Datashare 95

Quantifying sediment supply to continental margins: Application to the Paleogene Wilcox Group, Gulf of Mexico

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ESTIMATION OF SEDIMENT LOAD FOR THE PALEOGENE WILCOX GROUP USING SHELF-MARGIN CLINOFORMS

Introduction and Methodology

Petter et al. (2013) proposed an inversion scheme to estimate the sediment flux from the dimensions of shelf-margin clinoforms and the progradation and aggradation rates of the related shelf edge. This approach is able to give a reliable estimate of sediment flux with several limitations (e.g., influences from mass transport complexes and canyons; see also Salazar, 2014).

The sediment flux of the entire shelf-margin clinoform can be estimated by equation S1:

$$q_s(x) = \epsilon_{\text{bed}}\left[P\eta(\mathrm{x}) + \int_x^L A(x)dx\right] \qquad \text{(S1)}$$

where $q_s(x)$ is the sediment flux of the shelf-margin clinoform at the down-basin coordinate x; ϵ_{bed} is the 1-porosity (20% is used in this study); P is the shelf-margin progradation rate; $\eta(\mathrm{x})$ is the clinoform elevation at x; A is the shelf-margin aggradation rate; and L is the downdip location of the distal clinothem pinch-out.

The two-dimensional (2-D) estimate is extended into the three-dimensional estimate by summing up the results of each clinoform along the Wilcox shelf margin within each catchment (equation S2). The estimated sediment flux (units of length/time) is then transferred into sediment load (units of mass/time) by multiplying by an uncompacted grain density of 2 t/m^3:

$$Q_s = \int_0^L qsdl \qquad \text{(S2)}$$

where Q_s is the total sediment flux along one shelf margin; L is the length of the shelf margin; q_s is the sediment flux of each shelf-margin clinoform.

Explanation of Inputs

An interpreted 2-D seismic line for onshore–offshore Gulf of Mexico in Peel et al. (1995) is selected to estimate the dimensions of Wilcox shelf-margin clinoforms (Figure S1). The shelf-margin clinoform is divided into three parts: topset (shelf deposits), foreset (slope deposits), and bottomset (basin floor deposits) based on its gradient and thickness variations. The shelf edge between topset and foreset is recognized as the rollover from topset (~1.2° gradient, estimated from the original seismic line) to foreset (~3.5° gradient, estimated from the original seismic line). The shelf edge is located at 77 km (48 mi) from the left boundary of the cross section. From 77 to 235 km (48 to 146 mi), the slope-basin floor deposits thin basinward following an exponential trend. The toe of slope is difficult to define because of interruption by faults and salt tectonics. A previous study suggested the slope length is no longer than 270 km (168 mi) based on the modern graded slope angle (~0.8°) in the Gulf of Mexico (McDonnell et al., 2008). Our estimate shows a steeper slope angle and suggests a shorter slope length. The slope is defined by the thickness of accumulated strata. The toe of the slope is approximately located at the area where thickness tends to decay slowly or be nearly constant. The thickness of the Wilcox interval enters a less than 2000-m (6562-ft) zone from 160 km (99 mi) with slower decay rate and becomes even more stable from 235 km (146 mi) (~1300 m [~4265 ft] thick and ~8.5×10^{-5} m/yr [~2.8×10^{-4} ft/yr] sedimentation rate on average). We, therefore, suggest the slope length is close to 84 km (52 mi) and at least below 159 km (99 mi), which is close to the slope length in the Gulf of Mexico paleogeography map created by Fulthorpe et al. (2014). Pinch-out position and depth of the clinoform are estimated based on the exponential spatial decay of clinoform thickness as suggested in Petter et al. (2013) (equation S3).

