysis of natural samples [5], and even true 3D rock textures can be imaged and analyzed directly with the application of serial sectioning and X-ray CT analysis [6,7]. All of these techniques have advanced, and in some way been developed in order to push forward the range and types of analysis that it can perform on geological samples. The new developments in image analysis have the added advantage in that they can potentially provide increased capacity to undertake standard measurements, with more speed and accuracy than traditional methods [6]. For example, the quantification of rock porosity from thin sections impregnated with blue epoxy resin is routine in geosciences, and most commonly undertaken with point counting. Total porosity is defined as the ratio of void volume (pores) to the bulk volume of a rock and is commonly given as a percentage; hence, total porosity = Vp/Vb x 100, where Vp is the pore volume and Vb is the bulk volume [7].

Porosity is important in determining the reservoir properties of a rock (for both aqueous and hydrocarbon fluids), and in studies of diagenesis, compaction, and evolution of sediments [7,8]. A number of techniques exist to quantify porosity, including 2D texture measurements (e.g., point counting), mercury injection, and helium injection porosimetry. Measurements made from 2D sections, which form the basis of this study, record the porosity as resolvable from an image of the sample. The key to be able to perform accurate digital porosity measurements is the ability to generate a porosity threshold image (one which separates the porosity voids from the rest of the objects in the image). Poor quality data can arise from the introduction of noise and inadequate or overzealous preprocessing methods, increasing user bias during thresholding. Additionally, existing techniques can require very specific software (e.g., costly proprietary software, microscope specific software).

The jPOR method was described detailed in the study overcomes these problems by streamlining and standardising colour preprocessing by applying the newly developed custom 8-bit palette which has been developed in conjunction with the jPOR macro for ImageJ [9]. The newly developed macro jPOR.txt has been designed to make quick and accurate porosity analysis available to any researcher in possession of a personal computer and high resolution colour digital images of MicroCT Image Scan (MIS). The jPOR macro offers instructions at each stage so that inexperienced users with no prior image analysis experience will find it easy to use. The method uses technically nonspecific hardware and software which should be familiar to most computer users. The methodology is discussed with advice about image preparation, the steps required for analysis, and how the macro is installed. Results are presented for jPOR calculated porosity for the case of the ten ‘‘carbonate rocks’’.

2. METHODS

A. MicroCT Image Scan (MIS)

The study used “CT” is the abbreviation of “Computed Tomography.” Principle of an industrial CT is the same as that of a medical CT then we call as a MicroCT Image Scan (MIS). A sample to be inspected is mounted on a precise rotation table located between a microfocus X-ray tube and an X-ray Image Intensifier (I.I). On X-ray exposure, the I.I. captures fluoroscopic images of the sample with every angles of rotation. A computer linked with the I.I. collects the image data and calculates a reconstruction image of the sample cross-section. A current research of mCT in geological sciences focuses on the characterisation of reservoir rocks [10,11] like sandstones, carbonates and coal. The most important advantage of the mCT is the possibility of 3D visualisation and quantification of porosity and mineralogical pore-relating phases. Further research on the use of mCT will be focused on the characterisation of fractured reservoirs, which involves a 3D quantification of fracture sizes and orientation. Other research topics will focus on dynamic processes. A total of 10 samples were measured by SHIMADZU Microfocus X-ray CT machine at AIST Sapporo. Each sample has around 460 slices image.

B. jPOR Image

In this study photomicrographs from X-ray CT scan were processed to determine the average porosity of carbonate rocks using ImageJ. ImageJ is a fast and efficient method developed to measure the total optical porosity of thin sections that have been impregnated with blue-colored epoxy resin [6] but we tried to use images from X-ray CT scan which became succesfull. What made the ImageJ approach attractive was that the entire ImageJ process requires no specialized equipment and the software is free to be downloaded. Adobe Photoshop® was used to prepare the digital images in the correct format, an 8-bit paletted.bmp file. Once images were formatted correctly, they were analyzed in the ImageJ software and porosity was calculated.

3. RESULTS

A. MicroCT Image Scan (MIS)

The photomicrographs collected from Microfocus X-ray CT machine that showing 3D image (Figure. 1), Z-X-Y Slice image (Figure. 2), Z-Y-X Slice image (Figure. 3) and Y-Z-X Slice image (Figure. 4).

Figure. 1 Showing 3D image results of MicroCT Image Scan (MIS).

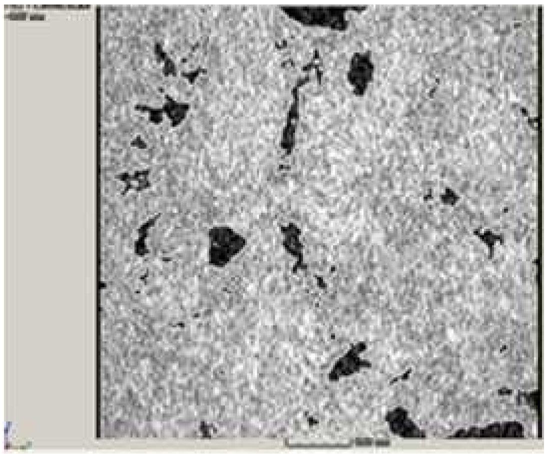

Figure. 2 Z-X-Y Slice image results of MicroCT Image Scan (MIS).

