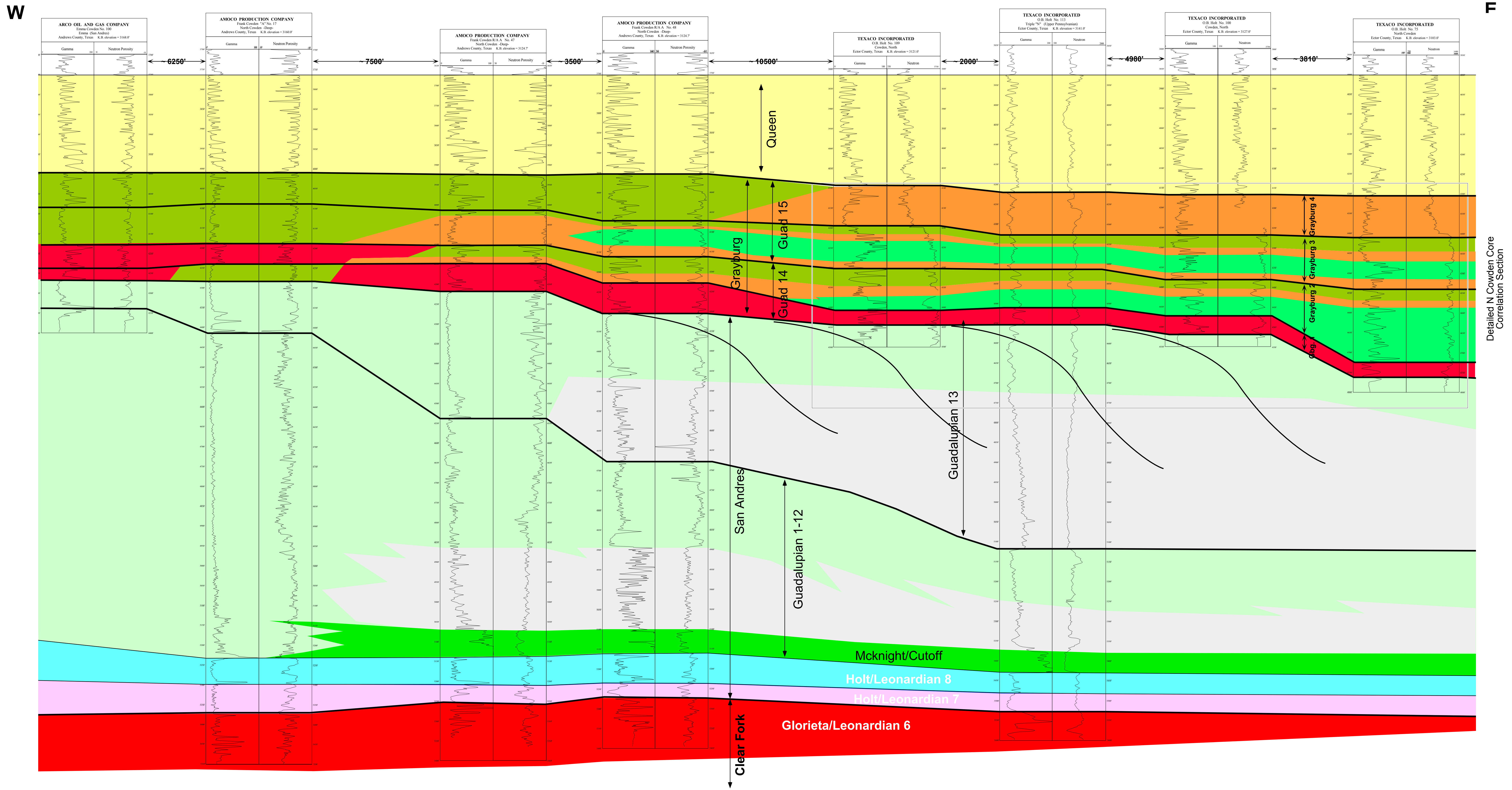
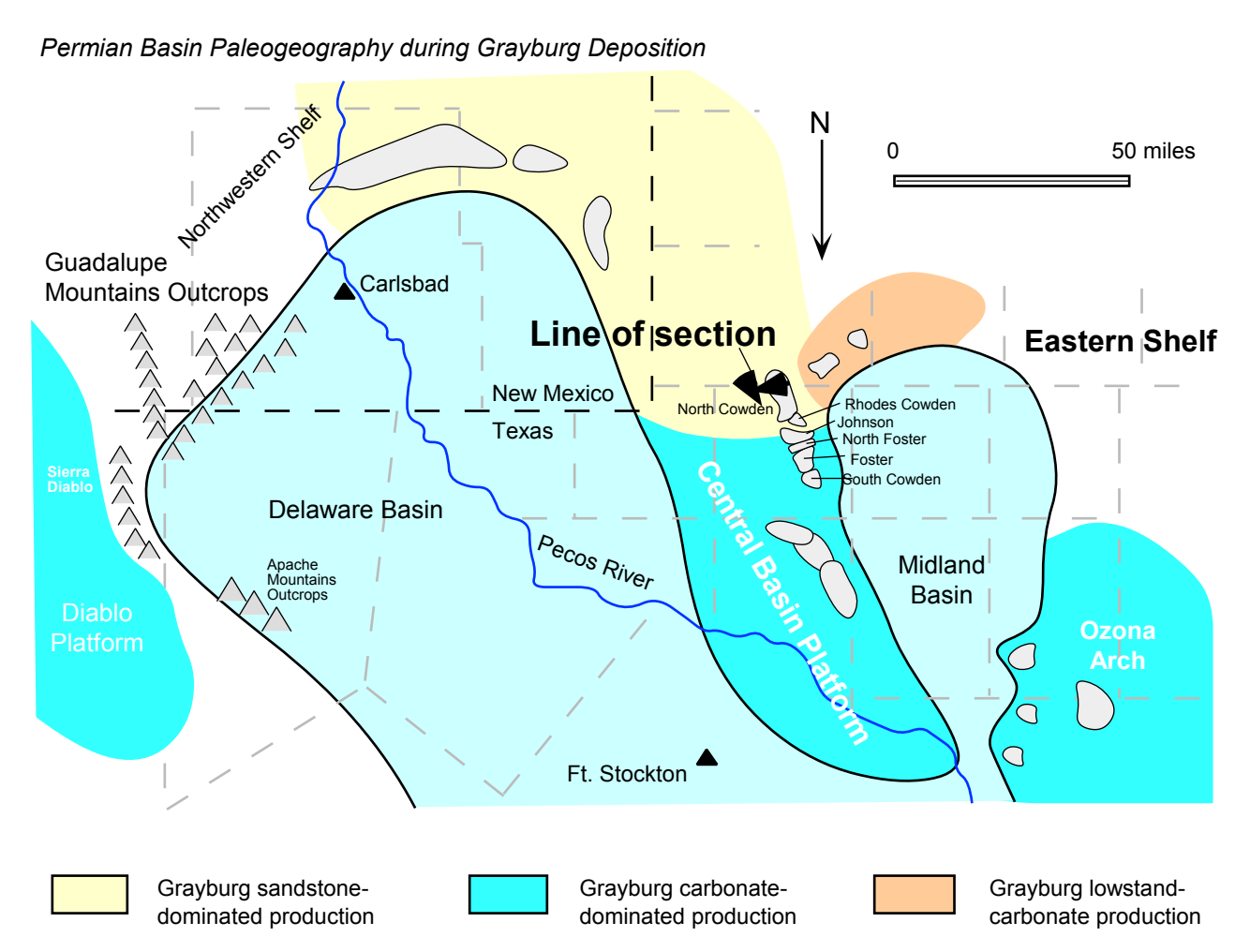
REGIONAL CROSS-SECTION OF MIDDLE PERMIAN STRATIGRAPHY

