Monday, February 7, 2005

Westchase Hilton • 9999 Westheimer
Social 5:30 p.m., Dinner 6:30 p.m.

Cost: $25 Preregistered members; $30 Nonmembers & Walk-ups

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*by **Keith Shanley** and **Robert M. Cluff***
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Understanding Myths and Realities of Basin-Centered Resources

With demand for efficient, environmentally clean sources of energy increasing, attention is sharply focused on natural gas resources. Within North America, much of this attention is directed at unconventional resources, particularly those commonly referred to as basin-centered or continuous-type gas accumulations.

We have re-examined the controls on gas production from very low-permeability reservoirs. Our work in the Green River Basin of southwest Wyoming clearly indicates that low-permeability reservoirs in this basin are not part of a continuous-type gas accumulation or a basin-center gas system in which productivity is dependent on the development of enigmatic "sweet-spots." Rather, gas fields in this basin occur in low-permeability, poor-quality reservoir rocks within conventional traps. Examination of fields with greater than 50 BCFE expected ultimate recovery indicates that 38% of the gas fields involve structural traps accounting for 50% of the gas production, 41% of the gas fields involve stratigraphic traps accounting for 30% of the gas production, and 21% of the fields occur in combination traps contributing 20% of the gas production. In no case was a significant gas field found to occur as a sweet spot within a background matrix of poor rock. Nor was there a significant gas field that could be explained as simply the preferred occurrence of natural fractures.

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We present evidence that the basin is neither regionally gas-saturated, nor is it at or near irreducible water saturation. Water production is both common and widespread. Our work shows that while overall water volumes are indeed low, water-gas ratios are much higher than can be explained as water of condensation. In the greater Green River Basin (GGRB), water of condensation should be less than approximately 1.0 bbl water/MMscf gas. Of more than 7500 producing gas wells in the GGRB, 70% of the wells have water-gas ratios in excess of 1.0 bbl wtr/MMscf gas. These wells account for almost 50% of the basin's gas production. In many fields, water-gas ratio data show a clear increase in water-gas ratios toward the down-dip margins of gas accumulations, something that is commonly observed in conventional petroleum provinces.

We have also re-examined key petrophysical relationships in low-permeability reservoirs through the collection of a large data-set of effective permeability measurements at varying water saturations and at overburden stress. These data show that unlike more traditional reservoirs, low-permeability reservoirs are characterized by having critical water saturations that are substantially less than irreducible water saturations and critical gas saturations in the vicinity of 50% water saturation. These observations have been captured in a model now known as "permeability jail" emphasizing the fact that there exists a relatively broad range of water saturations across which neither water nor gas can be effectively produced, despite the fact that both phases are present in the reservoir. The lack of water production does not relate to irreducible water saturation as had been previously suggested, rather it simply suggests that water saturation is less than critical water saturation.

We conclude that low-permeability gas systems similar to those found in the greater Green River Basin do not require a paradigm shift in terms of hydrocarbon systems as some have suggested. Rather, these gas systems are conventional in nature. Gas accumulations are not continuously distributed but rather are distributed in discrete accumulations whose boundaries are well explained. As a result, resource assessments have very likely greatly overstated the potential resource and at the same time have under-estimated the risks associated with exploration and development investment decisions in these low-permeability systems.

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For enterprises engaged in exploration and production in these settings, attention must be paid to the conventional elements of risk within the petroleum systems, namely, reservoir, trap, seal, source, migration and charge. Substantial opportunity remains in many of these basins. For enterprises engaged in gas-supply issues, it must be realized that there is greater risk associated with exploration and the identification of new sources of gas than is generally appreciated. Finally, for those groups engaged in public policy, land-use planning, etc., the increased uncertainty in supply should encourage the creation of alternate energy options as opposed to reliance on a limited suite of resources whose risks are greater than advertised. ■

Biographical Sketch

Keith W. Shanley is a consulting geologist with The Discovery Group in Denver, Colorado. Keith has more than 22 years of experience in exploration, development, research and technology development and has worked in a variety of basins around the world for both major and independent oil companies. Keith received his BA degree in geology from Rice University in Houston, TX., and his MSc and PhD degrees in geology from the Colorado School of Mines in Golden, Colorado. He has served as a volunteer with the U.S. Geological Survey and as an interim instructor at the Colorado School of Mines. He has published papers, edited volumes and organized conferences and seminars dealing with sequence stratigraphy, reservoir architecture, non-marine sedimentology and stratigraphy, and issues surrounding tight-gas. His current research interests include sequence stratigraphy and reservoir architecture, and the integration of petrophysics and risk analysis. Shanley is an Associate Editor for the AAPG and SPE. He is a member of the AAPG, SEPM, SPE, RMAG and SPWLA and is a registered geologist in both Texas and Wyoming.

Keith Shanley's most recent publications providing a critical review of tight-gas resources, insights to the controls on production and economic consequences appeared in the August 2004 AAPG *Bulletin* and the August 8 edition of the *Oil and Gas Journal.*