# HOLOCENE MUD ACCUMULATION ON THE CENTRAL TEXAS SHELF LINKED TO CLIMATE CHANGE AND SEA-LEVEL RISE

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**ABSTRACT**

The Texas Mud Blanket (TMB) is a large (~300 km3) depocenter that formed after the last (LGM – MIS 2) eustatic lowstand on the central Texas shelf, an area where no large rivers occur. The evolution of the TMB is determined from 26 new radiocarbon dates and from ~3000 km of high-resolution 2D seismic data. Sediment flux (km3/ka) was calculated from this combined dataset. XRD analysis reveals that the origin of sediments accumulated in the TMB are mainly local, coming mostly from the Colorado and Brazos rivers, with the Mississippi River having been a secondary source.

A large depression between the MIS 3 shoreline on the west and a linear reef trend on the east created accommodation for the TMB. The ancestral Colorado and Rio Grande deltas are the northern and southern boundaries, respectively. Between LGM and ~17 ka, terrestrial and lagoonal sediments filled the deepest parts of the depocenter. From ~17 to ~9 ka was a time of rapid eustatic rise and low sedimentation (flux= 0.4 km3/ka). At ~9 ka, sediment flux to the mud blanket dramatically increased to 41 km3/ka. During this time, older, falling stage Brazos and Colorado deltas were being ravened, producing an estimated 61 km3 of sediment, of which an estimated 58.3 km3 was silt and clay and contributed to growth of the TMB. By ~5.5 ka, Texas was experiencing maximum temperature and minimum precipitation for the Holocene, which led to a reduction in sediment accumulation in the TMB. During the last 3.5 ka the mud blanket experienced remarkable growth, having accumulated 172 km3 of sediment, accounting for 57% of its volume. Mineralogical data indicate that most of this sediment that comprises the TMB was derived from the Colorado and Brazos rivers and did not vary significantly over the time of its evolution. This calls for a dramatic increase in the sediment yields of these rivers during the late Holocene, which is best explained by a more variable climate at this time and elimination of accommodation space within the river valleys as they were filled to capacity.

