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Geochemical methods for evaluating liquid-rich shale plays – capabilities and pitfalls

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Summary

The results of organic geochemical analyses when integrated with other types of data (e.g. petrophysical, inorganic, structural, etc) are important in assessing liquid-rich source rock plays. Different types of geochemical data are used for the exploration and production stages of exploitation of these resources. In the exploration stage, the object is generally to evaluate the extent of the play and where the highest ratio of producible liquids to gas obtainable through fracking will be found. During production, changes in GOR, and understanding changes in the flow rate of the well are commonly being assessed. The latter tends to concentrate on analysis of the produced hydrocarbons while there is more consideration of the kerogen component during the exploration stage. While these plays are called 'liquid-rich' it is generally natural-gas liquids and condensates that are the real target. This means that many of the standard geochemical methods use for conventional oil plays are generally not applicable over the elevated maturity range of tight oil plays.

For a liquid-rich shale play to work, it must be sufficiently organic-rich, have organic matter type capable of generating liquids, and be of the correct maturity. Screening for these parameters is usually done through some combination of LECO for TOC and Rock-Eval/SRA type pyrolysis instruments for organic type, maturity and sometimes TOC. These analyses are usually done in the lab but can also be done at the well-site. Organic petrography can also be used to assess maturity (e.g. vitrinite reflectance) and organic matter type. These methods have the benefit of being relatively cheap and appearing to give data that is straight-forward to interpret. However, care must be taken to QA/QC the data (especially for the effects of drilling fluids) and be aware of the possible pitfalls of accepting data at face value. For Rock-Eval data, it is important to keep in mind that Tmax is an approximate parameter that can be affected by organic matter and that towards the end of the oil window (maturity range of most liquid-rich plays), it is getting harder for the instrument to measure due to the flattening of the S2 peak. Additionally, the Tmax reported may not be related to kerogen maturity but from a second S2 peak related to pyrolysis of bitumen in the sample. Vitrinite Reflectance is potentially more accurate than Tmax over the maturity range of liquid-rich plays but is subjective (operator dependent). Also, vitrinite is rare in many source rocks (e.g. Duvernay), so other organic matter types should be measured such as the reflectance of bitumen which then needs to be converted to a vitrinite reflectance equivalent. Refinements of these basic tools are occurring and more advanced techniques, both chemical and optical, are available to characterize the solid organic matter if desired.

Analysis of the gas and oil in the shale, either produced at the well head or still in the source rock is important for understanding what is in the reservoir and how it can be produced. Compositional data is routinely assessed, usually by gas chromatographic techniques. There is

a trend towards performing light hydrocarbon (C1-C10) compositional analyses at the well-site where methane carbon isotopic composition can also be performed. These methods are not as accurate as lab based gas chromatographic and mass spectrometric methods but have the benefit of providing data in real time and with less potential loss of the lighter hydrocarbons. Lab based analyses remain important. These often use samples collected in isotubes for free gases and isojars for “absorbed gases” and liquids obtained from the cuttings as well as core samples and gases from desorption of core. Besides routine gas chromatographic compositional analyses, more refined techniques can be utilized such as isotopic analyses including compound specific isotope analyses (CSIA) of gas and liquid hydrocarbons, diamondoids and occasionally biomarker analysis in less mature samples. Liquid hydrocarbon samples are often still obtained using conventional solvent extraction methods (e.g. soxhlet). Unfortunately, a significant proportion of the C5-C12 hydrocarbons, which are of most interest in liquid-rich plays, are generally lost due to evaporation with these methods Solutions to this may be to use thermal or head space extraction techniques.

While there are is a wide diversity of methods available for organic geochemical assessment of liquid plays, there is at present no optimum/standard methodology. Many techniques are compromised by the sampling protocol used or by drilling and fracking additives. Ideas will be presented as to what the future will bring regarding geochemical tools that can be used for assessment of liquid shale plays.