Deposition of Prograding Carbonate Sand Shoals and Their Subsequent Diagenesis—Lower Glen Rose (Cretaceous), South Texas

The lower Glen Rose in southwest Texas is a widely explored, but oil- and gas-barren, carbonate sequence (200 to 300 m thick) that was deposited on a broad, shallow-marine shelf. Three cyclic, shoal-water complexes, consisting of high-energy grainstone and coral-stromatoporoid-caprinid boundstone, developed over the Pearsall arch of south Texas. Facies distributions, determined from core and electrical logs, show that these linear complexes trend east-west for at least 125 km, and are located about 80 km inland of the Cretaceous shelf edge and 70 km seaward of the Cretaceous shoreline.

The shoal-water, cyclic sequences change upward from: (1) sandy, fossiliferous mudstone/wackestone deposited in an open-shelf environment; (2) echinoid-mollusk and oncolite-caprinid packstone deposited in intertidal shoals and subtidal grain flats; (3) coated-grain and echinoid-mollusk grainstone deposited in sand flats, tidal channels, spits, and bars; and (4) coral-stromatoporoid-caprinid boundstone and packstone deposited as patch reefs and flanking deposits. Lagoonal deposits, consisting of toucasiid-oyster-miliolid wackestone, boundstone, and mudstone enclose each of the shoal-water sequences, and indicate successive seaward progradations, interrupted by transgressions of open-shelf facies. The patch reefs may have prograded out across the shelf and formed the initial buildup of the Stuart City shelf margin.

Four gradational phases of grainstone diagenesis have caused almost continuous loss of porosity during burial. Micritic envelopes and isopachous crusts are early submarine cements. Next, development of an extensive meteoric-water system during burial to shallow depths led to dissolution or neomorphism of aragonite and precipitation of equant, isopachous cement, syntaxial cement, and nonferroan, equant calcite. As burial increased, subsurface brine displaced the original connate fluids and caused complex cementation and replacement by zoned ferroan and nonferroan calcite, lutecite and megaquartz, anhydrite, and saddle dolomite. The highest porosity is found in mappable facies of shoal-water grainstone.

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Stanley Field, North Dakota: New Model of Stratigraphically Trapped Oil, Mission Canyon Formation, Central Williston Basin

Stanley field provides a new model for exploration in the Mission Canyon Formation of the Williston basin. Moreover, it establishes for the first time the economic significance of early mechanical compaction of limestone with implications for both trapping and preservation of primary porosity.

Stanley field is a stratigraphically trapped oil accumulation producing from the Bluell interval of the Mission Canyon Formation. The field, discovered in 1977, lies midway between older established production along the Nesson anticline in the center of the basin and anhydrite stratigraphic traps paralleling the northeast side. There are currently 18 producing wells with the pay interval (maximum thickness, 37 m) cored in 16 wells in and near the field.

At Stanley field, during late Mission Canyon time, low, intertidal-supratidal barrier islands developed along depositional strike, separated laterally by marine channels and shoreward by shallow lagoons. Island sequences were syndepositionally cemented by both freshwater and beach rock-like marine cements whereas marine sequences remained uncemented, and both were overlain by massive anhydrite. Subsequent deposition of the overlying Charles Formation caused progressive mechanical compaction of upper Mission Canyon marine sediments, while cemented island sediments resisted compaction. The distribution of the different depositional facies and their control over subsequent diagenesis resulted in a reservoir formed of porous (primary interparticle porosity) marine grainstone-packstone and fractured, cemented island sediments locally retaining primary fenestral porosity. Trapping is accomplished by combination of overlying massive anhydrite and updip compacted marine (lagoonal) lime mudstone and wackestone.

