An Evaluation of Shale Gas Potential in the Bowland Shale, United Kingdom, Using Sequential High Water Pressure Pyrolysis and Methane Absorption

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ABSTRACT

A recent study of the early Namurian Bowland Shale gas potential in northern England (UK), obtained using a 3D geological model and a statistical simulation, indicated 264 tcf gas in place (GIP, HIo = 475) (Andrews, 2013). This estimate assumes that dry gas (>80% methane, CH4) is generated from kerogen in the range 1.1 to 1.9% Ro, even though the evidence from the USA is that maturities >1.4% Ro are required. In addition, the gas volume estimate assumes that the shale porosity and gas absorption in the Bowland Shale followed the trends published for USA analogues, e.g. Barnett Shale. The prediction of gas volumes generated assumes that gas is generated in a chemical reaction system containing only shale, whereas shales both prior and during gas generation contain water in pores and fractures and rock. Water plays important chemical and physical roles during both generation and absorption of petroleum. Using sequential (stepwise) pyrolysis involving repeated periods of heating (burial) with successively higher temperatures and time, followed by cooling (uplift) as in northern England, gas under non-hydrous conditions was generated containing <70% CH4, whereas under high water pressures (550 bar and higher) > 90% CH4 was generated. The maturity at which CH4 contents >80% were generated appears to be >2% Ro. The GIP estimates calculated (using gas yield obtained for 800 bar sequential pyrolysis) at different maturities between 1.26-2.34% Ro assuming that all the generated gas remains within the shale. The GIP was highest at maturity of 1.26 to 2.03% Ro, but was a factor of 2-3 lower at Ro >2.0%. To provide precise estimates, the wetness of gas and maturity range for dry gas generation needs to be defined. For example, over a maturity range of 2.25-2.34% Ro and a gas dryness of 90%, the GIP estimate was ca. 22 tcf, 12 times lower than 264 tcf reported by Andrews (2013). Porosity determined using nitrogen, CO2 and high pressure CH4 adsorption isotherms conducted on shales both with and without moisture was used to provide information on the shale micropore structure. The mono-layer coverage from a Langmuir plot was calculated to be 1.8mg at 100oC and 4.2mg at 25oC of CH4/g rock in wet samples, which are significantly lower (8-19 tcf) than that required to accommodate 264 tcf of gas. Andrews, I.J. 2013. The Carboniferous Bowland Shale: Geology and resource estimate. British Geological Survey for the Department of Energy and Climate Change, London, UK.