

Designing Tight-shale Production Strategies using Diamondoid Nanotechnology

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Organic carbon content (TOC), hydrogen to carbon ratio (H/C ratio) and thermal maturity all play an important role in mapping out potentially productive regions of tight shales (e.g. Barnett, Marcellus, Eagleford, Fayetteville etc). TOC and H/C ratio can be measured directly and accurately from cores and cutting samples. Thermal maturity, on the other hand, and in particular the extent of oil cracking (thermal conversion of liquid to gas), can only be qualitatively estimated based on indirect techniques such as vitrinite reflectance, gas isotope data and Rock-Eval pyrolysis. Furthermore, the lack or paucity of vitrinite in some shales such as the Marcellus, makes accurate thermal maturity assessment difficult. The determination of diamondoid concentrations in tight shale core and cutting samples provides the first direct indication of natural oil cracking and also provides the first means of calculating the percentage of liquid within the shale which has been converted to gas. Diamondoids are hydrogen-terminated nanodiamonds which are present in all oils and rock extracts. Like larger diamond, they have high thermal stability which makes them ideal natural internal standards for studying oil cracking.

Diamondoid results presented for Barnett cores and cuttings along with samples from other tight shales show that where there is no oil cracking (thermal conversion of liquids to gas), there is no production. Where there is extensive oil cracking, e.g. over 90% of the liquids have been converted to gas (resulting in very high diamondoid concentrations), there is only gas production with very little associated liquids. It is where diamondoids reveal intermediate amounts of cracking (10-90%) that both gas and liquids are produced and where adjacent oil fields occur. Furthermore, because it is possible to calculate the amount of cracking using diamondoid concentrations, combined with TOC and H/C one can estimate the increase in pore pressure due to the natural conversion of oil to gas. Our results show that intermediate amounts of natural oil cracking in the Barnett results in pressures in excess of those used to hydro-fracture the rock.

By making maps of tight shale TOCs, H/C ratios, and diamondoid concentrations, it is possible to map out regions where little or no production is possible, regions where the shale will be productive but the hydrocarbons produced will be gas with no or very little liquid, and regions where both gas and liquids can be produced and where adjacent oil fields may be found. Other measurements of thermal maturity including vitrinite reflectance, gas isotopes, and Rock-Eval, all provide complimentary information to diamondoid results and rather than choosing a single analysis, it is best to run them all. However of these methods, diamondoid analysis is the first and only direct, quantitative measurement of liquid to gas conversion, i.e. oil cracking, a process which appears to be fundamental to designing optimal tight shale productions strategies.