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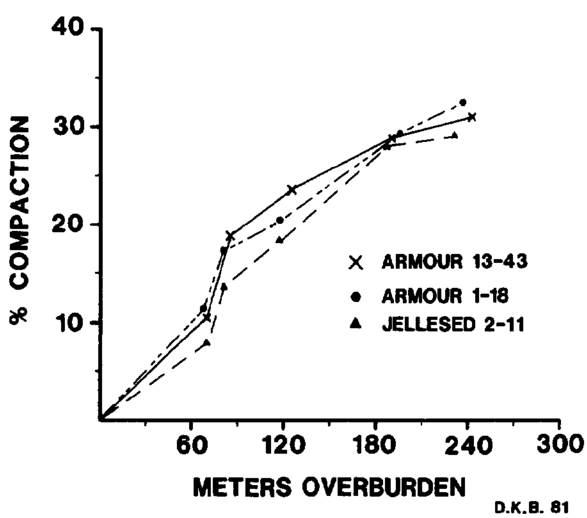
Stanley Field, North Dakota, Economic and Quantitative Significance of Mechanically Compacted Shallow-Water Limestone

Stanley field, producing from the Mississippian Mission Canyon Formation in the east-central Williston basin, establishes the economic significance of shallow subsurface mechanical compaction of shallow-water marine limestone, and provides a quantitative measure of mechanical compaction with increasing depth of burial.

MECHANICAL COMPACTION OF CARBONATE SEDIMENT IN THREE STANLEY FIELD WELLS



In the field the upper 65 m of the Mission Canyon is formed of subtidal marine and intertidal-supratidal island facies. Marine facies escaped pervasive early cementation and were significantly compacted. Evidence of mechanical compaction of marine facies in cores include: (a) horizontal aspect of mottling (burrows); (b) horizontal orientation of fossil fragments; (c) drag, drape, and penetration effects; (d) microstylolitic "horsetail" swarms; and (e) broken and crushed fossils (ostracods, trilobites, corals, and crinoids). Island facies, syndepositionally cemented by both fibrous marine (beach rocklike) and equant spar (freshwater) cements, show no evidence of significant mechanical compaction.

Compacted marine mudstone and wackestone form the updip seal for the field. Preserved primary interparticle porosity in compacted marine grainstone and packstone provides the principal reservoir facies.

Structure and isopach maps of various intervals of the Mission Canyon and overlying Charles Formations, in conjunction with cross sections through the field showing both formations, reveal timing of compaction and quantitative compensation by overlying deposits. Curves from 3 wells show percent compaction versus overburden. With 250 m of overburden, mechanical compaction is essentially complete and, on average, marine sections have been compacted 31%.

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Genesis of Mississippi Valley-Type Lead and Zinc Ore Deposits and Consequent Exploration Thinking

Mississippi Valley-type ore deposits provide most of the lead and a large part of the zinc presently mined in the world. They are stratabound epigenetic precipitates largely in dolostone host rocks that occur on the flanks of deeply subsiding sedimentary basins or between two sedimentary basins along an axis of reduced subsidence. They were commonly emplaced at or close to the platform-to-basin facies front, well removed from igneous or metamorphic influences. Sulfides commonly infill interstitial or intramoldic porosity in collapse breccias, and are formed by the intrastratal solution of evaporites and/or carbonates either by downward-percolating meteoric waters or by upward-escaping basinal fluids. In a few places, karstic caverns were precursors to ore precipitation; more commonly, lower grade deposits occur in intergranular or intercrystalline space. The strong force of crystallization of sulfide minerals may cause local pressure solution encroachment on the carbonate host rock, but the vast bulk of any deposit is void-filling and, therefore, the average porosity (% voids) determines the likely grades.

The mineralogy is simple: galena and/or sphalerite, marcasite and/or pyrite, accompanied by only a white sparry dolomite, in places calcite and/or quartz gangue.

The host rocks have many of the attributes of a carbonate rock petroleum reservoir of recognizable anticlinal or stratigraphic trap type. Residues of hydrocarbons and former evaporites are common characteristics.