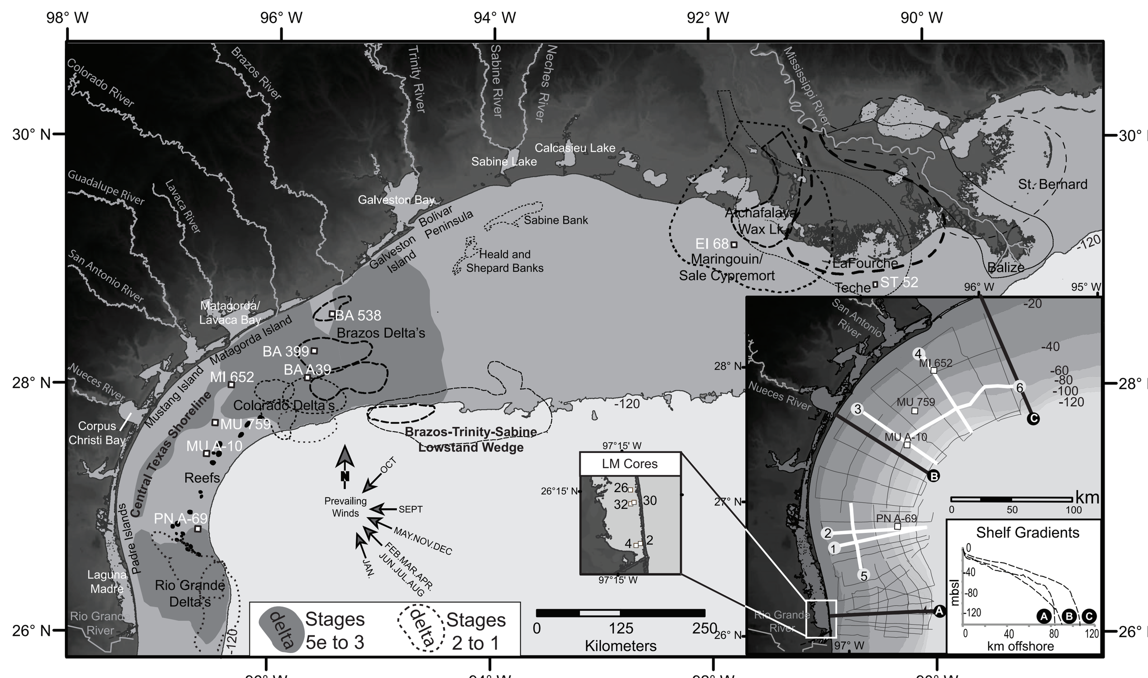


**Figure 1.** Important geographic and paleogeographic features within the study area. The larger inset map shows seismic lines, cross section lines (labeled with a letter) and the -120 bathymetry contour, which generally corresponds to the shelf break. Seismic lines in text are labeled with a number. The plot of shelf gradients (small inset) illustrates that Central Texas is a ramp between two relatively flat shelves with distinct shelf breaks. Core locations are shown as white boxes with a corresponding label. Laguna Madre cores are shown in the smaller inset map. Mississippi delta lobe locations are from Coleman et al. (1998). Brazos and Colorado delta locations are from Suter and Berryhill (1985), and from Abdullah et al. (2004). Locations of the Rio Grande delta's are from Suter and Berryhill (1985), and from Banfield and Anderson (2004). Reef locations are from Rezak et al. (1985), modified from Belopolsky and Droxler (1999).