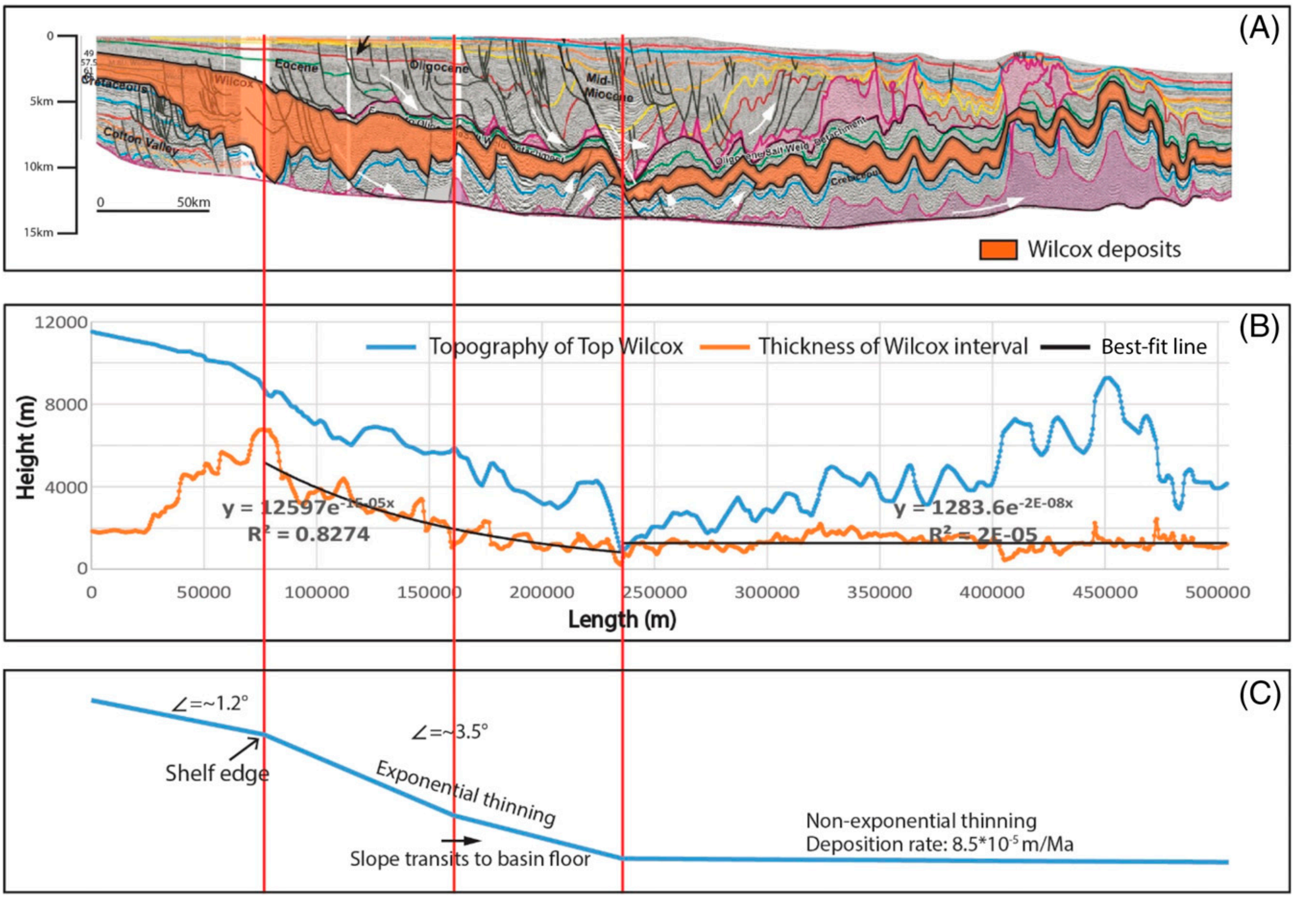

Figure S1. (A) Gulf of Mexico depositional-dip seismic cross section, orange-colored interval is Wilcox deposits (after Peel et al., 1995). (B) Topography of Top Wilcox and thickness variation of Wilcox Group through depositional-dip based on panel A; note the transition from exponential thinning (77–235 km [48–146 mi]) to nonexponential thinning interval (>235 km [>146 mi]). (C) Sketch showing Wilcox shelf-margin clinoform geometry. R^2 = coefficient of determination.

$$x_0 = \frac{\ln(T_p/a)}{k} \tag{S3}$$

x_0 is the distal pinch-out distance; T_p is the pinch-out thickness (10 m [33 ft] is used in this study); a is the initial coefficient; and k is the decay constant, determined by the slope geometry.

The clinoform height is estimated as 8700 m (28,500 ft), as the difference between shelf-edge height and pinch-out height. The inputs of each variable are summarized in Figure S1 and Table S1.

