Using Bayesian Belief Networks to Evaluate Continuous Gas Resources (Shale Gas, Tight Gas, and Coal Bed Methane): Tools to Calibrate the Expert and Exploit Knowledge

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In Unconventional Resources (Shale Gas, Tight Gas, and Coal Bed Methane) the hydrocarbon system elements (source, reservoir, seal, hydrocarbon recovery, etc.) are controlled by the properties of a single lithology or closely spaced groups of lithologies. The ability to commercially extract natural gas from Unconventional Resources represents the primary risk in these resource types, and the commerciality of a particular play varies spatially within the region of hydrocarbon occurrence. Therefore it is critical to identify and evaluate the commerciality of Play Fairways (aka Sweet Spots) and differentiate these fairways from non-commercial areas.

Although the properties of a single lithology can control Unconventional Resource commerciality, the properties of that single lithology represent the complex interaction of sedimentation and basin/tectonic evolution. In addition, Unconventional Resources require artificial stimulation (generally hydraulically induced fractures) in order to produce gas at commercial rates. Understanding/predicting commerciality in Unconventional Resources therefore requires understanding of a complex natural system and how that system will respond to engineering intervention.

In comparison to the complexity of the system, geoscientists generally have little data of sufficient quality to apply machine learning techniques. Expert systems such as Bayesian Belief Networks (BBN) are being used successfully to evaluate Unconventional Resources. BBNs are used to: 1) Break the complex system into smaller, tractable pieces. 2) As a flexible tool to incorporate beliefs based on theory, empiricism, and tacit expert knowledge. 3) Manage system and input uncertainty. 4) Improve expert understanding, improve communication, and as a tool to teach new practitioners.

To exploit the power of BBNs as a predictive tool, numerous tools that link BBNs to Geographic Information System (GIS) data have been developed within ExxonMobil. These tools: 1) Allow for output maps to be created based on BBN output and GIS based inputs 2) Visualize probabilistic output. 3) Aggregate probabilistic results to summarize resource estimates for areas of interest. In addition a GIS enabled database of calibration data has been created that allows for the comparison of BBN predictions to actual results. These validation tools are used by the expert to improve predictive ability and gain insight into Unconventional Resources systems.