

Title: Analysis for the Petroleum Prospectivity of the Marcellus Formation of Western Pennsylvania, USA, using Pyrolysis and SEM XRF Measurements together with GR, ChemoGR, Porosity and PHIE Logging

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An analysis for the petroleum prospectivity of a core from the Marcellus Formation of Western Pennsylvania, USA was done using pyrolysis and SEM XRF measurements together with GR (Gamma Ray), ChemoGR (calculated from Potassium, Thorium and Uranium), Porosity and PHIE (Effective Porosity) logging. The analyzed core comprised of a 15.4 ft (4.7 m) thick Lower Marcellus TST sequence overlain by a 3.8 ft (1.2 m) Marcellus core of undetermined sequence. Oil saturation was measured using both Classical Pyrolysis and HAWK-PAM methods. Based on TOC and $S_{1\text{free oil}}$ measurements of the analyzed core, two groups emerged, one of which consisted of the 6361.5 – 6374.5 ft (1939.5 – 1943.4 m) Lower Marcellus TST sequence whose TOC (wt. %) and $S_{1\text{free oil}}$ (mg HC/g rock) ranged from 6 – 18 wt. % and 8 – 12 mg HC/g rock respectively. Included in this first group is the 6329 ft (1929.8 m) Marcellus of undetermined sequence whose TOC and $S_{1\text{free oil}}$ were 7.88 wt. % and 5.81 mg HC/g rock respectively. The second group on the basis of TOC and $S_{1\text{free oil}}$ values was the Lower Marcellus TST sequence at 6377 ft (1944 m), whose TOC and $S_{1\text{free}}$ were 3.11 wt. % and 1.9 mg HC/g rock together with the undetermined sequence Marcellus core at 6326.4 ft (1928.8 m) and 6330.2 ft (1929.9 m) whose TOC (wt. %) and its mg HC/g rock $S_{1\text{free oil}}$ value ranged from 1 – 2. Out of all the analyzed interval, the 6367.3 – 6374.5 ft (1941.3 m – 1943.4 m) interval had the highest HAWK-PAM measured sum of Oil-1 (C₄) through to Oil-4 (C₃₆) (9.4 – 14.38 mg HC/g rock), highest sum of Oil-1 (C₄) through to Oil-3 (C₁₉) (4.25 – 6.4 mg HC/g rock) and highest porosity (2 – 11.1 porosity units). The effective porosity for this interval ranged from 0.06 to 0.13, with one sample having an effective porosity value of 0.03. This 6367.3 – 6374.5 ft (1941.3 – 1943.4 m) interval was also the only interval that had >40% Siliceous Mudstone content. The rest of the analyzed interval had Siliceous Mudstone values that were <40% whereby Argillaceous Mudstone ranged 30% to 80%, and the Carbonate was mostly in the single digits but at times was as high as 60%. GR and ChemoGR values did not have any discernable grouping but ranged from 200 to 800 API units. The analyzed core had a maturity of 455 to 486 °C (condensate/wet gas maturity zone). Based on the aforementioned analyses, the sweet spot for petroleum prospectivity in the analyzed Marcellus Formation core is 6367.3 – 6374.5 ft (1941.3 – 1943.4 m).