

Geological Characterization of Hydrothermally Altered Reservoirs and Future Exploration Potential in Eastern Michigan

David Katz¹, Terry Thyer², Lyn Canter¹, Ken Parrott¹, Paul Dellva², Marshall Jung¹, Charlie Harman¹, Mihai Ducea³, and John Humphrey⁴

¹Whiting Oil and Gas, Denver, CO

²Retired,

³University of Arizona, Tucson, AZ

⁴King Fahd University, Dhahran, Saudi Arabia

ABSTRACT

Michigan Basin carbonates contain abundant strata that are hydrothermally overprinted based on their morphology, distribution, and geochemical signature. The hydrothermal overprint is controlled by the migration of hot diagenetic fluids along fractured and faulted plumbing networks into the Precambrian Basement and/or basement derived clastic sediments. Dolomitization by hydrothermal fluids is not always related to reservoir favorable processes, however, in highly productive examples like Albion Scipio and Deep River Fields the hydrothermal activity is accompanied by structural enhancement related to basement derived wrench faulting, reidel shear sags, replacement by dolomite, aggressive dissolution by corrosive fluids, and partial cementation by saddle/baroque dolomite. Radiogenic isotopes using $87\text{Sr}/86\text{Sr}$ and $144\text{Nd}/143\text{Nd}$ of the saddle and replacive dolomites from these fields indicates that the dolomitizing fluids derived from old (> 1 BY) Rb-rich rocks such as granites, gneisses, and/or their reworked sedimentary equivalents. Empirical temperature derivation of $\delta 18\text{O}$ values from these dolomites indicate that dolomitization occurred from 80-180 °C, and is therefore geothermal-to-hydrothermal in origin. The association of reservoir favorable hydrothermal activity with northwest- southeast trending basement rooted faults across Michigan has implications for future hydrocarbon exploration along similar structural trends. Two-D seismic interpretations in the relatively underdeveloped Sanilac County also map northwest- southeast faults that project towards known resources like Deep River and Akron fields to the northwest. The $87\text{Sr}/86\text{Sr}$, $144\text{Nd}/143\text{Nd}$, and $\delta 18\text{O}$ analysis of Ordovician, Silurian, and Devonian carbonate strata from this county also confirm the presence of hydrothermal dolomitization. The relatively underexplored nature of Sanilac County and the presence of reservoir favorable structural trends coupled with hydrothermal geochemical signatures demonstrate the future potential for exploration of hydrothermally altered reservoirs in eastern Michigan.