Is microbial degradation of heavy hydrocarbons a major source of methane in CBM reservoirs? Evidence from Australia

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It is proposed that it is a misnomer that humic coals (Type III organic matter enriched in vitrinite and inertinite) predominantly generate methane, whereas Type I and Type II organic matter (enriched in liptinite) generate wet gases. Data from deep bituminous coals in Bowen, Surat, Galilee and Sydney basins of Australia indicate that humic coals containing only minor amounts of liptinite can generate significant amounts (>30%) of heavy hydrocarbons (Figure 1). However, subsequent to basin uplift most of the ethane and heavier hydrocarbons in shallow coals appear to be degraded to methane by microbal activity. In addition to alteration of wet gases, microorganisms can also degrade other organic components of coal including aromatics and secondary bitumens occluded in the coal matrix. In deeper, low permeability coals where microbial activity is not prevalent thermogenically generated heavy hydrocarbons appears to be well preserved.

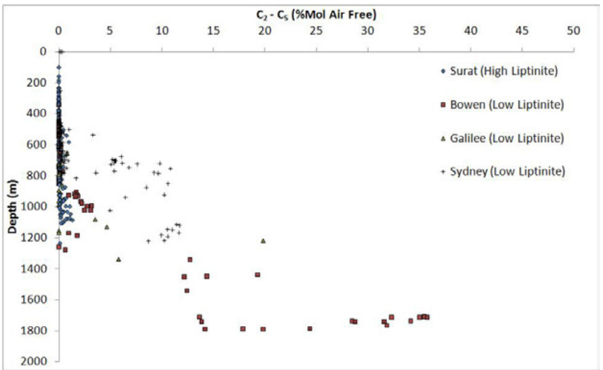

Figure 1: Coalbed gas wetness ($C_2 – C_5$) versus depth.

Microbiological studies including 16SrDNA analyses of coal and associated water samples from the Bowen and Surat basins have enabled the identification of bacteria and archaea capabale of degrading aliphatics and aromatics in coal to produce lighter hydrocabons including methane. The most prevalent bacterial phyla include the Proteobacteria and the Firmicutes and most commonly observed methanogen families include Methanobacteriaceae and Methanosarcinaceae.

Assessment of pore fluid pressure history in basin-centered gas accumulations using fluid inclusions

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Continuous gas charge of low-permeability tight-gas sandstones creates a dynamic system where pore pressure increases locally and temporarily to near lithostatic pressures, and fractures the rocks. Methane concentrations of aqueous fluid inclusions trapped in crack-seal fracture cements can be used as proxy to determine the pore pressure variations in these systems. The natural fracture network creates pathways that allow upward gas migration to form a continuous gas-saturation interval in the absence of a top seal in the deep-central parts of sedimentary basins. The Piceance Basin, Colorado, has been considered a basin-centered gas accumulation. This model contrasts with models of low-permeability reservoirs where gas accumulates in conventional traps. To test these models, we determined the temperature, pressure, and fluid composition history during fracture opening in Mesaverde Group sandstones of the Piceance Basin based on fluid inclusion microthermometry and Raman microspectrometry. Homogenization temperature of aqueous fluid inclusions record systematic temperature trends from ~140 to 185°C and to 158°C over time. In contrast, we observe oscillating pore fluid pressures ranging from ~55 to ~110 MPa over time. We interpret the oscillating pressure record to indicate migration of gas in high pressure cells that move upward by natural hydraulic fracturing. Repeated passage of high pressure cells result in cyclic fracture opening and sealing. Comparison of microthermometry data with burial models suggests that gas generation, migration of high pressure cells, and natural hydraulic fracturing lasted for ~33 m.y. in the Piceance Basin.