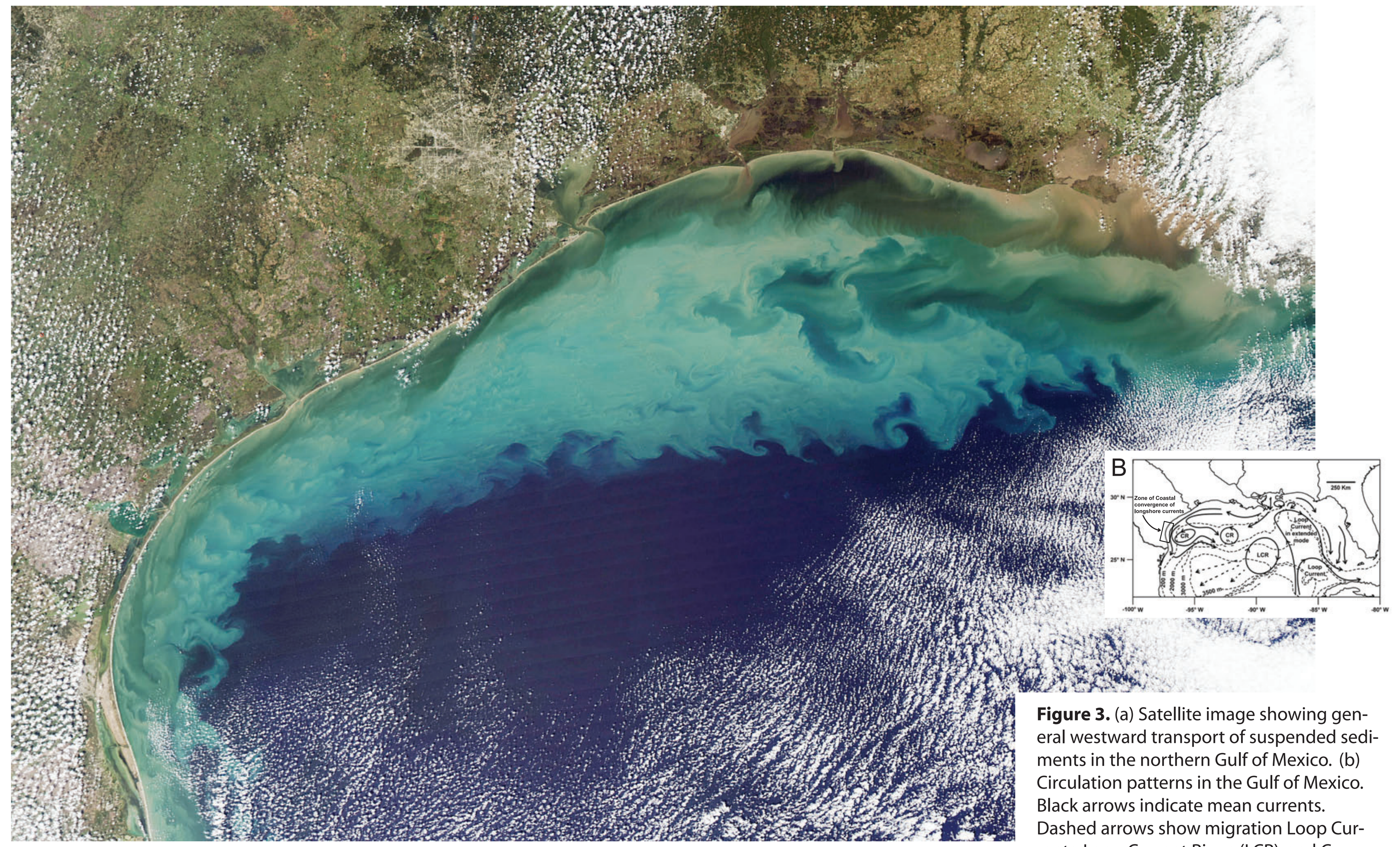


**Figure 3.** (a) Satellite image showing general westward transport of suspended sediments in the northern Gulf of Mexico. (b) Circulation patterns in the Gulf of Mexico. Black arrows indicate mean currents. Dashed arrows show migration Loop Currents, Loop Current Rings (LCR), and Cyclonic Rings (CR), (From Sionneau et al., 2008). Also shown is the coastal convergence zone from McGowen et al. (1977).

