Submarine mass transport complex evolution and control on overlying reservoir deposition, Permian Cutoff Formation, west Texas

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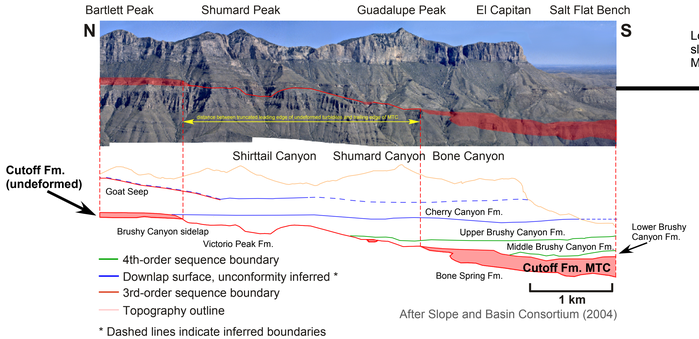
Abstract

The Williams Ranch Member of the Cutoff Formation consists of six offlapping, basinward-stepping lithologic units of highstand carbonate turbidites deposited across a drowned Early Permian carbonate platform, then partially redistributed in slumps on the slope and basin floor. Slumps are intercalated with undeformed carbonate turbidites; the ratio of slumps to undeformed sediment increases basinward. Upslope evacuation scars correlate to downslope slump bodies. Gravity flow deposition and subsequent mass movement caused basinward thickening of the Williams Ranch Member and caused the toe of slope to shift basinward relative to the underlying Bone Spring Limestone. This shift controlled landward pinchouts of the overlying Permian Brushy Canyon Formation channel and sheet sandstone bodies.

Williams Ranch Member deposition both responded to and modified inherited bathymetric relief. Williams Ranch isopach thicks correspond to larger underlying lows and smaller overlying highs and exhibit a higher ratio of undeformed to slumped sediment and a higher percentage of soft-sediment folds relative to soft-sediment truncation surfaces. These slump “pile-ups” appear to be concentrated in inherited lows. Slump bodies show a general southward transport vector, with significant local variation possibly reflecting underlying bathymetric influence. With repeated slump events, “pile-up” zones resulted in local positive bathymetry. Brushy Canyon sand fairways and ponded sheets are focused in bathymetric lows, and sands are sidelapped against highs atop the Williams Ranch Member. Increased understanding of mass transport complex evolution may lead to better prediction of overlying reservoir geometry, both within the Brushy Canyon Formation and in analogous reservoirs in other deepwater settings.

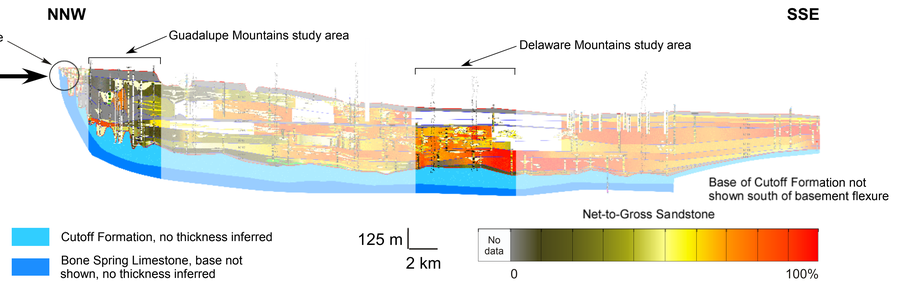
Western Escarpment of the Guadalupe Mountains Showing Gap Between Cutoff Mass Transport Complex (MTC) and Undeformed Cutoff Turbidites



After Slope and Basin Consortium (2004)

Location of truncated edge of undeformed Cutoff slope turbidites, western escarpment of Guadalupe Mountains

Regional Stratigraphic Cross Section of Cutoff and Brushy Canyon Formations Oblique to Depositional Dip

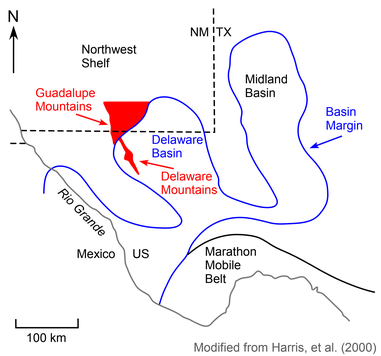


After Gardner (2002)

Research Questions

1) Can deformed Cutoff units in the southern Guadalupe and northern Delaware Mountains be correlated with the three formal members and five informal correlation units of Harris (1982b; 1987; 1988a; 1988b; 2000)?
2) Can a sequence stratigraphic framework be established for the Cutoff that correlates to work by Fitchen (1993; 1997), Kerans and others (1992; 1993), Kerans and Fitchen (1995), Sarg (1986; 1989), Rossen and others (1988), Sarg and Lehmann (1986a; 1986b), Sonnenfeld (1993) and Sonnenfeld and Cross (1993) on equivalent shelfal units?
3) How many mass transport events (MTEs) are represented in the Cutoff?
4) What were the MTE transport vectors?
5) How far did the MTE bodies (bodies of sediment transported to their present locations, each in a single MTE) travel?
6) Does the nature of the MTEs evolve over time?
7) Do contractional and/or extensional domains exist, and where are they located?
8) How do microscale (mms-cms) features relate to mesoscale (ms) and macroscale (100s ms-kms) features?
9) How does the thickness of the mass transport complex (MTC) vary within the basin?
10) How did the Cutoff Formation influence development of paleo-bathymetry below the Brushy Canyon Formation?
11) How can internal Cutoff Formation structure be used to predict paleo-bathymetry below the Brushy Canyon Formation?

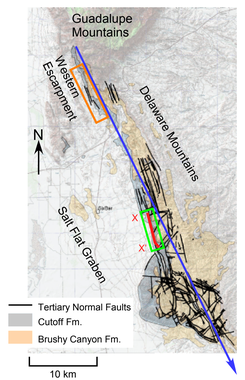
Paleo-Geographic Map of the Permian Basin



Modified from Harris, et al. (2000)

Geologic Map of Cutoff and Lower Brushy Canyon Formations

Blue line: Location of regional cross section
Red line: Location of study area cross section
Orange box: Guadalupe Mountains study area
Green box: Delaware Mountains study area



Fault locations from Kullman (1999). Lithologic contacts from Slope and Basin Consortium (2003).

Cutoff Formation Nomenclature and 2nd–4th Order Cyclicity

Units 6–10: Focus of study in the Delaware Mountains

4th-Order Cycles (Kerans and Fitchen, 1997)	Age	Shelf Equivalent	Basin Equivalent	Harris (1982)	Harris (1987)	Correlation Units: Harris (1982)	Correlation Units: This Study	Lithology
G1–G4	Guadalupian	Lower San Andres Fm.	Cutoff Fm.	Upper	Williams Ranch Mbr.	5	10	Carbonate turbidites, mass transport deposits
							9	
							8	
							7	
							6	
							5	
						4	4	Siltstone, local sandstone bodies
L7–L8	Leonardian				El Centro Mbr.	3	3	Carbonate turbidites
						2	2	Siltstone
				Lower	Shumard Mbr.	1	1	Carbonate turbidites

Leonardian–Guadalupian stage boundary (Lambert, 2000)

2nd-order stratigraphic cycle

3rd-order stratigraphic cycle