EMMA - NORTH COWDEN FIELD AREA


W
E
6250'
7500'
3500'
10500'
2000'
4900'
3810'
Queen
Guad 15
Guad 14
Grayburg
San Andres
Guadalupian 13
Guadalupian 1-12
Mcknight/Cutoff
Holt/Leonardian 8
Holt/Leonardian 7
Glorieta/Leonardian 6
Clear Fork
Detailed N Cowden Core
Correlation Section

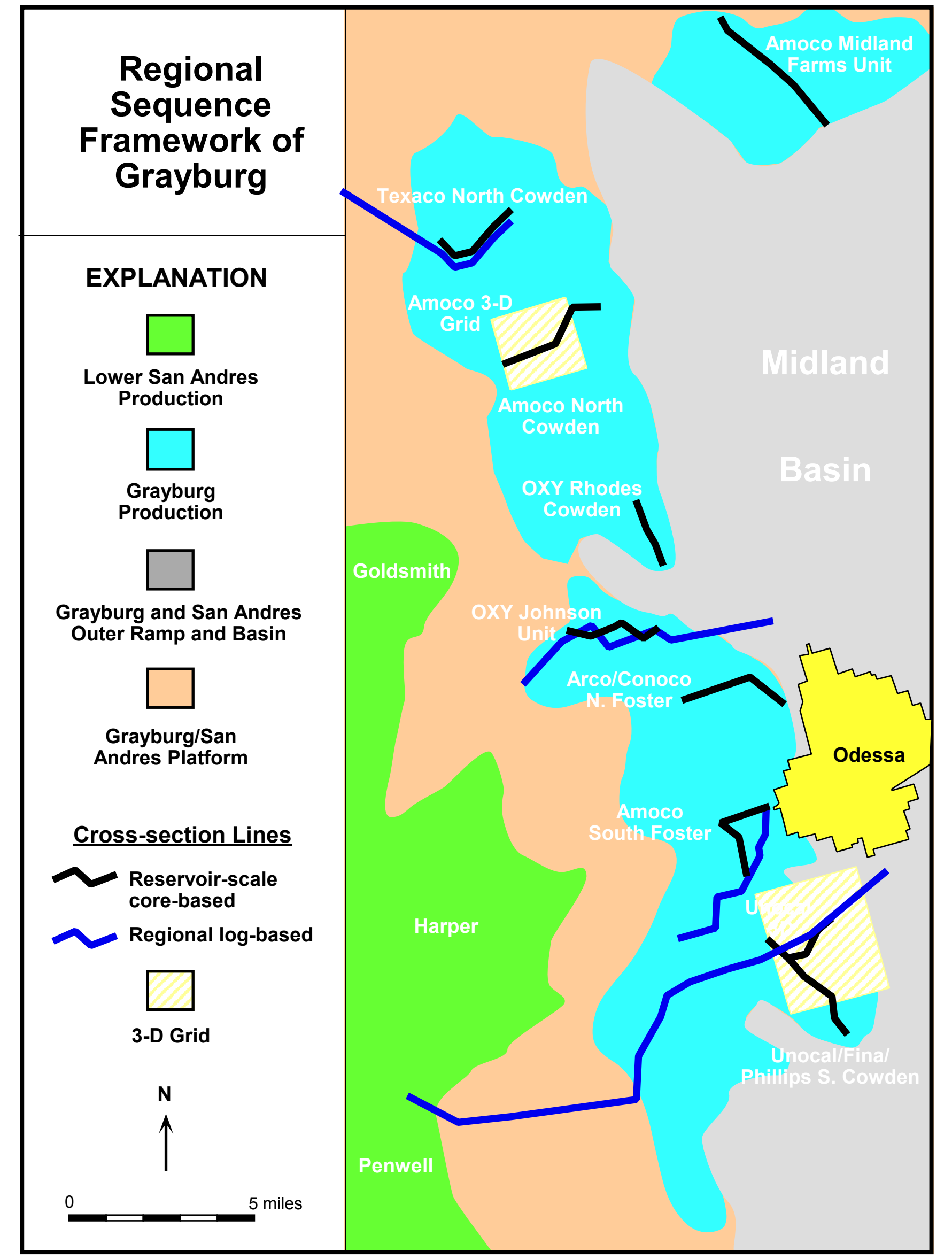
LOCATION of GRAYBURG FIELDS

and EMMA to N. COWDEN LINE of CROSS-SECTION


Permian Basin Paleogeography during Grayburg Deposition
N
0
50 miles
Northwestern Shelf
Guadalupe Mountains Outcrops
Carlsbad
Line of section
Eastern Shelf
New Mexico
Texas
North Cowden
Rhodes Cowden
Johnson
North Foster
Foster
South Cowden
Sierra Diablo
Delaware Basin
Apache Mountains Outcrops
Pecos River
Central Basin Platform
Midland Basin
Ozona Arch
Diablo Platform
Ft. Stockton
Grayburg sandstone-dominated production
Grayburg carbonate-dominated production
Grayburg lowstand-carbonate production