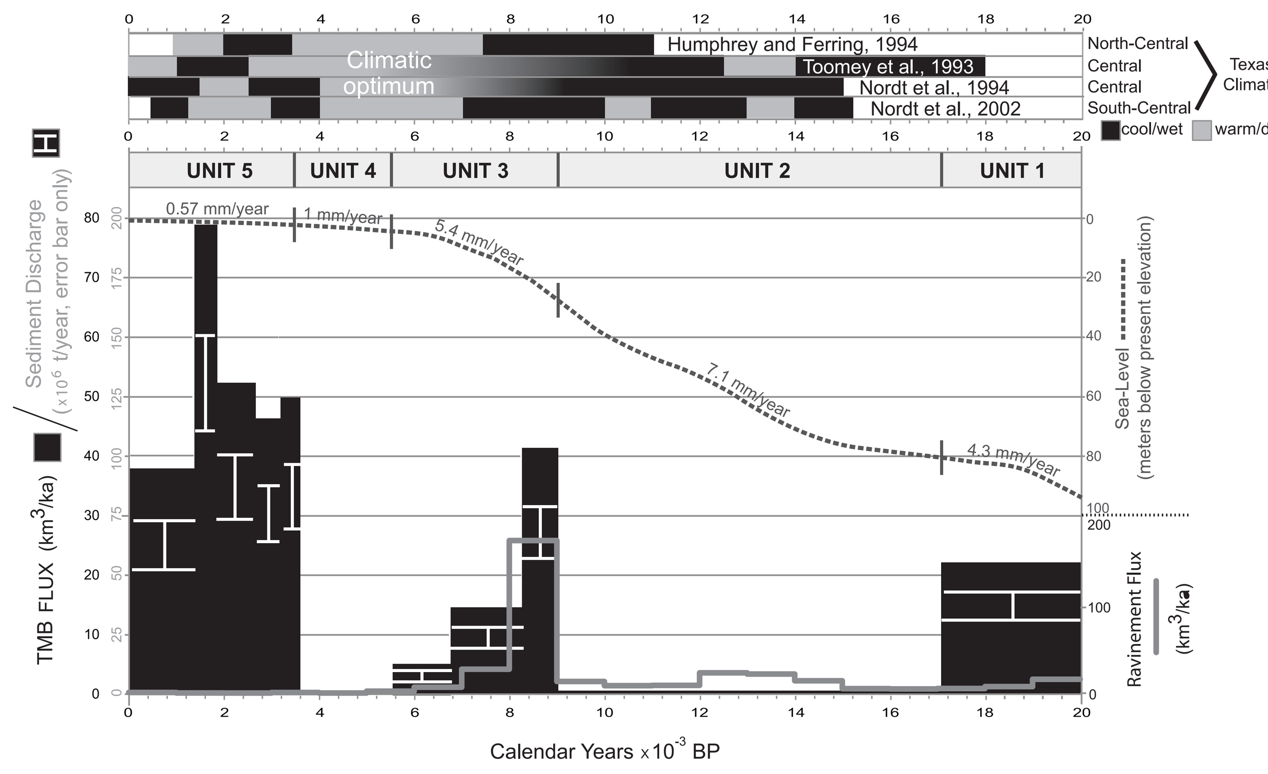


**Figure 10.** Central Texas shelf sediment flux in relation to sea-level and records of Texas climate change. The sea level curve is from Simms et al. (2007b). Ravinement flux is calculated using the area between shorelines at 1000-year intervals (for the area bounded by 26.5° N in the south, to 95° W in the east), and assuming a -10 m depth of ravinement (Rodriguez et al., 2001). Sediment discharge was calculated from TMB flux and mean grain size (Table 4) using grain size versus density plots of Hamilton and Bachman (1982) to make comparisons between modern fluvial sediment discharge (Table 1) and TMB flux. Sediment discharge is shown as white symbols showing the time period (x-axis) and the range of discharge (106 metric t/year) values (y-axis) based on the range of grain sizes observed in TMB sediments.

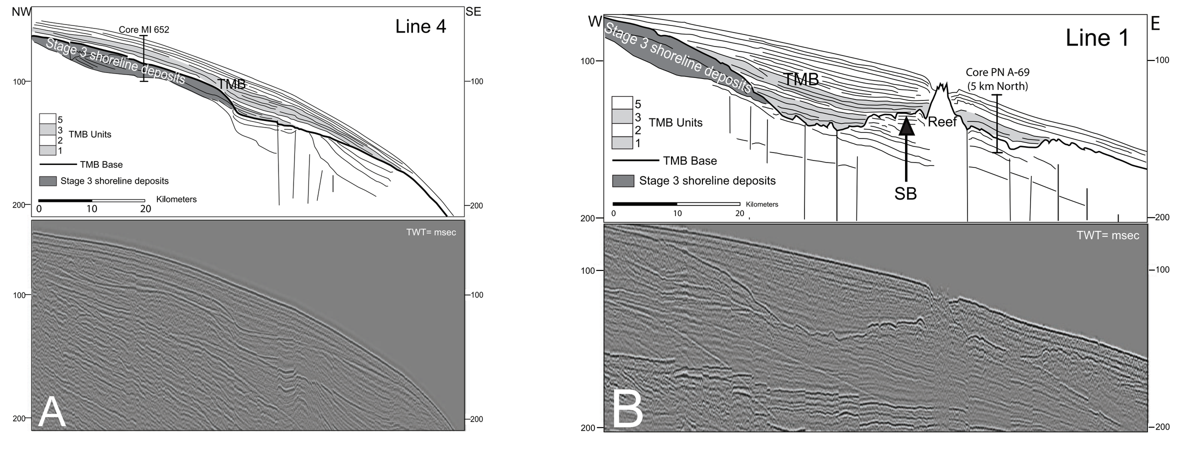
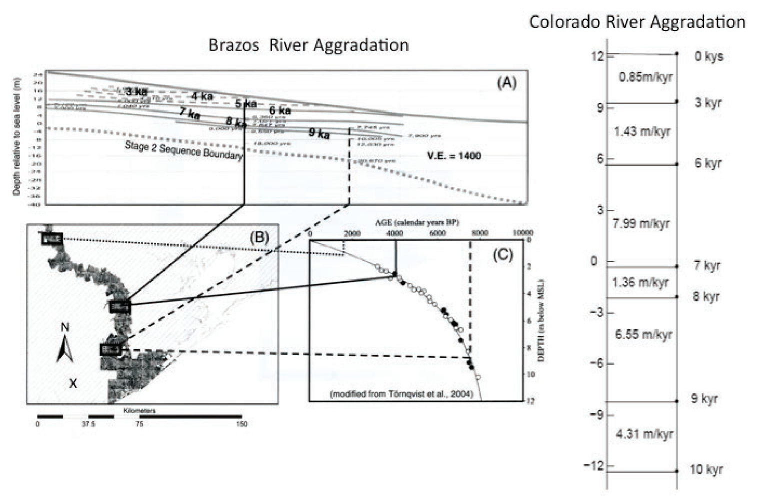


**Figure 2.** Interpreted and uninterpreted seismic lines 4 and 1 (see figure 1 for locations) illustrating a prominent erosion surface (Transgressive surface of ravinement) that defines an outer shelf depression in which the TMB accumulated. Also shown are the locations of cores PN A-69 and MI 652.



