



Contribution ID: 289

Type: **Poster (+) Presentation**

Dynamics of organic pore evolution in shale under varying thermal and oxygen environments

Friday, 4 June 2021 09:40 (1 hour)

The high heterogeneity of shale is a deterrent in the accurate assessment of reservoir characteristics, making gas exploitation a challenging task. Besides being a nearly impermeable permeable reservoir type, shale has a complex pore network exhibited by various pore types and pore-size distributions that influence gas storage and transport in the shale matrix [1,2]. Gas in shale is stored as (1) free gas in pores and fractures, (2) adsorbed gas inside organic matter and clay pores; and (3) dissolved gas in water [3,4]. Micropores, present in organic matter and clay minerals, primarily adsorb gas owing to their large specific surface area and more significant adsorption potential in small pores [3,4]. Temperature plays a vital role in modifying shale pore characteristics. Thermally mature shales have larger micropore volume and higher gas sorption capacity than immature shales [5]. With increasing temperature, the thermal cracking of kerogen takes place, leading to a restructuring of organic pores [6]. Although studies exploring the pore structure changes in oil shales through inert heating are plenty, such research rarely exists in the field of gas shale. Due to the probable harmful environmental effect of hydraulic fracturing, more research is being done worldwide to develop a greener solution to improve shale gas resource exploitation [7]. New studies suggest combustion as an alternative technique for porosity enhancement as the process eliminates kerogen and organic matter resulting in higher gas recovery from shale [8].

So far, studies on Indian shales have been analyzing overall pore characteristics and their relation to the organic matter properties and gas adsorption capacities [4,5,9,10]. However, very few works detail the influence of increasing temperature on Indian shale pore, when the thermal treatment takes place in oxygen. Hence, the prime focus of this study is to assess the dynamics of organic pore development in shale when it is combusted in the presence of oxygen. The pore attributes were estimated using low-pressure N₂ and CO₂ adsorption (LPGA) at each temperature interval, further supported by high-resolution microscopy. The temperature of 300°C is taken as a maximum as a further rise in the temperatures might alter clay, and kerogen's fundamental characteristics in shales [11].

The aliphatic hydrocarbon stretching bands of kerogens, identified from FTIR study, at 2920 cm⁻¹ and 2850 cm⁻¹ display a reduction of almost 13% in the aliphaticity from 100°C to 300°C. SEM images also confirm the growing connectivity of organic micro-pores with gradual temperature rise. LPGA analysis confirms the appearance of newer micropores with rising temperature and formation of larger pores at 300°C. However, when samples were heated in an inert environment, changes in pore characteristics occur differently. Oxidative heating causes a noticeable increase in the surface area and pore volume (almost 70-80%). Along with that, the pore size distribution peaks become sharper and of higher magnitude. But when the samples were heated in the absence of oxygen, pore-blocking occurs due to the generation and solidification of bitumen, resulting in a reduction of surface area and pore volume almost up to 30%.

Time Block Preference

Time Block A (09:00-12:00 CET)

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Session Classification: Poster +

Track Classification: (MS1) Porous Media for a Green World: Energy & Climate