The Wilcox shelf-margin map and the isopach map in previous publications (Galloway et al., 2000; Galloway, 2001) are used to estimate the shelf-margin progradation and aggradation rates. Each catchment is divided into several segments with the same shelf-margin progradation and aggradation rate. The progradation rate decreases from lower Wilcox to

Table S1. Summary of Input Parameters for Clinoform-Based Approach to Estimate Sediment Flux

Parameters	Shelf-edge aggradation rate (A)	Shelf-edge progradation rate (P)	Pinch-out position, X_0	Shelf-margin clinoform height, η
Range	3×10^{-5} to 3×10^{-4} ($10^{-4} \times 10^{-3}$) (Table S2)	0–30 (0–19) (Table S2)	713,900 (2,342,200)	8700 (28,500)
Units	m/yr (ft/yr)	km/Ma (mi/Ma)	m (ft)	m (ft)
Source and approach	Galloway (2001)	Galloway et al. (2000)	Estimated from Peel et al. (1995) by equation S3	Estimated from Peel et al. (1995)

Table S2. Shelf-Margin Length, Shelf-Edge Progradation and Aggradation Rate, and Estimates of Sediment Load of Each Catchment

Catchment	Segment Number	Shelf-Margin Length (L), km (mi)			Shelf-Edge Progradation Rate (P), m/yr (ft/yr)			Shelf-Edge Aggradation Rate (A), m/yr (ft/yr)			Sediment Load (Q_s), Mt/yr		
		Comments											
		Estimate from Galloway et al. (2011); consider 10% error			Estimate from Galloway et al. (2000); if SE retrogradation, P is assumed as 0			Estimate from Galloway et al. (2000); consider 20% error					
		Range											
		Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
Lower Wilcox													
Rio Grande	1	7 (4)	8 (5)	9 (5)	0.016 (0.052)	0.018 (0.059)	0.02 (0.066)	2.1E–04 (0.0007)	2.7E–04 (0.0009)	3.2E–04 (0.0011)	4	6	8
	2	12 (7)	13 (8)	14 (9)	0.012 (0.039)	0.014 (0.046)	0.016 (0.052)	1.4E–04 (0.0005)	1.8E–04 (0.0006)	2.1E–04 (0.0007)	5	7	9
	3	18 (11)	20 (12)	22 (14)	0.008 (0.026)	0.01 (0.033)	0.012 (0.039)	1.4E–04 (0.0005)	1.8E–04 (0.0006)	2.1E–04 (0.0007)	7	9	12
	4	89 (55)	99 (62)	109 (68)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	1.4E–04 (0.0005)	1.8E–04 (0.0006)	2.1E–04 (0.0007)	26	38	51
	5	84 (52)	93 (58)	102 (64)	0 0.000	0.002 (0.007)	0.004 (0.013)	1.4E–04 (0.0005)	1.8E–04 (0.0006)	2.1E–04 (0.0007)	18	28	41
	Sum										60	88	120
Colorado	1	63 (39)	70 (43)	77 (48)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	33	47	63
	2	35 (22)	39 (24)	43 (27)	0.008 (0.026)	0.01 (0.033)	0.012 (0.039)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	21	29	38
	3	32 (20)	36 (22)	40 (25)	0.012 (0.039)	0.014 (0.046)	0.016 (0.052)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	22	29	38
	4	56 (35)	62 (39)	68 (42)	0.016 (0.052)	0.018 (0.059)	0.02 (0.066)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	41	55	71
	5	54 (34)	60 (37)	66 (41)	0.02 (0.066)	0.025 (0.082)	0.03 (0.098)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	44	61	81
	6	23 (15)	26 (16)	29 (18)	0.016 (0.052)	0.018 (0.059)	0.02 (0.066)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	17	23	30
	7	20 (12)	22 (14)	24 (15)	0.012 (0.039)	0.014 (0.046)	0.016 (0.052)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	13	18	23
	8	131 (82)	146 (91)	161 (100)	0.008 (0.026)	0.01 (0.033)	0.012 (0.039)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	78	109	143
	Sum										270	372	488
Mississippi	1	18 (11)	20 (12)	22 (14)	0.008 (0.026)	0.01 (0.033)	0.012 (0.039)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	11	15	20
	2	75 (46)	83 (52)	91 (57)	0.012 (0.039)	0.014 (0.046)	0.016 (0.052)	2.1E–04 (0.0007)	2.7E–04 (0.0009)	3.2E–04 (0.0011)	41	55	71
	3	24 (15)	27 (17)	30 (18)	0.016 (0.052)	0.018 (0.059)	0.02 (0.066)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	18	24	31
	4	16 (10)	18 (11)	20 (12)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	2.9E–04 (0.0010)	3.7E–04 (0.0012)	4.4E–04 (0.0015)	8	12	16
	5	14 (9)	16 (10)	18 (11)	0 0.000	0.002 (0.007)	0.004 (0.013)	2.1E–04 (0.0007)	2.7E–04 (0.0009)	3.2E–04 (0.0011)	5	7	10
	6	98 (61)	109 (68)	120 (75)	0 0.000	0 0.000	0 0.000	1.4E–04 (0.0005)	1.8E–04 (0.0006)	2.1E–04 (0.0007)	21	29	39
	Sum										104	142	187
Tennessee	1	268 (167)	298 (185)	328 (204)	0 0.000	0 0.000	0 0.000	1.1E–04 (0.0004)	1.4E–04 (0.0005)	1.7E–04 (0.0006)	45	63	83
	Sum										45	63	83