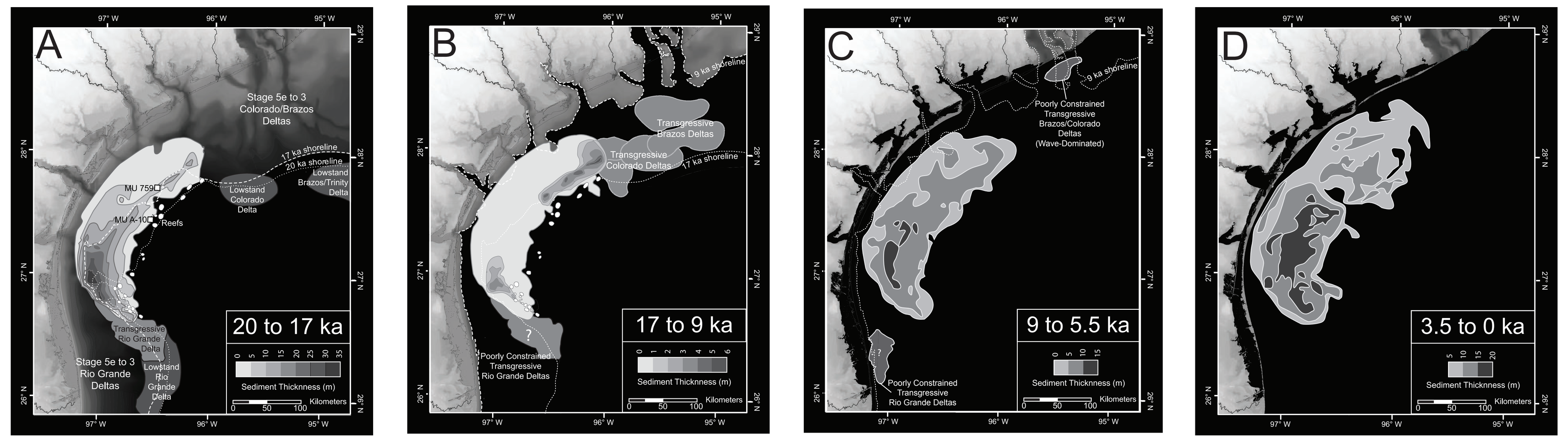



**Figure 9.** (a) Unit 1 (20-17 ka) isopach map and TMB isopach superimposed on stage 2 erosion surface from Simms et al. (2007a). (b) Unit 2 (17-9 ka) isopach map. (c) Unit 3 (9-5.5 ka) isopach map and TMB. (d) Unit 5 (5.5 ka to present) isopach map. Shorelines are based on Simms et al. (2007b) sea level curve. Delta locations are based on Banfield and Anderson (2004), Abdulah et al. (2004), and Suter and Berryhill (1985).

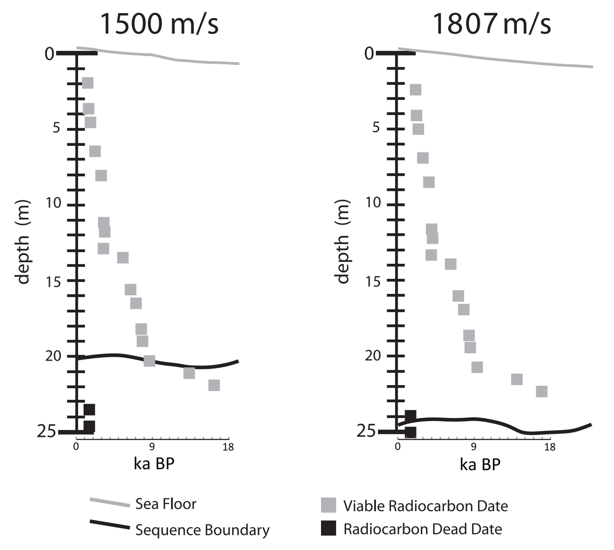



**Figure 6.** Results from seismic velocity test using core MU A-10 and surfaces from seismic line # 3 (see Figure 1 for core and seismic line locations). A velocity of 1807 m/sec more accurately places the sequence boundary above the radiocarbon dead dates.

