Tectonics and Sedimentation of Permian Delaware Basin Deepwater Systems

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Despite recording low-energy sedimentation, organic carbon-rich mudrocks (ORM) derived from subaqueous flows can be correlated to tectonics. This relationship explains changes in deepwater systems of the (1) Wolfcamp, (2) Bone Spring and (3) Cutoff (Avalon) formations and (4) Delaware Mountain Group (DMG).

Temporal phases of uplift>erosion, steady-state, and uplift<erosion characterize first-order mountain building and basin formation. Overlapping and far-field stress regimes from oblique WNW-directed plate collision and ENE-directed subduction generated the circular Permian Basin configuration and the bathymetry for carbonate production. Continental uplift sourced sand and silt from the north. The collisional suture connected the ocean and trapped sediment producing a paleogeography of plate collision resembling the Mediterranean Sea.

Oblique shear and subduction-related subsidence created the second-order Delaware and other sub-basins. Third-order flexures caused internal instability and bathymetry. Fourth-order slump scars and mass failures locally ponded sediment. Fifth-order depositional relief provided the local channel gradient for growth of submarine fans. These surface movements link tectonics to sedimentation.

Tectonics directly impact sediment source, subaqueous flow initiation and magnitude, and slope and canyon formation and indirectly affect marine algae, carbonate mud and hypersaline water incorporated into flows and failures originating from carbonate shelves. The ORM forms ripple interlaminations, matrix, sedimentary facies, drapes and thin continuous intervals. Hypersalinity explains anomalously negative carbon isotope values from Brushy Canyon ORM.

Catastrophic shelf failures and infrequent deposition from big events characterize the early Permian when U>E (~350 m; >15 my). Wolfcamp reservoirs are comparable to the high-magnitude Contessa Bed of the Miocene Marnoso-Arenacea Formation in Italy. The steady-state Bone Spring system (~850 m; 8 my) records reciprocal patterns of highstand carbonate ramp and lowstand fan deposition. Small turbidites form fine sandstone reservoirs recording molecular sieving and limited migration from ORM. The Cutoff system (~150 m; 2 my) records reorganization from steady-state to U<E. Smaller carbonate buildups are terraced inboard of older shelf margins incised by canyons. Regional sea-level change best explains the short duration formation of numerous small debris flows, resedimented turbidites and submarine unconformities. The ORM reservoirs drape complicated topography and poor-quality reservoirs record limited migration. Recycled eolian and basement uplifts sourced voluminous feldspar-bearing sands of the DMG when U<E (~1000 m; 10-my). The oldest Brushy Canyon Formation shelf record is a regional unconformity. Highly channelized fans overlap down-profile of canyons and later below reef inlets. The ORM interbeds source reservoirs consisting of small turbidites.

Biography

Michael H. Gardner received degrees in geology from the University of Colorado, Boulder (BA, 1986) and the Colorado School of Mines (PhD, 1993). After a long academic career, he is a consultant from Montana.