A Compilation of Articles on Shale Plays and Unconventional Resources: The Role of Access and the Making of Normative Standards*

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Abstract

The individuals and organizations that are most open with their information tend to be the ones that are most highly cited, and what they say becomes, by default, a normative standard (even the "truth") even if the information turns out later to be incorrect or incomplete. At the very least, they are "taste-makers" and help popularize certain technologies, techniques, or ways of looking at a problem.

This phenomenon illustrates that the getting of knowledge is at heart a socialization process, and it also suggests how hard it can be to be truly innovative because, in many senses, one has to be in the box to think out of the box. Therefore, it's necessary to convince those who have based their perceptions of reality on the published norms that there are other, equally valid points, and, perhaps more importantly, that much of the information that remains confidential and not openly accessible can utterly demolish a set of assumptions.

In the case of shale plays, the implications of the most accessible data becoming the normative standard are breathtaking in scope and could involve billions of dollars. This applies not just to leasing, but also for technologies that are employed for locating sweet spots, and then for optimizing horizontal drilling, completions, and stimulation (including multi-stage hydraulic fracturing). Because of the impact of "normative standards," it is important to take a close look at articles and publications that are readily available, including open source and downloadable for free from the Internet, commercial publications, as well as peer-reviewed journals from professional societies.

To that end, this article presents a brief bibliography and listing of categories within unconventionals and shale plays which allows the reader to take a look at a few of the most accessible (and ostensibly influential) articles and studies, which have, by dint of accessibility, become normative standards, and their authors (in some cases) influential thought leaders.

This review does not include blogs, investor forums, sales sheets, infomercials, or overtly politically motivated publications.

"Thought Leaders": A Function of Access?

In the past, "thought leaders" may have been those who were most highly cited in peer-reviewed journals or ones whose books were carried in the most libraries and which received the best reviews.

With the Internet and social media, "thought leaders" are often those who have become very influential because their articles, posts, and presentations are easily accessed. For that reason, they tend to be picked-up and quoted in presentations, blogs, social media (FB, LinkedIn, Twitter), and their statistics and graphics are often liberally quoted and referenced. In addition, those who make white papers available through their company websites are also often referenced, but less so, since white papers are often not found by search engines because they're too nested in a company website, and retrieval often requires registration (for sales / marketing / tracking purposes).

In the case of easily accessed information, the articles and presentations are deemed credible via a relatively democratic process, although it can be said that some of the people who claim certain work is credible and go on to disseminate the information are not necessarily in a position to evaluate. In this case, I'm referring to activist groups, reporters, and bloggers who may wish to weigh in on a topic such as shale gas, but who do not have the requisite background to be able to debunk or dismiss specious claims, dated techniques, or simple errors.

In this context, emergent thought leaders should be considered alongside those whose work appears only in prestigious, refereed journals. In many cases, the authors who make their work available in open, easy-to-access locations also publish in refereed journals.

Further, it is useful to remember that it can take 2 years or so for a book to be published, while open-access sites can range from virtually instantaneous publication to a few months.

This is a brief compilation of recent articles and presentations pertaining to shale plays and unconventional resources. Many (but by no means all) "thought leaders" appear here, and it is very useful to take a look at what they are saying in relation to the other people who are publishing. The "conversation" is absolutely important to the advancement of science and technology, along with continued innovation and adoption.

Framing Thoughts: Where Are We Today Versus 2-3 Years Ago?

- Integrative, cross-disciplinary approach yields new insights.
- Case studies allow comparisons across plays.
- Not all sweet spots are the same // productive, economic zones vary by play.

- Petrophysics underutilized; should review, reprocess, re-evaluate old data (seismic, petrophysics, well logs, etc.).
- Geomechanical data is vital (pore pressure, ductility, brittleness, rock strength).
- Biostratigraphy / palynology can tie to other sources of information.
- Numerical methods and modeling: reservoir characterization enters new era.
- Lithology matters: tie core information, geochemistry, mud-log information, grain size, mineralogy.
- Geochemistry applies to origins and migrations: use geochemistry to discuss maturity, TOC, migration pathways, and to type the hydrocarbons to determine their source.
- Seismic: microseismic, tie to image logs; 3D seismic, wide and multi-azimuth acquisition.