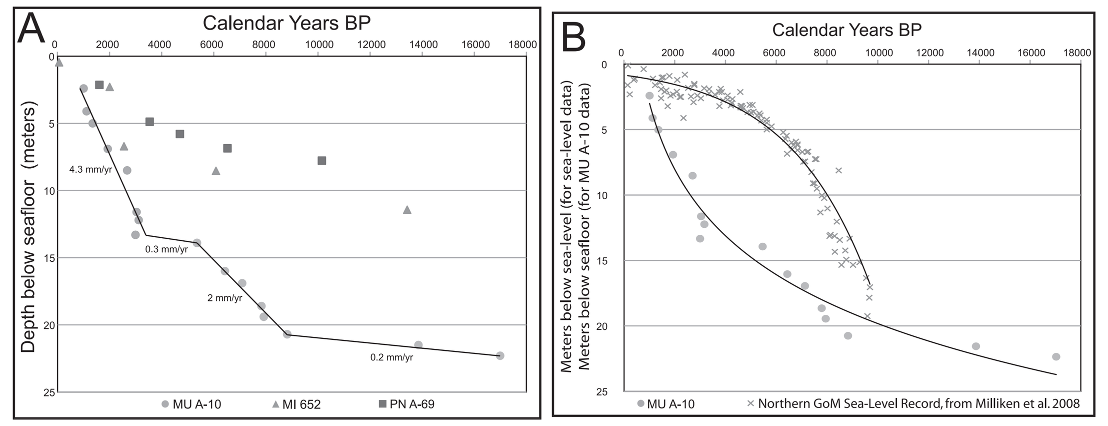


**Figure 7.** A- Age-depth plots for three cores (MU A-10, MI 652, and PN A-69) and accumulation rates for core MU A-10 based on linear regressions. B- Mud blanket age-depth plot for core MU A-10 and the northern Gulf of Mexico sea level curve for the last ~9 000 years from Milliken et al., 2008). Note inverse relationship between mud blanket rate of accumulation and the rate of sea level rise.

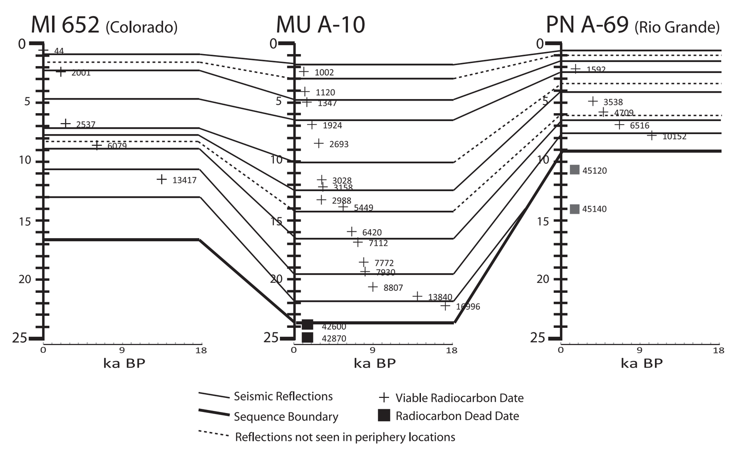


**Figure 8.** Ten prominent seismic reflections correlated between core sites with radiocarbon dates used for subdividing the TMB into units for volume and sediment flux calculations (For core locations see figure 1).

