AAPG Datapages/Search and Discovery Article #90310 ©2017 AAPG/SEG International Conference and Exhibition, London, England, October 15-18, 2017

Advanced Pyrolysis Data and Interpretation Methods to Identify Unconventional Reservoir Sweet Spots in Fluid Phase Saturation and Fluid Properties (GOR, API Gravity) From Drill Cuttings and Cores

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ABSTRACT

Understanding the EUR and producibility of unconventional reservoirs depends on, among other factors: 1) distinguishing hydrocarbons present as a producible fluid phase saturation from those in the sorbed state that are not producible; and 2) reservoir fluid properties including GOR and API gravity. We present geochemical techniques that address both based on analysis of cores from the Marcellus and Burkett Formations, WV, USA, using the HAWK pyrolysis instrument's Petroleum Assessment Method (HAWK-PAM) and the t!PsSAT2016 tool. HAWK-PAM employs multiple ramps at a rate of 25 °C/min to generate 5 pyrolysate yields: 4 on 'Oil Fractions' and 1 on 'Kerogen'; Tmax is measured on each. Calibrated against pure compounds, the 4 'Oil Fractions' correspond to: C5-6, C7-10; C11-17; and C18-43 hydrocarbons. C44 plus hydrocarbons as well as hydrocarbons cracked from resins and asphaltenes occur in the 'Kerogen' peak. Knowing their carbon number ranges, we can interpret their relative abundance using PVT data from reservoir fluids, relating the PAM 1-4 'fingerprint' to the GOR of the 'live' fluid and to the API gravity of the 'dead' flashed liquid. Thus the PAM 1-4 fingerprint can be used to predict fluid characteristics of each analyzed sample. To separate the oil in the rock samples into sorbed versus producible fluid phase states, we then analyzed the organic carbon and pyrolysis data of each sample using t!PsSAT2016, a tool that models sorbed versus total oil yields. The resulting 'Caterpillar' plot and fluid phase saturation log for the WV well highlight zones of fluid phase saturation that are potential targets for liquids production along with the Marcellus gas stream, which is confirmed by condensate production along with gas in this area of the Marcellus play. Using the same technique we also show examples of 'sweet spot' detection in fluid phase saturation in Barnett, Eagle Ford and Bakken oil phase reservoirs. Combining the two techniques in the Marcellus well, we find that zones with the highest predicted fluid phase saturation do indeed have a characteristic PAM fingerprint, with the two independent methods confirming each other. The combination of the HAWK-PAM method and t!PsSAT2016 has great promise in identifying storage and producibility sweet spots that are critical to the further success of unconventional oil plays at low prices. Our current research focus is on a multi-component sorption model that works with the individual PAM 1-4 multi-component data.