Unconventional Shale Reservoir Characterization: a Study from Raniganj Field, Damodar Valley Basin, India

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Abstract

The Damodar Valley Basins in India are considered as major potential source for future shale gas production. An investigation was carried out to evaluate properties of the Permian shale of Raniganj Field, Damodar Valley, India and found to be rich in hydrocarbon source potential (4-21%) with kerogen type III (gas prone). Micro Computer Tomography (m CT) technique was used and it results approximate porosity ranges between 3- 5%. The high resolution images of pore system as well as micro pores, meso pores and both isolated and connected pores were observed in the studied samples. The m CT derived images indicate the presence and orientation of micro fractures in the shale and illustrates its heterogeneity.

Introduction

Raniganj field of Damodar Basin is located in West Bengal and partly in Jharkhand state, about 185 Km North-West of Kolkata. The Gondwana sediments here are represented by Talchir, Barakar, Barren Measures and Raniganj Formation overlain on the basement metamorphic rocks of Pre Cambrian age. The Barren Measure Formation of the Permian age is the shale gas prospective horizon in the Raniganj field. The formation is the thick sequences of monotonous grey to black micaceous and often carbonaceous shale with thin sand intercalation. The Shale has undergone different phases of maturation at different stratigraphic levels and depressions. It is rich in Total Organic Matter (4-20%), matured (0.5-1.3 Ro), mainly Kerogen type III gas prone with enough shale volume for hydrocarbon generation and accumulation. However, the heterogeneity and low permeable nature of shale always hinder in commercial production of shale gas and so extensive natural fractures or induced fractures are requires for shale gas production. The another factor is that the gas in the shale may be stored as both free gas and adsorbed as, therefore it may not be enthusiastically understood the storage and flow mechanisms in shale. Special techniques are requires to resolve the porous media in shale. The present study discussed the storage mechanism and reservoir quality of Barren Measure shale using Micro Computer Tomography (m CT). The computerized micro tomography is one of the non- destructive, fast and accurate techniques to reveal the internal structure and also helps in building 3D internal structure of the shale cores.

Experimental Details

A total of 32 shale cores from different locations and depth intervals were analyzed using Rock Eval Pyrolysis technique and two core samples were selected for the m CT analysis from zone1(depth interval X55-X60m)and zone 2(depth interval X85-X90M). In case of m CT studies, for acquisition of image, the magnification was set by adjusting the ratio of the distance between the X-ray source and the specimen to the distance between the X-ray source and the camera. Images were acquired at 2048 voxels with and no. of projections was 2880. Acquisition time for a sample was 14 hours. Images were acquired at 2048^3 voxels to get maximum resolution. The projections were linearized and reconstructed using Feldkamp method in Q-MANGO (Medial Axis and Network Generation) software to get the tomogram (2048^3 voxel size). The tomogram (3D representative of the rock) was segmented into two-phase (pore and grain) and three-phase (pore, grain and intermediate). Different noise reducing filters are applied before segmentation for better visualization of the tomogram. Image processing was run by Q-MANGO. The images were achieved by acquiring a series of radiographs at different viewing angles. Pores and grains in the tomogram image can be differential by filling with blue, red and grey colours respectively. Based on system generated tentative values of pores and grains, segmented images were analysed with the help of Q-Mango software and pore network of the rock samples were extracted. 3D visualization of the pore-network was developed using visualizing software Paraview. Different filters like eluclidean distance, smooth distance map, watershed transform, cluster region mergin etc were used to enhance the resolution quality of the tomogram images to analyse texture and the pore & pore throat network.

Results and Discussion

The shale samples are rich in Total Organic Carbon content (TOC) ranges from 4 to 21% and Kerogen type III gas prone. Images of mCT of core samples are shown in Figure 1 and 2. The lighter areas indicate areas of greater density. Several regions of high density material that are roughly spherical are seen in slices figure 1 and 2. A high density lamina which is most noticeable in the figure 1b goes almost through the center of the core. There are a number of thin low density regions that appear to be fractures which are most apparent in the figure. There is another fracture which can just be seen at the extreme left hand point of the third slice that can also be followed through the rest of the plug. A porosity value of 4% and 5% were measured for the samples. A variety of pore geometries were noticed i.e. (a) relatively large disconnected pores; (b) large pores connected by very thin conduits; (c) porosity system where the large pores are interconnected by both large conduits and very thin conduits are interconnected and also connected to the large pores.

