MOUNTJOY CARBONATE
RESEARCH CONFERENCE III
AUGUST 14-18, 2022 | Banff Centre, AB, Canada

Reassessing Dolomitization Models for the Smackover Formation, Southeastern Gulf Coast, U.S.A.

Bradford E. Prather
University of Kansas

Robert H. Goldstein
University of Kansas

David C. Kopaska-Merkel
Geological Survey of Alabama

Ezat Heydari
Jackson State University

Karena Gill
University of Alabama

Marcello Minzoni
University of Alabama

Smackover dolostone reservoirs have been the subject of considerable study in past decades because of their importance to the oil and gas industry along the Gulf Coast. This legacy work produced an extensive database of petrographic observations and 2605 geochemical measurements covering an area from eastern Mississippi to the panhandle of Florida. As individual studies to date tend to be data and/or geographically limited, we show new insights from assembling and analyzing this database as a whole.

Whereas there is a consensus that $\delta^{18}O$-enriched dolomites in the Smackover originate from reflux, there is no agreement for the origin of the $\delta^{18}O$-depleted dolomites, which characterize the majority of Smackover dolostones across the region. The lack of agreement is illustrated by the numerous dolomitization processes proposed including: 1) mixing of meteoric water and burial brines, 2) penecontemporaneous supratidal [sabkha], 3) mixed-water, 4) thermal convection, 5) seawater-seepage, and 6) aquifer mixing of meteoric and connate fluids.

Recrystallization has produced as much as -12‰ PDB shift in $\delta^{18}O$ during 160 My of burial, as indicated by: strong positive correlation between mean $\delta^{18}O$ and burial depth; and dolomite crystals with mottled cathodoluminescence microfabrics, cloudy cores, and clear zoned cathodoluminescent rims. Additionally, $\delta^{18}O$-enriched dolomite intervals occur throughout the Smackover platform but are thicker updip. $\delta^{18}O$-depleted dolomites also occur throughout the Smackover platform but have a more even distribution than that observed of $\delta^{18}O$-enriched dolomites. Generally, $\delta^{18}O$-enriched dolomites occur in overlying Buckner downward to as much as 50 m below the top of the Smackover in updip wells. In downdip wells $\delta^{18}O$-enriched dolomites occur only in the Buckner and the top 10 m of the Smackover.

We conclude that before the recrystallization, early, near-surface to shallow burial period of reflux dolomitization took place throughout the early Oxfordian as gypsum-saturated brines descended into the Smackover from coeval Buckner coastal sabkhas displacing connate seawater present in

the aquifer. As burial continued, salterns formed in the platform interior as the Smackover shelf evolved from non-rimmed to rimmed. During this episode halite-saturated brines descended into the Smackover aquifer, displacing the gypsum-saturated brines. Buckner saltern brines may have acted as a source for reflux later as the basin tilted due to regional subsidence. This process continued until the source of halite-saturated brine was exhausted possibly as late as the Kimmeridgian.

Reflux was followed by a prolonged period of thermal/compaction fluid drive, hydrocarbon generation and migration, which together drove recrystallization and dolomitization well into the Late Cenozoic. This episode of fluid flow produced the -12‰ $\delta^{18}O$ PDB shift observed in dolostone reservoir rocks. Deep burial $\delta^{18}O$-depleted saddle dolomite and calcite cements with more radiogenic $^{87}Sr/^{86}Sr$ indicate dolomitization took place in water that interacted with stratigraphically adjacent terrigenous-clastic units such as the Norphlet and/or Haynesville formations. A $\delta^{18}O$-depleted dolomite mean value of -7.03‰ PDB and preliminary fluid inclusion homogenization temperature data of 130°C implies a $\delta^{18}O_w$ SMOW of ~6.5‰, well within the 5.1 to 7.3‰ $\delta^{18}O_w$ SMOW range measured from Smackover oil field brines in the area.