Diagenetic Controls on Reservoir Character of Chert-Rich Mississippian (Osagean) Strata: Porosity Enhancement from Subaerial Exposure or Hydrothermal Fluids

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TIMING: Significant results reported to membership
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Purpose
“Chat” is an informal name for high porosity, low resistivity chert reservoirs in the mid-continent (Watney et al., 2001). The most productive and economic chat reservoirs are tripolitic chert exhibiting variable amounts of sponge-spicule molds, chert microporosity, vuggy porosity, and breccia (Rogers et al., 1995; Montgomery et al., 1998). Porosity distribution is clearly related to dissolution of both carbonate fine-grained silica phases. This study will attempt to develop an understanding of the diagenetic controls on porosity distribution in a system underlying a major unconformity and in a region subject to significant porosity modification by hydrothermal fluids. The effect of each of these variables on porosity distribution will be evaluated as a means of improving models for exploitation of chat and other reservoirs in similar settings. Using diagenetic concepts, it may be possible to predict enhanced reservoir porosity elsewhere.

Project Description
The Mississippian strata in Kansas are cherty, partially dolomitized skeletal (especially crinoidal) packstones and grainstones and cherty, partially dolomitized and argillaceous wackestones and mudstones (Watney et al., 2001; Franseen, 2006). In ramp-margin settings, the Osagean strata are siliceous sponge-dominated and heterozoan carbonate facies. The sub-Pennsylvanian unconformity represents an extended period of subaerial exposure and its subcrop defines the main structural provinces in Kansas (Figure 1), (Merriam, 1963; Montgomery et al, 1998; Watney et al., 2001, Franseen, 2006). Comparable to many major carbonate reservoirs, porosity was modified during weathering in association with this unconformity.

Alternatively, there is extensive evidence for expulsion of hydrothermal fluid during the Permian and later, and the migration of these fluids may have been equally responsible for porosity enhancement (Banner et al., 1998a, Banner et al., 1998b, Brannon et al., 1996, Coveney, 1992, Coveney, 1999). The area of study is just adjacent to the Tri-State Mississippi Valley Type (MVT) Zn-Pb deposits in Missouri, Kansas, and Oklahoma (Figure 2). Successful radiometric dating indicates formation of the MVT ore deposits during the late Paleozoic Alleghenian-Ouachita orogeny (Brannon et al., 1996). The presence of mineralization, coarse baroque dolomite, hydrothermal geochemical signatures, and elevated thermal maturity of organic matter in the Osagean chert indicate hydrothermal fluids moved
through these rocks (Watney et al., 2008, Wojcik et al., 1992, Wojcik et al., 1994, Wojcik et al., 1997). Regionally, the brecciated strata immediately below the Miss-Penn boundary are known to be the preferred flow unit for MVT mineralization.

If porosity enhancement is related to subaerial exposure and karst at the Miss-Penn boundary, then pore-forming events will predate collapse of karst features, infilling of Pennsylvanian shale, and compaction. If it is related to migration of hydrothermal fluids, it should be proximal to fractures/faults and surfaces acting as conduits for fluid migration. It will form after compaction features and be paragenetically or spatially related to ore and gangue minerals in fractures, faults, and breccia openings. Major diagenetic events will be analyzed using cathodoluminescence petrography, cement stratigraphy, and fluid inclusions (Dickson, 1966, Meyers, 1974, 1991; Kaufman et al., 1988; Goldstein and Reynolds, 1994).

**Deliverables**

Using petrographic analysis to determine paragenesis will unveil timing of porosity enhancement. Paragenesis will also unveil diagenetic enhancement of porosity in association with either the sub-Pennsylvanian unconformity of migration of hydrothermal fluids. Fluid inclusions will reveal timing, and influence of hydrothermal fluids on the system.

Results show that there is porosity enhancement during subaerial exposure at the Miss-Penn boundary. Porosity enhancement also forms well below the alteration zone near the unconformity, after compaction and initiation of hydrothermal fluid circulation. Porosity enhancement is preferential in fault and fracture zones and in stratigraphic breccia zones that act as preferred conduits for late fluids. Porosity enhancement forms during the ramping up of the hydrothermal system from 80°C to 155°C.

The results of this study contribute to better prediction of enhanced reservoir porosity and delineating additional conventional and unconventional gas reservoirs in systems associated with unconformities or hydrothermal fluids.

**References**


COVENEY, R.M.JR., 1992, Evidence for expulsion of hydrothermal fluids and hydrocarbons in the Midcontinent during the Pennsylvanian: in Johnson, K.S., and Cardott, B.J., eds,


Figure 1. Mississippian subcrop map for the state of Kansas (modified from Merriam, 1963; Gerlach 1998)

Figure 2. Surface structures on bedrock geologic map of eastern Kansas and western Missouri. The proximity of faults, the matrix porosity, and the brittle nature of these cherts make them especially prone to serving as paths for fluid migration. Red lines indicate lineaments; purple line indicates location for cross section on following page. Green triangles indicate well location; Xs mark P&M core holes (modified from Watney et al., 2008).