Overviews of Shale Gas Reservoirs (with Reservoir Characterization)

Summary of Useful Aspects of the Literature and Key Limitations

It is tempting to try to standardize metrics so that it's possible to longitudinally compare shales and shale plays. The problem with the approach is that the plays themselves are so heterogeneous that it's difficult to assign values to rock properties. So, it might be more helpful to look at degree of variability and to compare rate / type of facies changes. It's important to bear in mind that the statistics used may be outdated, and it may be difficult to obtain information on key wells. Obviously not everyone is privy to the same information, and cores and petrophysical information along with seismic are not often publicly released if they are sensitive.

AAPG / Open Source

Passey, Q.R., K.M. Bohacs, W.L. Esch, R. Klimentidis, and S. Sinha, 2012, My Source Rock is Now My Reservoir - Geologic and Petrophysical Characterization of Shale-Gas Reservoirs: Search and Discovery Article #80231 (2012), http://www.searchanddiscovery.com/documents/2012/80231passey/ndx_passey.pdf
Overview of geochemistry, petrophysics, geology; includes description of TOC, organic matter type, models of TOC; also includes Woodford (Turner Falls roadcut) 20 wt% TOC / 40% Kerogen, looks at Woodford, Niobrara, Mowry, etc. Does rock composition matter? Reviews Eagle Ford, Vaca Muerta, Haynesville, Posidonia, Barnett, Horn River, Marcellus, Poland. TOC vs. Total Porosity in gas-bearing mudrocks. Review of shale oil. Summary: Shale gas reservoirs are overmature oil-prone source rocks; the parasequence is the fundamental building block of shale gas reservoirs; porosity, TOC, and gas content are all positively correlated for shale-gas reservoirs; free gas is likely to be largely in organic-matter porosity; gas-filled porosity (BVG) is better characterization term than Sg; the porosity system for fluids in organic-rich systems evolves with increasing maturity and is influenced matrix lithology. See SPE 131350 below.

Waldo, David Waldo, 2012, A Review of Three North American Shale Plays: Learnings from Shale Gas Exploration in the Americas: Search and Discovery Article #80214 (2012), http://www.searchanddiscovery.com/documents/2012/80214waldo/ndx_waldo.pdf

This is a very helpful review of Barnett, Eagle Ford, and the Marcellus. Overview of why shale gas is important (2000 tcf in North America alone). Article contains a list of rough in-place estimates for the major plays in the U.S. and Canada. Discusses how and why shales are all different. What do you need to know?
Parameters and Optimal Targets:

- Source Rock Quality – TOC- 2 – 5% by weight
- Source Maturity: Ro for dry gas and wet gas
- Gas Quality: Ideally less than 2% CO_2, N_2, no H_2S
- Structural Complexity: simple structural architecture
- Timing of Burial / Uplift: Ideally at peak maturity, no inversion and uplift with induced fractures of top seal
- Clay content / brittle index: less than 40 percent Vclay; direct measurement of brittle index required
- Presence of water-filled aquifer: separated from target source intervals by ductile barriers
- Geomechanics (stress regime): knowledge required for orientation of laterals and subsequent frac orientation
- Pore Pressure: Pressure gradient from 0.53 to 0.76 psi/ft – knowledge required to select frac fluids and proppants

Review of elements required to make the shale gas play work (environment, water, proppant, infrastructure, manpower, community and government support
Review of Shales:

- Cretaceous Eagle Ford
- Mississippian Barnett
- Devonian Marcellus Shale

Roth, Murray, North American Shale Gas Reservoirs – Similar, yet so different: Search and Discovery Article #80136 (2011), http://www.searchanddiscovery.com/documents/2011/80136roth/ndx_roth.pdf
Overview of how / why shales are different. Review of the kinds of maps that can be very useful: hydrocarbon potential maps, rock crackability maps, and existing fractures maps.

Journals

Spaw, Joan M., 2012, Identification, Integration and Upscaling of Mudrock Types - A Pathway to Unlocking Shale Plays: SPE/EAGE European Unconventional Resources Conference and Exhibition, 20-22 March 2012, Vienna, Austria / Document ID 153111-MS.

Dicman Alfred, Dieman, and Lev Vernik, 2012, A New Petrophysical Model For Organic Shales: SPWLA 53rd Annual Logging Symposium, June 16 - 20, 2012, Cartagena, Colombia.

Q.R. Passey, K.M. Bohacs, W.L. Esch, R. Klimentidis, and S. Sinha, 2010, From Oil-Prone Source Rock to Gas-Producing Shale Reservoir - Geologic and Petrophysical Characterization of Unconventional Shale Gas Reservoirs: SPE 131350, 29p., http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-131350-MS

Commercial Press

Joanne Wang and Duane Dopkin (2012) Shale plays can be interpreted and characterized using seismic attributes, http://www.worldoil.com/October-2012-Shale-plays-can-be-interpreted-and-characterized-using-seismic-attributes.html

Unconventional Reservoirs

Summary of Useful Aspects of the Literature and Key Limitations:

AAPG / Open Source

The articles are very helpful in developing a standardized way in which to view, measure, and evaluate properties of unconventional resources. Since technology is evolving very quickly, it's best to consider all works as points of departure, and to ask about lessons learned when contacting a service company or discussing completion experiences with an operator.