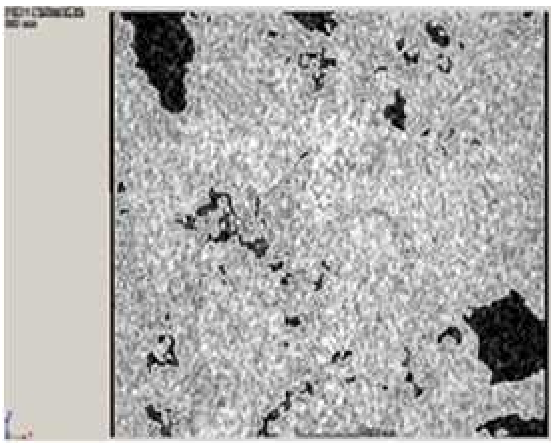

Figure. 3 Z-Y-X Slice image results of MicroCT Image Scan (MIS).

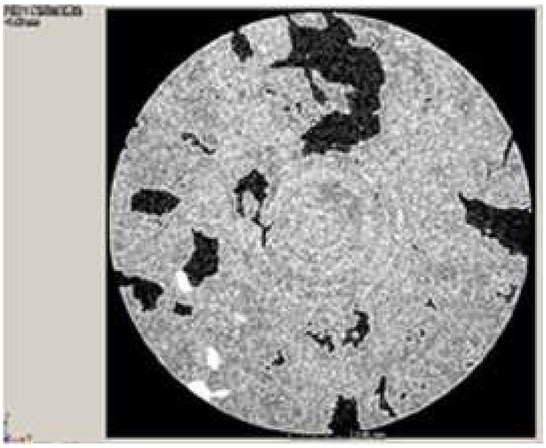

Figure. 4 Y-Z-X Slice image results of MicroCT Image Scan (MIS).

The photomicrographs are showing pores inside the rocks (black colour) that we can calculated by using jPOR image analysis.

B. jPOR Image Analysis

In jPOR analysis we need to changing the image to binary (binary or automatic threshold). Figure 5 to clarify the rock image to be measured and shows the images in black and white binarized image and figure 6 is the result of the ImageJ software manipulation in which the red colour is counted as a porosity. All images were choosen from Microfocus X-ray CT images, for slices of numbers 0200 for each sample.

Figure 5. Binary image product of threshold operation.

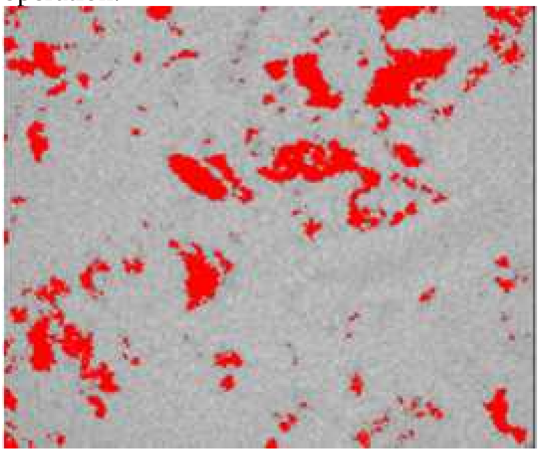

Figure 6. Red mask during thresholding operation covering thresholded pixels.

Table 1. Result of ImageJ Analysis for Sumpang Labbu (SLB).

Sample Code	Slices Number	Porosity Calculation
SLB01	0200	Total pixels= 126447 Pixels forming porosity= 10541 Porosity=8.3363%
SLB02	0200	Total pixels=124968 Pixels forming porosity= 15735 Porosity=12.5912%
SLB03	0200	Total pixels=126224 Pixels forming porosity= 20253 Porosity=16.0453%
SLB04	0200	Total pixels=127104 Pixels forming porosity= 23734 Porosity=18.6729%
SLB05	0200	Total pixels=125775 Pixels forming porosity= 6471 Porosity=5.1449%

Table 2. Result of ImageJ Analysis for Salo Ningo (SN).

Sample Code	Slices Number	Porosity Calculation
SN-1	0200	Total pixels=125624 Pixels forming porosity= 3054

		Porosity=2.4311%
SN-4	0200	Total pixels=123909 Pixels forming porosity= 13559 Porosity=10.9427%
SN-7	0200	Total pixels=127588 Pixels forming porosity= 2346 Porosity=1.8387%
SN-8b	0200	Total pixels=124218 Pixels forming porosity= 4271 Porosity=3.4383%
SN-8c	0200	Total pixels=127380 Pixels forming porosity= 6970 Porosity=5.4718%

Result of ImageJ calculation of Sumpang Labbu (SLB) samples in table 1 showing the total porosity around 12.15% while for the result of ImageJ calculation of Salo Ningo (SN) samples in table 2 showing the total porosity around 4.82%. The Total Porosity of Sumpang Labbu (SLB) is higher than Total Porosity of Salo Ningo (SN).

4. DISCUSSIONS

The porosity analysis of carbonate rocks in Taccipi limestone in this study have been done. A new method to calculated the total porosity of Taccipi limestone have not been established. The results showing the total porosity of Taccipi limestone was good. As we know that The Taccipi Formation deposited during the Middle Miocene to Early Pliocene in an intra-arc or forarc setting. Deposition, diagenesis and hydrocarbon potential of these carbonates were strongly influenced by the tectono-stratigraphic setting, faulting, subsidence and possibly eustatic sea-level variations. Carbonates of the Tacipi Formation unconformably overlie altered volcanic lithologies, probably of the Langi Formation [12]. Taccipi limestone was known as reservoir rock of petroleum system in Sengkang Basin.

5. CONCLUSIONS

Calculation of the total porosity of the rocks especially in carbonate rocks was good result by using jPOR combined with MicroCT Image Scan (MIS).

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