Conclusion

The analysed samples were excellent hydrocarbon generation potential. X-ray computed tomography identified the spatial distribution of gas storage in shale rocks. The presents study results the 3 to 5% computed porosity and it may be much higher as the m CT resolved up to 4.08 micron pores. The porosity results and m CT images show that the rock is having poor to moderate reservoir quality, highly heterogeneous, moderate to well sorted. Both connected and isolated pores are present. The intergranular pores and micro fractures are filled by clay, fine matrix or organic matter at many places.

References

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Figures

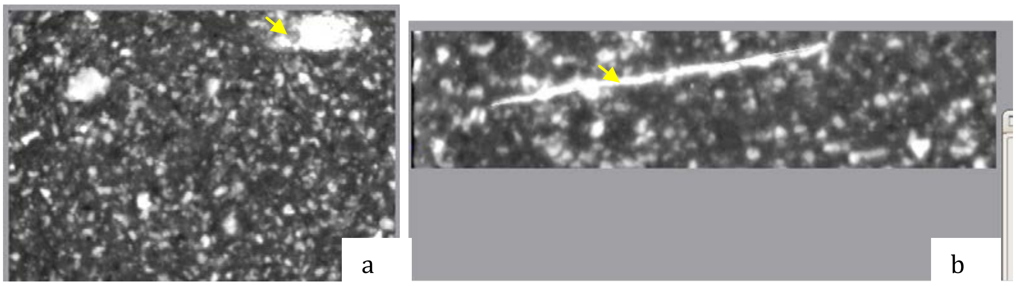

Fig 1: Segmented image showing (a) high density mineral grains; (b) a lamina of high density minerals (depth zone2).

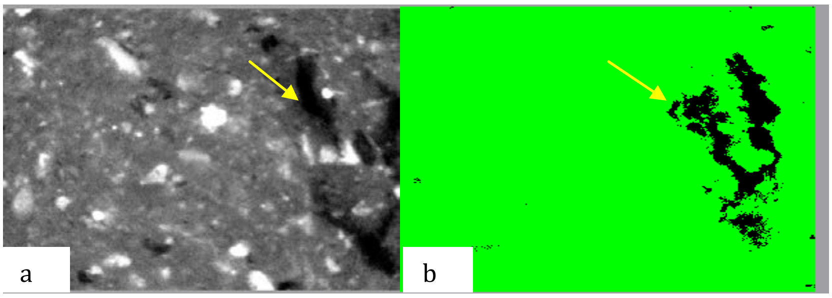

Fig 2: Porous space, Zone 2(a) isolated pores (b) micro-fracture at depth zone1. (c) Analyzed image of b indicating the porous space + organic matter by blue colour, matrix with fine grains are by in grey colour and comparatively higher density grains are by red colour.

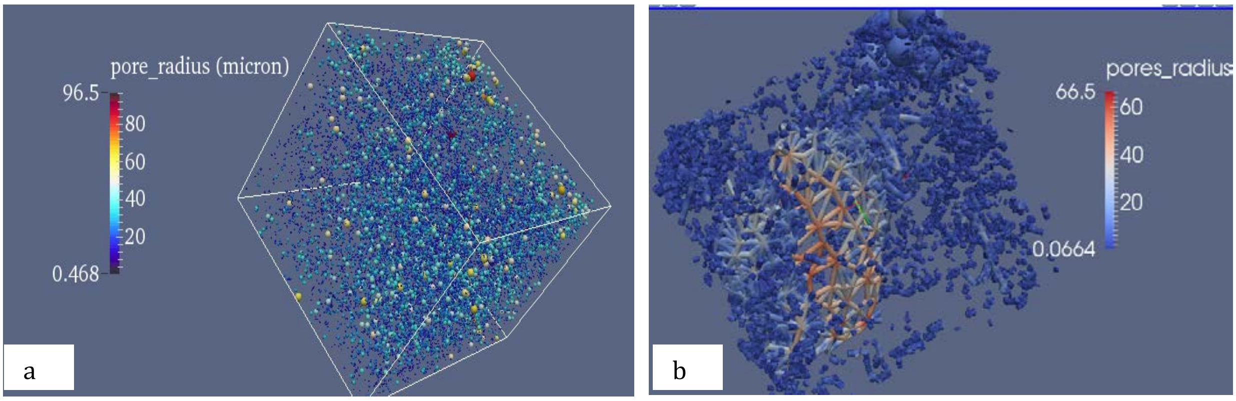

Fig3 (a), (b) m CT derived 3D image of pore network of samples from the depth zone1, and zone2 respectively. Both isolated and interconnected pore are present.