Cander, Harris, 2012 What Are Unconventional Resources? A Simple Definition Using Viscosity and Permeability: Search and Discovery Article #80217 (2012), http://www.searchanddiscovery.com/documents/2012/80217cander/ndx_cander.pdf (abstract and poster)

Daniel J. Soeder (2012) The Successful Development of Shale Gas Resources in the United States: Search and Discovery Article #41058 (2012), http://www.searchanddiscovery.com/documents/2012/41058soeder/ndx_soeder.pdf

Society Journals

Maity, D., and F. Aminzadeh, 2012, Reservoir Characterization of an Unconventional Reservoir by Integrating Microseismic, Seismic, and Well Log Data: SPE Conference Paper 154339-MS.

Marcellus

Summary of Useful Aspects of the Literature and Key Limitations

As is the case with all "hot" plays, the information is rather dated by the time it is released. However, the presentations do help bring together regional structural geology and the highly variable lithologies and fracture patterns. The most valuable papers discuss how to integrate disparate data, including rock properties (Poisson's ratio, Young's modulus), geochemistry, and well logs.

AAPG / Open Source

Lash, Gary G., and Randy Blood, 2012, Barite Mobilization in the Upper Devonian Succession of Western New York – Evidence for Anaerobic Methane Oxidation and Methanogenesis during Quasi-Steady State Burial: Search and Discovery Article 50744 (2012), http://www.searchanddiscovery.com/documents/2012/50744lash/ndx_lash.pdf

Avary, Katharine Lee, and Katherine Schmid, 2012, The Marcellus Shale.... By the Numbers: Search and Discovery Article #10447 (2012), http://www.searchanddiscovery.com/documents/2012/10447avary/ndx_avary.pdf

William Zagorski, William, 2010, The Appalachian Marcellus Shale Play – Discovery Thinking, Timing, and Technology: Search and Discovery Article #110138 (2010), http://www.searchanddiscovery.comwww.searchanddiscovery.com/documents/2010/110138zagorski/ndx_zagorski.pdf

Commercial press

Inman, Mason, February 29, 2012, Estimates Clash for How Much Natural Gas in the United States (Terry Engelder cited) http://news.nationalgeographic.com/news/energy/2012/03/120301-natural-gas-reserves-united-states/

Service Company White Papers

Schlumberger, 2011, Technical Paper: Seismic Reservoir Characterization in Marcellus Shale http://www.slb.com/resources/technical_papers/westerngeco/seg2011232.aspx

Baker Hughes, 2012, Technology Integration: A Methodology to Enhance Production and Maximize Economics in Horizontal Marcellus Shale Wells http://www.bakerhughes.com/news-and-media/resources/spe-technical-papers/technical-paper-135262-ms

Woodford

Summary of Useful Aspects of the Literature and Key Limitations

There has been a tremendous amount of energy and enthusiasm with respect to this play. The optimistic recoverable reserves projections do not necessarily reveal all their underlying assumptions about rock properties, reservoir connectivity and compartmentalization, fracture characterization, and lateral variability of lithology. Reality could be much higher than projected (as in the case of the Bakken, where the USGS will release in 2013 an update to their 2008 reserves estimate, and the results are expected to more or less double the original reserves). On the other hand, the play's ultimate recoverable reserves could be lower. Much depends on the development of technology along with better reservoir characterization.

USGS / Open Source

Higley, Debra K., 2011, Undiscovered petroleum resources for the Woodford Shale and Thirteen Finger Limestone–Atoka Shale assessment units, Anadarko Basin: U.S. Geological Survey Open File Report 2011–1242, 3 sheets, http://pubs.usgs.gov/of/2011/1242

AAPG / Open Source

Slatt, Roger M., and Neal R. O'Brien, 2011, Pore Types in the Barnett and Woodford Gas Shales: Contribution to Understanding Gas Storage and Migration Pathways in Fine-Grained Rocks (abstract and presentation): Search and Discovery Article #80166 (2011), http://www.searchanddiscovery.com/documents/2011/80166slatt/ndx_slatt.pdf