EXPLANATION

Queen Fm.	(yellow)	Inner-ramp mixed clastic-carbonate-anhydrite cycles of Queen Formation
Grayburg Fm.	(red)	Inner-ramp to ramp-crest siliciclastic-rich tidal flat cycles
	(olive green)	Inner-ramp-crest carbonate-dominated fenestral tidal flat and associated peritidal facies
	(orange)	Outer-ramp-crest peloid packstones and grain-dominated packstone with lesser ooid grainstone
	(green)	Outer-ramp fusulinid-peloid wackestone and packstone
San Andres Fm. and Equivalents	(red)	Inner-ramp to ramp-crest siliciclastic-rich tidal flat cycles
	(pale green)	Undifferentiated inner-ramp, ramp-crest, and outer-ramp (peloidal, oolitic, skeletal pkstn-gnstn, fusulinid-peloid pkstn.)
	(light gray)	Distal-outer-ramp cherty dolomudstones (equivalent to upper portion of Cutoff Fm and equivalent San Andres Fm. (Guadalupian 1-12 HFS)
	(bright yellow)	Distal outer ramp/slope dolomitic sandstone
	(bright green)	Organic-rich shale (McKnight unit) equivalent to lower Cutoff Fm. of Guadalupe Mountain outcrops
	(cyan)	Open marine bioclastic packstone, common fusulinids (Leonardian 8 HFS of Guadalupe Mts.).
	(pink)	Open marine bioclastic packstone, fusulinid-poor (Leonardian 7 HFS of Guadalupe Mts.).
Glorieta	(red)	Inner ramp to ramp-crest siliciclastic-rich tidal flat cycles


Regional Sequence Framework of Grayburg
EXPLANATION
Lower San Andres Production
Grayburg Production
Grayburg and San Andres Outer Ramp and Basin
Grayburg/San Andres Platform
Cross-section Lines
Reservoir-scale core-based
Regional log-based
3-D Grid
N
0
5 miles
Amoco Midland Farms Unit
Texaco North Cowden
Amoco 3-D Grid
Amoco North Cowden
Midland
Basin
OXY Rhodes Cowden
Goldsmith
OXY Johnson Unit
Arco/Conoco N. Foster
Odessa
Amoco South Foster
Harper
Unocal/Fina/ Phillips S. Cowden
Penwell

Geology by
C. Kerans and S. C. Ruppel
Bureau of Economic Geology
Austin, Texas

Regional Cross Section from Emma San Andres Field to northern North Cowden Field

Interpretation by C. Kerans and S. C. Ruppel
Constructed by Kirt Kempter

Overview

This simplified 1"=100 ft scale west-to-east cross section covers 7 mi from the middle of the San Andres shelf at the Emma field (Ruppel and Cander, 1988) to a position close to the Guadalupian 13 HFS margin with the Midland Basin beneath Texaco's North Cowden Holt leases, northern Ector Co.. This section illustrates the geographic and stratigraphic separation between typical San Andres production (lowermost portion of westernmost well) and Grayburg Formation production, predominantly from Grayburg 2 in the easternmost wells. Also illustrated is the preferential development of reservoir facies in the Grayburg above the easternmost youngest San Andres clinoforms. The basinward-sloping upper surface of the San Andres and the well developed clinoforms within it, suggest a period of deposition coincident with strong base-level fall (i.e. forced regression).

Stratigraphic Units

Leonardian 6 HFS/Glorieta: The section begins in the uppermost part of the youngest Clear Fork high-frequency sequence, referred to here as Leonardian 6 HFS or L6. The silt-rich thin peritidal cycles that define the hot gamma zone at the top of this sequence is commonly referred to in the subsurface as the "Glorieta" silt or member. Thus the Glorieta is only a portion of a high-frequency sequence, not a sequence in itself. Just eastward of this cross section the hot gamma-ray signature of the silt-rich Glorieta tidal flat cycles passes into a clean carbonate signal, marking the approximate position of the terminal Clear Fork (L6) shelf margin.

