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Estimation of Porosity and Pore size distribution from Scanning Electron Microscope image data of Shale samples: A case study on Jhuran formation of Kachchh Basin, India.

Shubham Saraf
Pandit Deendayal Petroleum University
School of Petroleum Technology,
Gandhinagar, Gujarat, India.
E-mail: sarafshubh94@gmail.com

Ajendra Singh
Pandit Deendayal Petroleum University
School of Petroleum Technology,
Gandhinagar, Gujarat, India.
E-mail: ajjusingh1989@gmail.com

Bhawanisingh G Desai
Pandit Deendayal Petroleum University
School of Petroleum Technology
Gandhinagar, Gujarat, India.
E-mail: bhawanigd@gmail.com

SUMMARY

The work is aimed at estimating the porosity of shale from the Jhuran formation (Kachchh Basin) through non-destructive technique. Shale is a sedimentary rock formed by compaction of fine grained silt and clay sized mineral particles. In recent times, free gas is present in clay-mud shale complexes also within laminae that are enriched in bioturbation. However, a significant amount of natural gas is present in organic pores located within insoluble organic matter which is called kerogen. And also, there is still a lack of knowledge on the effect of bioturbation on porosity and pore size distribution in unconventional reservoir, especially in Indian context. The shales of Jhuran formation are characterized by low permeability on account of bioturbation. The purpose of the paper is to demonstrate use of non-destructive technique for defining effect of bioturbation on pore volume of shale sample. The Scanning Electron Microscope (SEM) images were examined for a porosity and pore size distribution analysis using an open source image processing software (ImageJ). The methodology developed allows estimation of porosity and pore size distribution from the image processing technique which validated with routine core analysis (Helium porosimeter). SEM image analysis is essential as shale properties can be directly observed and key details regarding unconventional reservoir conditions better understood.

Key words: SEM (Scanning Electron Microscope), Porosity, Permeability, Kerogen, Bioturbation, Software (ImageJ).

INTRODUCTION

Shale properties are described in different scales of observation mineral grains (nano and micro-scale), packages of lithologically uniform laminae (millimetre or centimetre scale), higher order sedimentary complexes displaying internal lithological variability and higher order patterns of the sedimentary structure (scale of metres).Shales form a particular petroleum system where in the same rock formation is simultaneously source, reservoir rock, sealing rock and the trap, while gas migration occurs solely in a micro-scale or is absent. [[1] Harsh sahani et al. 2018].

In recent times, most of the producing unconventional reservoirs are found to be quantitative (%) content of organic matter, contrary to the initial belief. Image processing technique has been found to be a powerfull tool for extracting usefull information from SEM images. This method is used to evaluate porosity and pore size distribution from scanning eletron microscope images. Sample preparation requires professional, precise equipment having a high level of repeatability and accuracy regardless of sample type.

A pore size distribution can characterize from pore space and, in consequence, unconventional reservoir parameters of shale sample. Estimated porosity from helium porosimeter has been used to validate porosity from the SEM image processing on prepared sample. And void spaces also occur between rock grains (nano-pores and micro-pores), but their pore volume is minimal. Effective porosity appears as a result of fracturing. Hence, In order to fully utilize non-destructive technique image processing has been used to reduce computation repeatative process by using thresholding algorithm. Then using ImageJ software for reducing time and evaluating SEM images of shale sample pore space and pore radius.

METHOD AND RESULTS

The SEM images are used for defined petrophysical parameters of shale. Electron microscopes utilize the same basic principles as light microscopes, but focus beams of energetic electrons rather than photons, to magnify an object.

Figure 1. Scanning Electron Microscopy (SEM) Instrument for taking Microscopy Images of shale sample.

Jhuran formation is a shale dominated unit underlieing sandstone rich Bhuj formation. Jhuran Formation is present in basin and the offshore (GK-29 A-1 well) as well. [[2] Desai, B. G. And Thakkar, M. G. 2016]. For estimating porosity, bioturbated shale rocks from Jumara, Jara, Nikona and Ratia locations were collected.