(continued)

Table S2. Continued

Catchment	Segment Number	Shelf-Margin Length (*L*), km (mi)			Shelf-Edge Progradation Rate (*P*), m/yr (ft/yr)			Shelf-Edge Aggradation Rate (*A*), m/yr (ft/yr)			Sediment Load (Q_S), Mt/yr		
		Estimate from Galloway et al. (2011); consider 10% error			Estimate from Galloway et al. (2000); if SE retrogradation, *P* is assumed as 0			Estimate from Galloway et al. (2000); consider 20% error					
		Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
Middle Wilcox													
Rio Grande	1	41 (25)	45 (28)	50 (31)	0 0.000	0.0002 (0.001)	0.0004 (0.001)	7.2E−05 (0.0002)	9.0E−05 (0.0003)	1.1E−04 (0.0004)	4	6	8
	2	204 (127)	227 (141)	250 (155)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	7.2E−05 (0.0002)	9.0E−05 (0.0003)	1.1E−04 (0.0004)	37	56	78
	Sum										42	63	86
Colorado	1	230 (143)	256 (159)	282 (175)	0 0.000	0.0002 (0.001)	0.0004 (0.001)	1.4E−04 (0.0005)	1.8E−04 (0.0006)	2.2E−04 (0.0007)	50	71	94
	2	34 (21)	38 (24)	42 (26)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	1.4E−04 (0.0005)	1.8E−04 (0.0006)	2.2E−04 (0.0007)	10	15	20
	3	29 (18)	32 (20)	35 (22)	0 0.000	0.0002 (0.001)	0.0004 (0.001)	1.6E−04 (0.0005)	2.0E−04 (0.0007)	2.4E−04 (0.0008)	7	10	13
	4	88 (55)	98 (61)	108 (67)	0 0.000	0 0.000	0 0.000	1.4E−04 (0.0005)	1.8E−04 (0.0006)	2.2E−04 (0.0007)	19	27	35
	Sum										86	122	162
Mississippi	1	268 (167)	298 (185)	328 (204)	0 0.000	0 0.000	0 0.000	7.2E−05 (0.0002)	9.0E−05 (0.0003)	1.1E−04 (0.0004)	29	41	54
	Sum										29	41	54
Tennessee	1	271 (168)	301 (187)	331 (155)	0 0.000	0 0.000	0 0.000	4.0E−05 (0.0001)	5.0E−05 (0.0002)	6.0E−05 (0.0002)	16	23	30
	Sum										16	23	30
Upper Wilcox													
Rio Grande	1	191 (119)	212 (132)	233 (145)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	1.9E−04 (0.0006)	2.4E−04 (0.0008)	2.9E−04 (0.0009)	70	101	136
	2	89 (55)	99 (62)	109 (68)	0 0.000	0.002 (0.007)	0.004 (0.013)	1.9E−04 (0.0006)	2.4E−04 (0.0008)	2.9E−04 (0.0009)	26	40	56
	Sum										96	140	192
Colorado	1	29 (18)	32 (20)	35 (22)	0 0.000	0.002 (0.007)	0.004 (0.013)	1.8E−04 (0.0006)	2.2E−04 (0.0007)	2.6E−04 (0.0009)	8	12	17
	2	48 (30)	53 (33)	58 (36)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	1.4E−04 (0.0005)	1.8E−04 (0.0006)	2.2E−04 (0.0007)	14	20	28
	3	146 (91)	162 (101)	178 (111)	0 0.000	0.002 (0.007)	0.004 (0.013)	9.6E−05 (0.0003)	1.2E−04 (0.0004)	1.4E−04 (0.0005)	21	35	52
	4	16 (10)	18 (11)	20 (12)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	5.6E−05 (0.0002)	7.0E−05 (0.0002)	8.4E−05 (0.0003)	3	4	5
	5	59 (36)	65 (40)	72 (44)	0 0.000	0.002 (0.007)	0.004 (0.013)	5.6E−05 (0.0002)	7.0E−05 (0.0002)	8.4E−05 (0.0003)	5	9	14
	6	27 (17)	30 (19)	33 (21)	0.004 (0.013)	0.006 (0.020)	0.008 (0.026)	5.6E−05 (0.0002)	7.0E−05 (0.0002)	8.4E−05 (0.0003)	4	7	9
	7	81 (50)	90 (56)	99 (62)	0 0.000	0.002 (0.007)	0.004 (0.013)	7.2E−05 (0.0002)	9.0E−05 (0.0003)	1.1E−04 (0.0004)	9	16	24
	Sum										63	103	149

