THE EFFECT OF SHALE COMPOSITION AND PORE CHARACTERISTICS ON ADSORBED GAS CONTENT: IMPLICATIONS FOR SHALE GAS EXPLORATION IN RANIGANJ BASIN, INDIA

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Keywords

Adsorb gas, Barren Measures shale, Pore, Shale Gas, Raniganj

Summary

Methane adsorption capacity is a key factor in shale gas exploration for determination of shale gas in place (GIP) while gas adsorption capacity is controlled by several geological factors like mineralogy, organic content, diagenesis, pore networks, surface area, etc. This study is an effort to highlight the pore system and adsorption desorption mechanism in Silty shale, carbonaceous shale, claystone and ironstone shale unit of Barren Measures Formation of Raniganj Field at various scales. SEM, X- ray diffraction, BET and Permeability test manifest significant information about role of clays, organic matter and mineral composition in development of pore network and permeability, which also governs the gas storage and transport properties.

Introduction

The global shale gas ‘‘Revolution” in US extended the interest on shale sedimentary rock with that converted the role of shale from conventional source rocks and cap rocks into unconventional reservoirs. As shale act as both source and reservoir for gas storage, organic richness, organic matter type (kerogen type) and maturity are the factors to be assessed for shale gas characterization. Shale is a tight reservoir characterized by abundant nano-pores unlike the conventional sandstone and carbonate reservoirs. The knowledge of the pore types, including pore size distribution (PSD), surface area and porosity parameters were essential to determine the shale reservoir characters. Understanding the pore system in shale is important as the shales require induced fracture systems for gas production through hydraulic fracture stimulation combined with horizontal drilling. The pore size and porosity are controlled by several factors like mineralogy, depositional environment, provenance Moreover; porosity may be reduced under overburden pressure due to diagenetic processes like compaction, cementation, etc. However, the exploration and development of the shale resources requires exhaustive characterization of physical, chemical, mechanical properties and flow characteristics of particular shale in different scales. Mineralogy, organic geochemistry and pore system in shales are the functions of the stress and/ or strain and brittleness (Curtis, 2002; Chen et al., 2011).

Methodology

Rock-Eval pyrolysis was carried out using a Rock Eval 6 pyrolyser (Turbo version-Vinci Technologies) for determination of kerogen type, hydrocarbon generation efficiency and maturation.
The samples were analyzed under scanning electron microscope to understand the mineralogy, pore geometry, clay structures, diagenetic effects, pore size & structure, lamination, micro fractures and micro scale reservoir heterogeneity. The SEM photomicrographs were taken using JEOL, JSM-6460 LV Scanning Electron Microscope operating at 10 to 20 kV to bring out the desired features under high magnification up to 20,000X. Micro CT of limited samples aided in understanding the micro scale vertical heterogeneity of the shale. BET technique was used to analyze the surface area and pore size distribution of the samples.

Results and Discussion

The total organic carbon content of Barren Measures shale is ranging between 3.56 to 12.85 wt%. The rock eval pyrolysis results signify the kerogen type III (fig 1).

The fundamental reservoir properties of shales were assessed and envisaged multiscale pore system, pore structure in the clay and organic matter (OM) components. The absorption capacity declines with progressive TOC and organic matter is acting as primary control factor in the adsorbed gas volume. The analysed shale samples reveal the presence of gas in three forms, i.e. free gas in the pores, free gas in the microfractures and adsorb gas in the micro/nano pores. The adsorbed gas volume increases with the confining pressure, whereas it decreases inversely to the temperature. The relationship of the adsorbed gas volume to the porosity, pore size, specific surface area and mineralogical parameters are far more complex. In general, micropores represent the controlling factors for gas adsorption and storage, where the adsorption quantity increases with an increase in micro-porosity and quantification of pore-structure important parameter in modeling behavior of porous media, where, minor pores have large specific surface areas and nano pore typically hold larger specific surface areas. The different types of pores in shales can be classified as: (a) intergranular porosity (Fig. 2A & 2B); (b) intragranular porosity (Fig. 2C); (c) secondary porosity developed due to diagenesis, dissolution activities etc; (d) matrix porosity (Fig. 2C) and (e) porosity associated with organic matter (Fig. 2F) and (f) fracture porosity (2E). Dissolution of different types of cements and unstable detrital grains generate secondary porosity in Barren Measures Formation, while the nano pores of~ 10nm to 500nm in diameter Specific surface area ranges from11.75m^2/g to15.11 m^2/g and adsorbed gas content ranges between 0.1 to 21 cc/g. Under low pressure, adsorption effect has impact on shale permeability, which renders shale permeability and the reciprocal of average pore pressure. Under high pressure, desorption effect has impact on shale permeability resulting in the shale permeability increases along with gas desorption.