Leonardian 7 and 8 HFS: The Leonardian 7 and 8 HFS contain mixture of limestone and dolomite which is shallow subtidal open marine in L7 HFS and transitional into deeper outer ramp in the L8 HFS. L7 contains basal tidal-flat capped backstepping cycles followed by entirely subtidal brachiopod-pelmatozoan-skeletal packstone and grainstone cycles. L8 is distinguished by the appearance of fusulinids, and also by the local occurrence of fenestellid bryozoan mounds. Deposition of Leonardian 7 and 8 HFS directly following Leonardian 6 tidal-flat-capped cycles marks the beginning of a basin-wide transgression that is also recognized throughout North America and represents a probable eustatic rise. These HFS, informally referred to together as the Holt in the subsurface (Kerans and Ruppel, 1994) comprise an important productive horizon where a top-seal is provided by the overlying McKnight shale (organic-rich silty dolomudstone).

Guadalupian 1-12 HFS: The Guadalupian 1-4 and Guadalupian 12 intervals are combined on this cross section because the paucity of biostratigraphic data and absence of key stratal relationships do not permit recognition of the major break that must exist associated with the Brushy Canyon lowstand widely recognized in the Delaware Basin. This complex interval in this cross section contains three distinguishable lithofacies, the McKnight shale, deeper water cherty mudstones (together equivalent to the Cutoff Fm. of the outcrop) and fusulinid-peloid packstones that form the distal fronts of prograding San Andres ramps. The McKnight is a key log marker, being a shale-rich interval that consistently yields a high gamma radioactivity. This unit and the overlying mudstones (gray on this section) contain the condensed toes of the Guadalupian 1-4 HFS ramps. The McKnight interval is particularly important in an exploration sense as it represents a potential intra-San Andres seal. The McKnight passes into outer ramp carbonates westward in the area of the main San Andres reservoirs (as in the Emma area well shown here). No subdivision of the outer ramp carbonates has been made in this section, but it must be recognized that the major stratigraphic boundary within the San Andres, that exists between the lower and upper San Andres composite sequences (Kerans et al, 1994), occurs within this interval.

Guadalupian 13: The Guadalupian 13 HFS, the uppermost HFS of the San Andres Formation, is subdivided into an upward cleaning silt-rich deeper-water carbonate interval and an upper outer-ramp to ramp-crest fusulinid-peloid packstone to grain-dominated packstone. The clinoform stratal geometry shown in this interval is based on that observed in 2D and 3D seismic data. Clinoforms have 400-600 ft of toplap to downlap topography across 2,000-3,000 ft laterally. The upper surface of the San Andres is a karst unconformity across this interval whose upper surface is sloping basinward. This surface also represents a composite unconformity of multiple exposure events and is a forced regression. Final exposure and bypass of the San Andres to form a basal Grayburg lowstand is recorded only basinward of the study area.

Guadalupian 14-15: The Grayburg Formation can be subdivided into four HFS, although at this scale, only two are clear. The Grayburg 1 and 2 are combined into what was originally recognized as the Guadalupian 14 HFS Kerans et al, 1992), with the Grayburg 1 consisting in this section largely of backstepping silt-rich tidal-flat-capped cycles. The major transgression at the base of Grayburg 3, represented on this section as the most shelfward extension of fusulinid peloid packstones, is the most widely recognizable event in terms of facies stacking. Subdivision of the Guadalupian 15 HFS into the Grayburg 3 and 4 HFS is on the basis of a widespread progradational pulse within this interval, marked by a couplet of silt-based tidal-flat-capped cycles that extend across the study area in a basinward direction.

Guadalupian 16-17: The Queen Formation in this cross section is not subdivided, but marks a major seaward facies tract offset. No cores were available along the line of this section, but where observed Queen peritidal facies step seaward at least 1 mi. A gradual basinward thickening of the Queen is shown on this section. Generally, marked thickening of the Queen is observed basinward of the Leonardian 6 (terminal Clear Fork) shelf margin.