The thresholding operation is used in image processing technique for petrography image analysis. It is implemented in open source software ImageJ. After thresholding done

binarization operation procedure, And the porosity is determined by using the image volume method to summing up porosity pixels of all analysed images and by dividing that value by the sum of the areas observed on these images. Then this obtained value was multiplied by 100%. These calculations have been conducted without taking into account those areas, which are revealed in the segmented images.

Figures and Tables

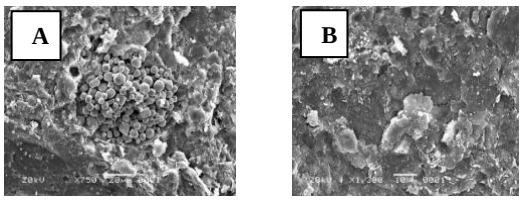


Figure 2. The SEM Images of Shale from Jhuran formation of (A) Jara and (B) Ratia, Kachchh basin, 20x.

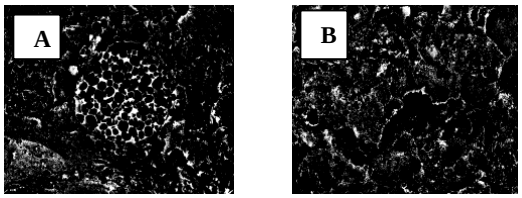
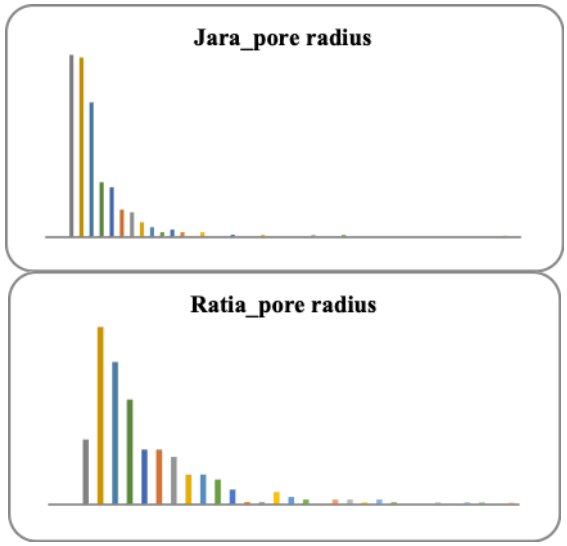


Figure 3. Binarized the images by Image processing using threshold operation on (A) Jara and (B) Ratia samples.



Graph 1. The frequency plot of the pore radius of SEM image of Jara and Ratia shale sample.

Table 1. Results of two methods compared (Porosity through Image processing and routine core analysis).

Parameter	Sample Name			
	Jara	Jumara	Nirona	Ratia
Porosity [%] through SEM Image Analysis	9.4038	8.7184	6.9596	9.0645
Porosity [%] through Routine core Analysis	9.66	9.23	7.69	10.12

The image processing has been utilized to evaluate the petrophysical parameters such as porosity and pore size distribution. By establishing porosity from routine core analysis as standard results, the porosity obtained from image processing is compared with it. It is found that both the porosity values are found in agreement to each other with error of 2.65%, 5.54%, 9.49% and 10.42% for Jara, Jumara, Nirona and Ratia respectively.

Citation

[1] Harsh Sahani, Ajendra Singh, B. G. Desai et al. 2018. Characterization of organic potential of Jhuran shale formation of Kutch basin. Conference: 4th South Asian Geoscience Conference and Exhibition -2018, At Noida, India

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CONCLUSIONS

The image analysis software was used to measure fundamental textural properties observed in scanning electron microscope (SEM). Data sets were generated from the SEM image analysis using point counting variables such as porosity and pore size distribution. The developed methodology successfully estimated porosity, which was validated from routine core analysis (Helium Porosimeter).

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