Tuesday, January 20, 2004

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Social 11:30 a.m., Lunch 11:45 a.m.

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HGS NorthSiders
Luncheon Meeting

by ***Kevin M. Bohacs***
ExxonMobil Upstream Research Company

Slime, Sand, and Shells: Lacustrine Hydrocarbon Play Elements Within a Continental-Environment Phase Stability Framework

Lake basin types have characteristic associations and distributions of hydrocarbon source, reservoir and seal strata. These differences arise mainly from distinct histories of lake hydrology, which control the evolution of lake water chemistry, the nature and stability of food webs and clastic sediment supply rates. Hydrocarbon sources are influenced strongly by these controls on the ecosystem and reservoir- and seal-prone strata are linked to these controls through the timing of clastic sediment supply relative to lake level and the influence of water chemistry on the dominant lithology (e.g., clastic, carbonate, evaporite).

The strong genetic association of play elements requires an integrated approach to prediction, which is facilitated by expanding the lake-basin-type diagram (Carroll and Bohacs, 1995, 1999) to a full continental-environment phase stability framework. This framework places fluvial, floodplain, coal, aeolian and the three lake-basin-type strata into relative stability fields, constrained by their inter-related controls: the rate of potential accommodation relative to supply rates of sediment and of water. The phase trajectory of basin evolution determines the proportion of each lake basin type in the resultant strata. This approach helps explain why all lake basins do not contain the full suite of lake basin types and how the fill of a chain of ancient lakes may be genetically related. One can predict phase trajectories in a forward sense from estimates of basin subsidence, paleoclimate and sediment yield, or one can reconstruct phase trajectories from relative thicknesses and areal extents of each continental environment stratal package: thick underfilled lake packages point to dominant control of potential accommodation rates whereas thin underfilled lake packages indicate dominant control of supply rates of sediment plus water.

Hydrocarbon sources are influenced strongly by these controls on the ecosystem.

Associated fluvial styles among the lake basin types appear to vary systematically, with perennial, high-sinuosity streams in overfilled, intermittent to perennial low-sinuosity streams in balanced fill and a wide range from ephemeral sheetflood/braided streams to perennial high-sinuosity streams in underfilled lake basins. Lateral distributions of reservoir-prone strata also vary significantly among lake basin types and lake shoreline shapes encompass a richer diversity than typically seen in marine settings: shorelines tend to be more highly constructive and dispersive in more persistently closed hydrologic basins. Fundamental changes in shoreline type and lake character between highstands and lowstands may even obviate the application of Walther's Law for predicting lateral distributions, especially in underfilled lake basins. Ultimate reservoir quality may be related to phase trajectory through the diagenetic effects of fluctuating groundwater tables. Each lake-basin type has a characteristic history of groundwater level changes, recorded in recurring associations of paleosol types and ichnofossil assemblages: histosols and shallow single-tier burrows, tracks and trails in overfilled, vertisols and multi-tier, moderate depth insect burrows in balanced fill, and aridisols and entisols with multi-tier, multiple-generation, relatively deep burrows in underfilled lake basins.

Observations indicate that these associations of hydrocarbon play elements occur in a wide variety of tectonic settings and ages, from continental rift to convergent foreland basins of Cambrian to recent age. Continued success in economic discovery and efficient recovery of hydrocarbons depend upon continued testing and elaboration of these concepts and a deeper understanding of the essential processes controlling deposition of lacustrine strata. ■

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Biographical Sketch

KEVIN M. BOHACS (BSc Honors, Geology, University of Connecticut, 1976; ScD in experimental sedimentology, M.I.T., 1981) is a sedimentologist and stratigrapher with ExxonMobil Upstream Research Company. At URC, he leads investigations of organic-rich rocks from deep sea to lakes, in basins around the world. He tries to keep the "geo" in geochemistry by integrating field work, subsurface investigation, and laboratory analyses. He divides his time between geological research, collaborative studies with exploration companies, and teaching stratigraphy and hydrocarbon-system analysis in the classroom and field. His awards include AAPG's Jules Braunstein Memorial Award (1995), Best International Paper (1998), AAPG Distinguished Lecturer (1999–2000), and Petroleum Exploration Society of Australia Distinguished Lecturer (2001).