Preliminary Conclusions and Conceptual Model Building

Preliminary Conclusions of the Study

Although still quite early in the process of interpreting the data, early results indicate subtle differences in the water chemistry of different formations as shown in the historical analyses.

In general, the TDS of a water is a function of the original depositional environment of the formation. However, there is much overlap and it is these departures from the averages that will be used understand the distribution of different water chemistries in the subsurface.

The most signficant early result is the strong correlation between TDS and fracture density for the Frontier Formation. If this trend holds for the other formations, as we believe it will, this lends stronger support for the high TDS anomolies along fracture traces shown by Smith (1998). Further, this can be developed into an important tool for remediation of excess water production.

Conceptual Model Building

A key task of the project is to use the compositional, stratigraphic and geographic information assembled in the Database phase to define the limits of variability inherent in the produced waters. In so doing, criteria can be developed upon which to judge the nature, distribution and role of the fluids in the reservoirs.

For example:

Are the produced waters originally native to the sediments or have they been circulating as part of a deep hydrologic cell?

Do the waters move through interstitial pores or are they moving in frac tures? The entire basin centered concept is structured around pore throat size and its impact on entry pressures. How does this concept need to be altered to integrate natural fractures into the equation?

Are the waters part of a “conventional” gas/water reservoir system developed within the overall basin-centered accumulation or part of another, yet to be described system?

Do the waters play one role, or several and what are they and their associated settings? ie Seal? Secondary porosity generator? Merely a production head ache?

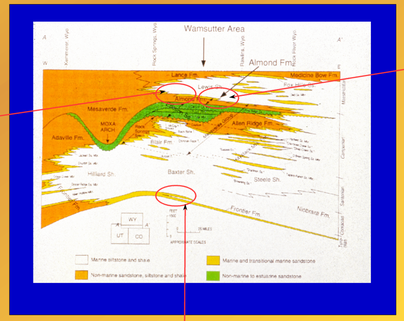
Is it possible to estimate the amount of moveable water in a reservoir and evaluate the economics of a drawdown scenario?

Are there additional criteria or indicators that can be used to forecast presence/absence of move able water in a deep, geopressured reservoir?

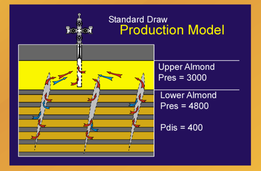
Can the basin-centered hypothesis be refined and strategies developed to economically recover additional resources from presently uneconomic, deep, tight reservoirs?

The major objective of the conceptual modeling portion of this project is to use the assembled data to organize and follow a critical path towards answer(s) to questions such as these.

The Roehler (1990) cross section of the eastern Greater Green River Basin can be used to demonstrate the diversity of the water problem in basin centered operations.

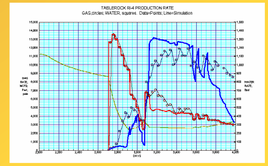


Smith (1998) identifies apparent coal and basement influence on water composition in Echo Springs/Standard Draw fields.



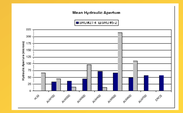
Time series chemical analyses and isotopes indicate a complex production scenario.

Billingsley et al (2003) build reservoir model of apparent conventional, fractured Frontier reservoir at Table Rock deep in the “basin-centered” Frontier interval.



The Table Rock Frontier reservoir has undergone severe fracturing and later shearing during Laramide tectonic activity, creating a well interconnected dual permeability fractured reservoir deep in geopressures.

Evans (2000) describes an apparent aperature sensitivity of water production in the Siberia Ridge Mesaverde play.



The Siberia Ridge 5-2 produced significantly more water out of the lower Almond section than the SR 27-4, likely because of the greater hydraulic aperatures of the fractures. Proximity to a fault was hypothesized as the reason for the disparity in aperature size.

Acknowledgements

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Future Directions

Although a great deal can be learned from the historical samples and previous work, water chemistry has advanced along with experience and ideas regarding the distribution and role of water in basin centered accumulations.

A new sampling program is currently being planned and will begin this summer. New water samples will be more extensively analyzed. In addition to the seven major components and pH, we will be analyzing the new samples for minor components and isotopes. The minor components will include silica (Si), aluminum (Al), barium (Ba), and Sr (strontium), among others. We will also measure total dissolved carbon (TOC). We will also include stable isotopes of oxygen and hydrogen and radiogenic isotopes of strontium.

The minor components and TOC will delineate subtle changes in water chemistry than might be discerned from the seven major components. The stable and radiogenic isotopes will allow us to more precisely fingerprint individual samples. Stable isotopes are a means of examining two issues with water from gas wells. First, the stable isotopes can be used to determine whether or not the water being sampled was actual formation water or water resulting from condensation of water vaporized in the gas stream (dew point water). The radiogenic isotopes record the history of the water-rock interaction and will be used to ascertain if a water sample is originally from the reservoir where it was sampled or if it has migrated from elsewhere. Radiogenic isotopes can also be an indication of isolated compartments. Thus they are a valuable addition to the water chemistry toolbox for examining sources of water and the remediation of water production.

The water chemistry data will be integrated with the geology of the producing areas (in particular, the Waltman/Cave Gulch Field Demonstration area) to delineate conceptual models for the distribution and role of water in these complex settings. Strategies for remediating or avoiding highly mobile water will be built and tested from these models.

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