Title: Investigation and Identification of Pyrolysis Attributes that can Assist in Predicting Producible Hydrocarbon in the Unconventional Eagle Ford Formation

Authors/Institutions: Albert Maende[1], Brian Horsfield[2], Sascha Kuske[2], Brian Jarvie[3], Dan Jarvie[1], and W. David Weldon[1]
(1) Wildcat Technologies, LLC, Humble, TX, United States (2) German Research Centre for Geosciences (GFZ), Potsdam, Germany (3) GeoMark Research, Ltd, Humble, TX, United States

Abstract
Prediction of producible hydrocarbon in unconventional formations, is vital because it governs returns on investments. Kuske *et. al*., 2019 used a PhaseSnapShot workflow to model target well hydrocarbon phases based on PVT data and nearest slightly less mature well. Gorynski *et. al*., 2019, showed low-maturity shales can be dominated by heavy (C_{32+}) oils and that the ratios of SARA components in the C_{15+} fraction of produced fluid and core extract can be used to estimate the mobile oil. Pepper *et.al*., 2019 discriminated fluid saturation from sorbed oil. Prediction of producible hydrocarbon in unconventional formations is complicated by the co-occurrence of sorbed oil with fluid saturation. Our objective was to investigate and identify pyrolysis attributes that can assist in predicting producible hydrocarbon in unconventional formations. Seven core samples spanning the Eagle Ford Formation's early mature, oil window and condensate/wet gas zones were analyzed on the HAWK pyrolysis instrument using both classical bulk-flow pyrolysis and HAWK-PAM the latter of which provides insights into boiling ranges. Hydrocarbons were extracted using DCM, while the extracted rock was analyzed using both pyrolysis methods. The extract was quantified and fingerprinted using both gas chromatography and PAM. The suppression effect of 'S2 shoulders' on maturity was evident on four cores. While the S1 mg HC/g rock values for the seven core samples were 5.3, 2.23, 2.82, 2.19, 8.33, 6.68 and 3.94 for Tmax (°C) maturity values of 436, 442, 458, 465, 443, 434 and 435 respectively, their S1+ ($S2_{\text{whole rock}} - S2_{\text{extract rock}}$) values were 20.07, 5.13, 5.18, 3.41, 15.32, 25.6 and 12.54 mg HC/g rock respectively. These two measurements, however, do not enable the discrimination of producible hydrocarbons because of the presence of sorbed oil which is highest in early mature cores. Conversion of mg HC/g rock measurements to their respective organic carbon using the assumption that 85% of hydrocarbons content is organic carbon, together with conversion of the quantified extracted organic matter (EOM) from ppm to weight % enabled the identification of a new set of pyrolysis attributes; For the Tmax (°C) maturity values of 436, 442, 458, 465, 443, 434 and 435 respectively, S1 organic Carbon/EOM was 0.18, 0.27, 0.34, 0.3, 0.42, 0.18, and 0.23; The ($C_4 - C_{19}$)/EOM ratio was 0.05, 0.1, 0.14, 0.14, 0.17, 0.05 and 0.09 while that of ($C_4 - C_{36}$)/EOM was 0.31, 0.36, 0.5, 0.39, 0.55, 0.24 and O.34 respectively. The ratio of ($C_4 - C_{19}$)/($C_4 - C_{36}$) yielded values of 0.17, 0.27, 0.28, 0.37, 0.31, 0.22 and 0.25. These four pyrolysis attributes enable ranking of predicted producible hydrocarbons, with the highest to lowest values in each of the attributes, corresponding to highest to lowest producible hydrocarbon contents. Determination of these pyrolysis attributes for a producing interval can provide calibration for predicting similar production.