Caldwell, Craig D., 2011, Lithostratigraphy of the Woodford Shale, Anadarko Basin, West-Central Oklahoma: Search and Discovery Article 50518 (2011), http://www.searchanddiscovery.com/documents/2011/50518caldwell/ndx_caldwell.pdf

Badra, Henry, 2012, Fracture Characterization and Analog Modeling of the Woodford Shale in the Arbuckle Mountains, Oklahoma, USA: Search and Discovery Article #80207 (2012) (note: Roger Slatt was Henry Badra's advisor), http://www.searchanddiscovery.com/documents/2012/80207badra/ndx_badra.pdf

Buckner, Nichole, Roger M. Slatt, Bill Coffey, and Robert J. Davis. (2009) Stratigraphy of the Woodford Shale from Behind-Outcrop Drilling, Logging, and Coring: Search and Discovery Article #50147 (2009), http://www.searchanddiscovery.com/documents/2009/50147buckner/ndx_buckner.pdf

Service Company White Papers

Schlumberger, 2011, Case Study: Advanced Logging Technology Reveals the Most Productive Zones in Woodford Shale Wells, http://www.slb.com/resources/case_studies/technical_challenges/unconventional_gas/shale_gas/advanced_logging_woodford_shale.aspx

Commercial Press

Redden, Jim, 2013, Woodford Shale: SCOOP helps advance Oklahoma's drive for oil: World Oil, v. 234, no. 1, http://www.worldoil.com/January-2013-Woodford-Shale-SCOOP-helps-advance-Oklahomas-drive-for-oil.html

Kulkarni, Pramod, 2012, Woodford growing revenues by farming to oily shale: World Oil, January 2012, http://www.worldoil.com/January-2012-Woodford-growing-revenues-by-farming-to-oily-shale.html

Kulkarni, Pramod, 2011, An unconventional play with conventional E&P constraints: World Oil, February 2011, p. 93-98, https://slb.com/~/media/Files/industry_challenges/unconventional_gas/industry_articles/201108_wo_woodford_shale_complexities.pdf

Eagle Ford

Summary of Useful Aspects of the Literature and Key Limitations:

The future of the Eagle Ford seems to tie with the adjacent formations as well, and so the articles that discuss systems rather than individual formations are most useful.

AAPG / Open Source

Bowman, Thomas D., 2011, Hydrocarbon Potential of Upper Cretaceous Shale Sections, Including Eagle Ford, Woodbine, and Maness Shale, Central Texas: Search and Discovery Article #10328 (2011), http://www.searchanddiscovery.com/documents/2011/10328bowman/ndx_bowman.pdf

Treadgold, Galen, Bill McLain, Steven Sinclair, and David Nicklin (2011) Eagle Ford Shale Prospecting with 3D Seismic Data within a Tectonic and Depositional System
Framework (abstract): Search and Discovery Article #90122 (2011), http://www.searchanddiscovery.com/abstracts/pdf/2011/hedberg-texas/abstracts/ndx_treadgold.pdf

Basu, N., G. Barzola, H. Bello, P. Clarke, and O. Viloria, 2012, Eagle Ford Reservoir Characterization from Multisource Data Integration: Search and Discovery Article #80234 (2012), http://www.searchanddiscovery.com/documents/2012/80234basu/ndx_basu.pdf

Operator White Papers

Marathon Oil Corporation, 2012, Eagle Ford Oil and Natural Gas Fact Book, 20p., http://www.marathonoil.com/content/documents/news/eagle_ford_fact_book_final.pdf

Service Company White Papers

Schlumberger, 2011, Technical Paper: Understanding Production from Eagle Ford-Austin Chalk System, http://www.slb.com/resources/technical_papers/technical_challenges/unconventional_gas/145117.aspx

Commercial Press

Redden, Jim, 2012, Eagle Ford: Rig Count Down: Operators Cautiously Bullish as Permits, New Wells Soar: World Oil July 2012, http://www.worldoil.com/July-2012-Eagle-Ford-rig-count-down-operators-cautiously-bullish-as-permits-new-wells-soar.html

Bakken

Summary of Useful Aspects of the Literature and Key Limitations:

The USGS is revising its 2008 estimates of 4.3 billion barrels of technically recoverable oil from the Bakken (in the U.S. side of the play) and plans to have the study completed by late 2013. What is technically recoverable in 2013 is dramatically different than when the study was previously conducted. Harold Hamm, CEO of Continental Resources, has publicly stated that they believe that the Bakken holds at the least 24 billion barrels of recoverable oil. Most expect at least a doubling to 8 billion barrels. This holds out a great deal of promise for innovative engineers who can develop new technologies to produce the liquids-rich hydrocarbons of the play.