The metals probably migrated considerable distances as soluble chloride complexes in low-temperature, high-salinity brines and precipitated where these brines encountered host-rock brines with abundant reduced sulfur. Lead and sulfur isotopic and trace-element compositions of the ores and host rocks are complex and the brines strongly resemble petroleum-associated basinal fluids, but, so far, geochemical criteria have failed to impose a consensus on metal(s) source(s). Some Mississippi Valley-type deposits appear to be little younger than their host rocks; others may lag by long periods of time.

Genetic models lead to consequent exploration thinking that mimics many aspects of oil finding.

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Exploration Along Lower Cretaceous Shelf Margin—Golden Lane, Mexico, to Louisiana

Exploration for hydrocarbons from Lower Cretaceous shelf-margin carbonates began more than 40 years ago and continues today along the Gulf Coast of Mexico, Texas, and Louisiana. The early discovery of the oil-rich Golden Lane and Poza Rica fields of Mexico provided encouragement for exploration for similar fields in Texas and Louisiana. Exploration along the shelf margin of the U.S. Gulf Coast has resulted in the discovery of smaller gas fields in south Texas.

Detailed core studies along the shelf-margin indicate the existence of a nearly continuous trend of rudist banks and associated tidal bars. Seaward, argillaceous carbonate mud was deposited in deeper water; landward, shallow-water lagoon and shelf sediments were diverse and resulted in the accumulation of a wide variety of facies.

In the Mexican fields, extremely high early secondary porosity in the Golden Lane is believed to have formed when the carbonates were exposed to subaerial weathering during early stages of the Laramide orogeny. In the Poza Rica field, production is from intercrystalline dolomite porosity. Along the U.S. Gulf Coast, most porosity is primary within the preserved rudist shells and permeability is very low. Originally high intergranular porosity in the grainstone facies was destroyed by several layers of calcite cement deposited during subsequent burial. The source rocks for the hydrocarbons of the entire area are probably the argillaceous, dark-colored mudstones and wackestones of the Gulf basin.

The Mexican fields have been prolific and have produced a billion barrels of oil. In contrast, the south Texas fields have produced 150 bcf of dry gas and are estimated to have reserves of 1 to 1.5 tcf of gas. Major differences in postdepositional burial history account for these extreme differences in hydrocarbon production.

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Structural Evolution of Chihuahua Tectonic Belt

The Chihuahua tectonic belt is a Laramide foreland fold and thrust belt that is in the initial phase of exploration. It can be compared to the Southern Overthrust belt prior to the Pineview discovery in 1975. The part within the United States is approximately 300 mi (483 km) long and extends from southeast of El Paso to Presidio, Texas. The frontal thrusts of the belt lie against the Diablo platform.

The stratigraphic sequence involved in thrusting is Permian to Lower Cretaceous. Thrusting has been accomplished by decollement of Jurassic and Permian evaporates. The Malone Formation (Jurassic) is the proximal part of a fan-delta complex and contains marine, subtidal, intertidal, and supratidal facies.

Two distinctive locally derived conglomerate facies are present: (1) clast-supported, bimodal, dolomite-pebble conglomerate (sheet-flood facies); and (2) a matrix-supported, dolomite-pebble conglomerate that lacks sorting (debris-flow facies). Probable correlatives of the Malone Formation occur at Sierra del Kilo and Sierra de la Alcaparra in Chihuahua 60 mi (97 km) to the southwest.

By using new surface-mapping and surface-sampling plus interpretation of seismic and gravity data, a sequence of tectonic events can be inferred: (1) Late Triassic(?) faulting and formation of the Chihuahua trough; (2) Laramide folding and thrusting; (3) late Laramide en echelon left-lateral strike-slip folding; and (4) basin-and-range faulting.

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A Three-Dimensional Seismic Study of Challenger Knoll

Several intersecting multichannel seismic lines shot by The University of Texas Marine Science Institute in the deep Gulf of Mexico provide a three-dimensional grid in the vicinity of Challenger Knoll. Seismic stratigraphic sequences identified on the lines include the Sigsbee, Cinco de Mayo, Upper and Lower Mexican Ridges, Campeche, and Challenger units. Isotime