(continued)

Table S2. Continued

Catchment	Segment Number	Variables																				
		Shelf-Margin Length (L), km (mi)						Shelf-Edge Progradation Rate (P), m/yr (ft/yr)						Shelf-Edge Aggradation Rate (A), m/yr (ft/yr)						Sediment Load (Q_s), Mt/yr		
		Comments																				
		Estimate from Galloway et al. (2011); consider 10% error						Estimate from Galloway et al. (2000); if SE retrogradation, P is assumed as 0						Estimate from Galloway et al. (2000); consider 20% error								
		Range																				
		Low		Mid		High		Low		Mid		High		Low		Mid		High		Low	Mid	High
Mississippi	1	95	(59)	105	(65)	116	(72)	0	0.000	0	0.000	0	0.000	3.2E–05	(0.0001)	4.0E–05	(0.0001)	4.8E–05	(0.0002)	5	6	8
	2	93	(58)	103	(64)	113	(70)	0	0.000	0.002	(0.007)	0.004	(0.013)	3.2E–05	(0.0001)	4.0E–05	(0.0001)	4.8E–05	(0.0002)	4	10	17
	3	25	(16)	28	(17)	31	(19)	0.004	(0.013)	0.006	(0.020)	0.008	(0.026)	3.2E–05	(0.0001)	4.0E–05	(0.0001)	4.8E–05	(0.0002)	3	5	7
	Sum																			12	21	32
Tennessee	1	42	(26)	47	(29)	52	(32)	0.004	(0.013)	0.006	(0.020)	0.008	(0.026)	3.2E–05	(0.0001)	4.0E–05	(0.0001)	4.8E–05	(0.0002)	5	8	11
	2	122	(76)	136	(85)	150	(93)	0	0.000	0.002	(0.007)	0.004	(0.013)	1.6E–05	(0.0001)	2.0E–05	(0.0001)	2.4E–05	(0.0001)	3	9	17
	3	142	(88)	158	(98)	174	(108)	0	0.000	0.002	(0.007)	0.004	(0.013)	1.6E–05	(0.0001)	2.0E–05	(0.0001)	2.4E–05	(0.0001)	3	11	19
	Sum																			12	28	47

Each catchment is divided into several segments from west to east.
Abbreviations: Mt = million tons; SE = shelf edge.

middle and upper Wilcox, ranging from 0 to 30 km/Ma. The aggradation rate ranges from 3×10^{-5} to 3×10^{-4} m/yr $(10^{-4} \times 10^{-3})$. The progradation and aggradation rate along the Wilcox shelf margin from west to east are shown in Table S2.

Results

Following the approach described here, the estimated sediment load of each catchment for lower, middle, and upper Wilcox is plotted in Table S2. The results of lower and middle Wilcox are averaged to yield the sediment load of the Paleocene Wilcox Group when compared with BQART Monte Carlo simulation (BQART-MCS) results. We notice that the ranges for sediment load tend to be narrower in the clinoform method than in the BQART-MCS. This probably reflects that (1) we have used only one cross section to characterize the shelf-margin architecture, and it is likely that the dimensions of the shelf-margin clinoforms vary at different locations along depositional strike; and (2) aggradation and progradation rates are averages over millions of years, and probably do not capture the full range of progradation- and aggradation-rate variability over shorter time scales.

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