AAPG / Open Source

Sonnenberg, Stephen A., 2012, The New Bakken Play in Eastern Montana, http://www.searchanddiscovery.com/documents/2012/10424sonnenberg/ndx_sonnenberg.pdf

Journal

L. Alcoser, L., W. Ketcham, A. Ovalle, and M. Parsons, 2012, The Bakken: Utilizing a Petroleum System Based Analysis to Optimally Exploit One of the World: SPE Hydrocarbon Economics and Evaluation Symposium, 24-25 September 2012, Calgary, Alberta, Canada Document ID 158918-MS.

Service Company White Papers

Schlumberger, 2012, Case Study: Accurate Total Porosity for Bakken and Three Forks Formations http://www.slb.com/resources/case_studies/evaluation/litho_scanner_bakken_three_forks_cs.aspx

Commercial Press

Tyson, Ray, 2013, PN Bakken: Bakken reserves to jump -- USGS next recoverable oil estimate expected to double to 8 billion barrels: Petroleum News, v. 17, no. 16, http://www.petroleumnews.com/pntruncate/709714248.shtml

Redden, Jim, 2012, Bakken/Three Forks Infrastructure, takeaway woes only threats to high activity: World Oil, May 2012, http://www.worldoil.com/May-2012-Bakken-Three-Forks-Infrastructure-takeaway-woes-only-threats-to-high-activity.html

Hydraulic Fracturing

Selected Useful Literature

AAPG / Open Source

Maxwell, Shawn, and Mark Norton, 2012, The Impact of Reservoir Heterogeneity on Hydraulic Fracture Geometry: Integration of Microseismic and Seismic Reservoir Characterization: Search and Discovery Article #40993 (2012), http://www.searchanddiscovery.com/documents/2012/40993maxwell/ndx_maxwell.pdf

Dussealt, Maurice, 2011, Massive Multi-Stage Hydraulic Fracturing: Where Are We?: American Rock Mechanics Association e-Newsletter, January,, 2011, 14p., http://www.armarocks.org/documents/newsletters/dussealt_massive_multistage_hydrolic_fracturing.pdf

White Papers

COGA, 2011, Hydraulic Fracturing White Paper: Colorado Oil and Gas Association, 4p., http://www.coga.org/pdfs_facts/Hydraulic%20Fracturing%204.pdf

Journals / Society Publications

Agarwal, A., Chevron; Y. Wei, and S.A. Holditch, 2012, A Technical and Economic Study of Completion Techniques in Five Emerging US Gas Shales: A Woodford Shale Example: SPE Drilling & Completion, v. 27, no. 1, p. 39-49; SPE-135396-PA.

George King, George E., 2012, Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Oil and Gas Wells: SPE 152596, http://www.kgs.ku.edu/PRS/Fracturing/Frac_Paper_SPE_152596.pdf

Commercial Press

Daneshy, Ali, 2012, Diagnostic Tools for Hydraulic Fracturing: World Oil, November, 2012, http://www.worldoil.com/November-2012-Diagnostic-tools-for-hydraulic-fracturing.html

Geochemistry

Selected Useful Literature

AAPG / Open Source

Laughrey, C.D., T. E. Ruble, H. Lemmens, J. Kostelnik, A.R. Butcher,
G. Walker, and W. Knowles (2011) Black Shale Diagenesis: Insights from Integrated High-Definition Analyses of Post-Mature Marcellus Formation Rocks, Northeastern Pennsylvania: Search and Discovery Article #110150 (2011),
http://www.searchanddiscovery.com/documents/2011/110150laughrey/ndx_laughrey.pdf

Jarvie, Dan, 2011, Worldwide Shale Resource Plays and Potential: Search and Discovery Article #80144 (2011),
http://www.searchanddiscovery.com/documents/2011/80144jarvie/ndx_jarvie.pdf

Journals / Society Publications

Loucks, R.G., R.M. Reed, S.C. Ruppel, and D.M. Jarvie, 2009, Morphology, genesis, and distribution of nanometer-scale pores in siliceous mudstones of the Mississippian Barnett Shale: JSR, v. 79/12, p. 848-861.

Commercial Press

Edman, Janelle, 2012, How local variations in thermal maturity affect shale oil economics and producibility: World Oil, March, 2012,
http://www.worldoil.com/March-2012-How-local-variations-in-thermal-maturity-affect-shale-oil-economics-and-producibility.html