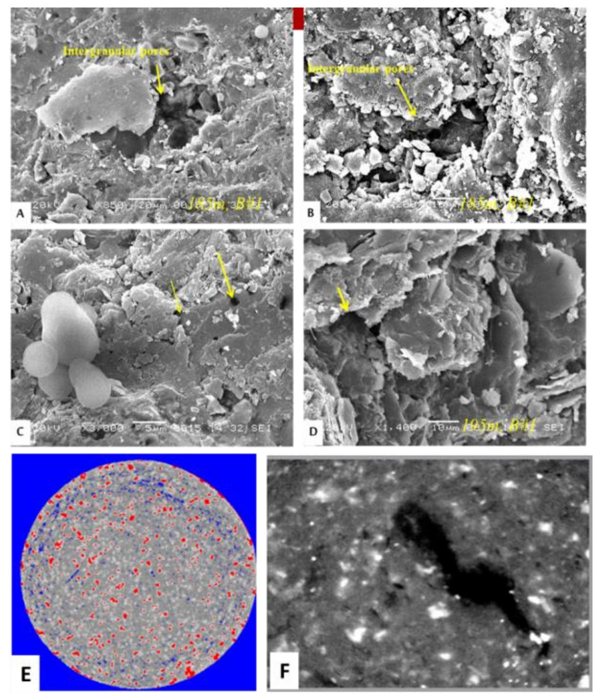

Fig 2. Photomicrographs. A. Intergranular pores in Raniganj shale, B. Intergranular shale in Cambay shale, C. Intragranular and matrix pores in Barren Measures shale, D. pores between the grains and matrix, E. m CT image showing fracture porosity, F. m CT image showing pores associated with organic matter.

Though gas transport may be negligible via the pore throats due to presence of nanoscale pore throat, however the high connectivity of organic matter and clays can offer the potential pathways for gas flow in forms of diffusion and/or adsorption-desorption in nanoscale pores within the organic matter.

Conclusion

A large portion of pores in Barren Measures shales ranges between 20 nm to 55nm. Adsorption desorption mechanism is controlled by clay content, organic meter. The carbonaceous shale unit has larger

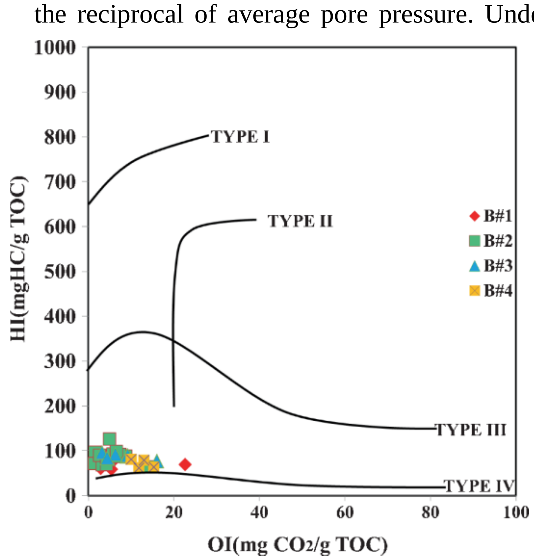

Fig 1: Modified Van Krevelen diagram indicating the kerogen type for Barren Measures shale.

surface area 15.11m2/g followed by claystone (14.19m2/g), silty shale (13.27m2/g) and ironstone facies (11.75m2/g). Barren Measures shales of Raniganj Field are rich in organic content and consist of Kerogen type III, deposited in anoxic condition, have excellent prospects for shale gas exploration, Barren Measures properties are identical to most of the US commercial gas shales (eg- Antrim shale). The study infers the organic matters and clay mineral as more dominating factor for nano to micro pore development and gas adsorption.

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