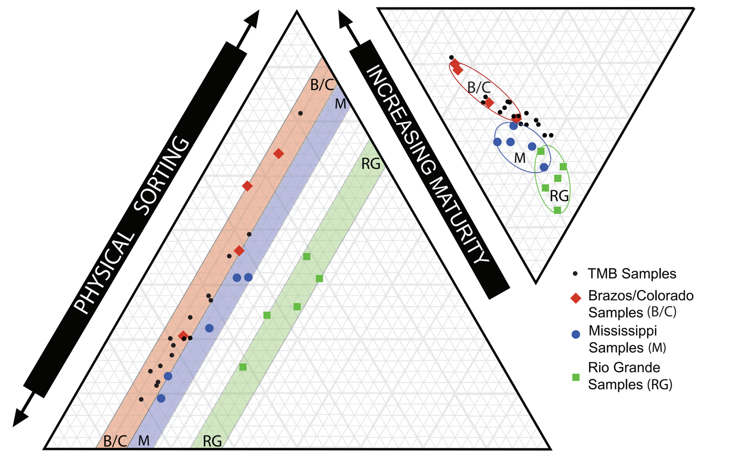


**Figure 11.** QPK and QPClay ternary diagrams illustrating differences between sediments of the Rio Grande (RG), Brazos/Colorado (B/C), and Mississippi (M) drainage basins. The QPClay diagram plots total clays with the Q and P proxy for maturity. The Q and total clay relationship is largely controlled by variations in grain size variations.

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**CONCLUSIONS**

1. The Texas mud blanket (TMB) has mostly accumulated in a mid-to-outer shelf depression that is situated between the MIS 3 and MIS 2 shorelines. Deposition was mostly confined by the ancestral Colorado Delta to the north and the Rio Grande Delta to the south. Reef growth on the MIS 2 shoreline enhanced the eastern margin of the depocenter. In the south, faulting has deepened the shelf depocenter.

2. XRD data reveal that the Brazos and Colorado rivers were the dominant sediment sources of the TMB, with the Mississippi River having served as a secondary source.

3. Five sediment flux intervals observed in the TMB record variations in the dominant controls on sedimentation; antecedent topography, rates of eustatic rise, efficiency of transgressive ravinement, and climate-controlled sediment delivery from rivers.

4. From ~20 to ~17 ka there was a transition from terrestrial to marine sedimentation with shallow marine and possibly fluvial sediments having filled the deepest accommodation. By ~17 ka, a mixed siliciclastic/carbonate depositional system was established. A new shoreline had developed on the landward side of the depocenter and a series of reefs were growing on the ancestral MIS 2 shoreline. Marine foraminifera in sediments of this age indicate a back-reef depocenter that was open to marine waters.

5. Low sediment flux to the TMB occurred from ~17 to ~9 ka. During this time, sea level rose at its highest rate of ~7mm/year, which corresponds to a phase of Colorado and Brazos delta growth that was most pronounced from ~12 to ~9 ka. Hence, sediments appear to have been sequestered in shelf deltas that largely escaped transgressive ravinement.

6. From ~9 to ~5.5 ka was a period of rapid growth of the TMB related to the ravinement of both falling stage and transgressive Brazos and Colorado deltas. As these sediment sources were depleted, sediment flux decreased.

7. A period of low sedimentation rates and a hiatus in TMB growth from ~5.5 to ~3.5 ka corresponds to the warm and dry conditions of the Holocene Climatic Optimum (~4.5 to ~6.0 ka, Nordt et al., 1994) and sequestration of fluvial sediments in onshore valleys.

8. The final episode of TMB growth (~3.5 ka- present) is associated with high frequency climate oscillations of this time period. During this time, approximately 57% of the total TMB volume accumulated.

9. The most pronounced trend in the evolution of the TMB is the anti-correlation between its evolution and rates of sea-level rise. This indicates that efficiency of transgressive ravinement and sediment production by this process is closely regulated by rates of transgression.

10. One of the most surprising outcomes of this study is the shear volume and extraordinarily high flux rates associated with TMB growth during the last 3.5 ka. The order of magnitude increase in volumes and flux provokes a desire to include a higher-discharge source like the Mississippi River to help contribute to the huge volumes of sediment observed over this time interval. However, the mineralogical data suggest a dominantly Brazos/Colorado source. For these rivers to be the major suppliers of sediment to the shelf, pronounced changes in transport efficiency and/or sediment supply must have occurred during the late Holocene because a decreased rate of transgression resulted in transgressive ravinement being of little importance after 6 ka. A change in oceanographic circulation could have increased transport efficiency to the TMB by changing the location of convergence and offshore flow. Still, an increase in sediment supply of these rivers, likely caused by more variable climate, was necessary to provide the order-of-magnitude increase seen at this time.

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