Depositional facies of estuarine upper-bay deposits in arid climates; Baffin Bay, Texas

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Abstract

Estuaries represent significant sediment depo-centers throughout the Earth's history. Owing to high sedimentation rates and preservation potential, estuaries are excellent localities to study coastal response to changes in climate and sea level. 6 jackhammer cores and 55 vibra-cores were taken from the upper bay of Baffin Bay, Texas to study the unique suite of depositional environments found within estuaries in arid climates. Thirteen sedimentary facies were identified within cores: valley margin sand, channel sand, floodplain, erosive lag, shelly spit/internal barrier island, serpulid worm tube reef, mud flat, pro-mud flat, upper bay mud, open bay mud, and bay-head delta. Within Baffin Bay the typical bay-head delta is replaced by expansive, low-lying mud flats covered in abundant algal mats. Previous studies indicate that the mud flat did not form until the on-set of xeric conditions in southern Texas at 5.5 ka. Cores from the mud flat suggest it retreated 4.5 km to its present location, prograded 2.0 km, and retreated 2.0 back to its present position over the last 5,000 years. Despite the large area covered by the mud flats the processes operating on the mud flats are largely unknown. The mud flats contain only one main distributary channel and are seasonally submerged owing to wind-tides from increased prevailing southeast winds from March through October. Examination of aerail photographs from 1989, 1995, and 2002 show that the mud flat has remained fairly static while shelly spitsand shelly internal barrier islands have retrograded landward. These mud flats are a poorly understood sedimentary sink along the pathway betweenthe hinterland and the deep ocean.

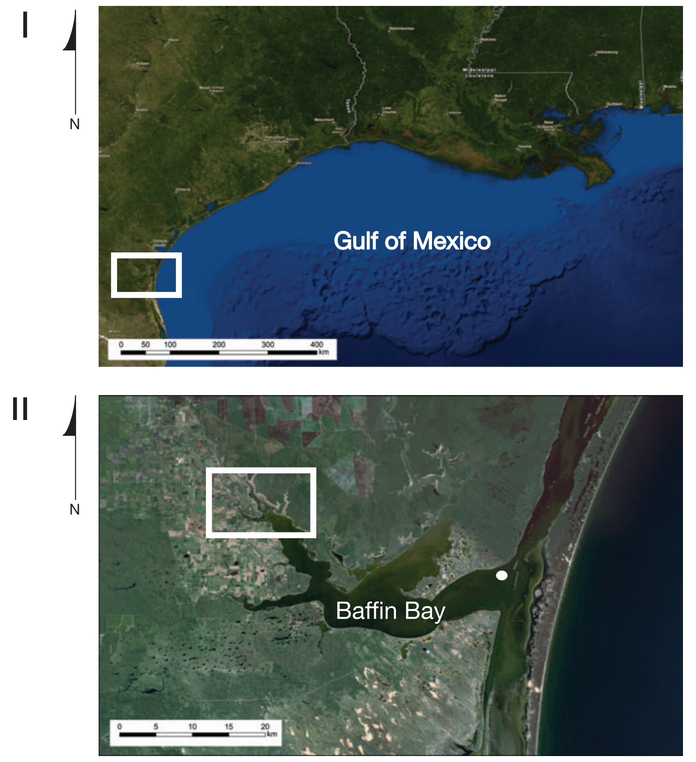

Figure 1. Regional location of Baffin Bay (I) Baffin Bay inset (II). White dot indicates bay mouth wind/tide gauge. See Fig. 3 for inset

Introduction

- Estuaries within arid climates are relativey understudied
- Baffin Bay exhibits sevaral environments unique to bays in arid climates including: mud flats in place of typical bay head delta deposits, serpulid worm tube reefs, shelly spits/internal barrier islands, and well-laminated open bay carbonate muds
- More work is needed to understand proccesses controlling upper bay sedimentation within bays in arid climates

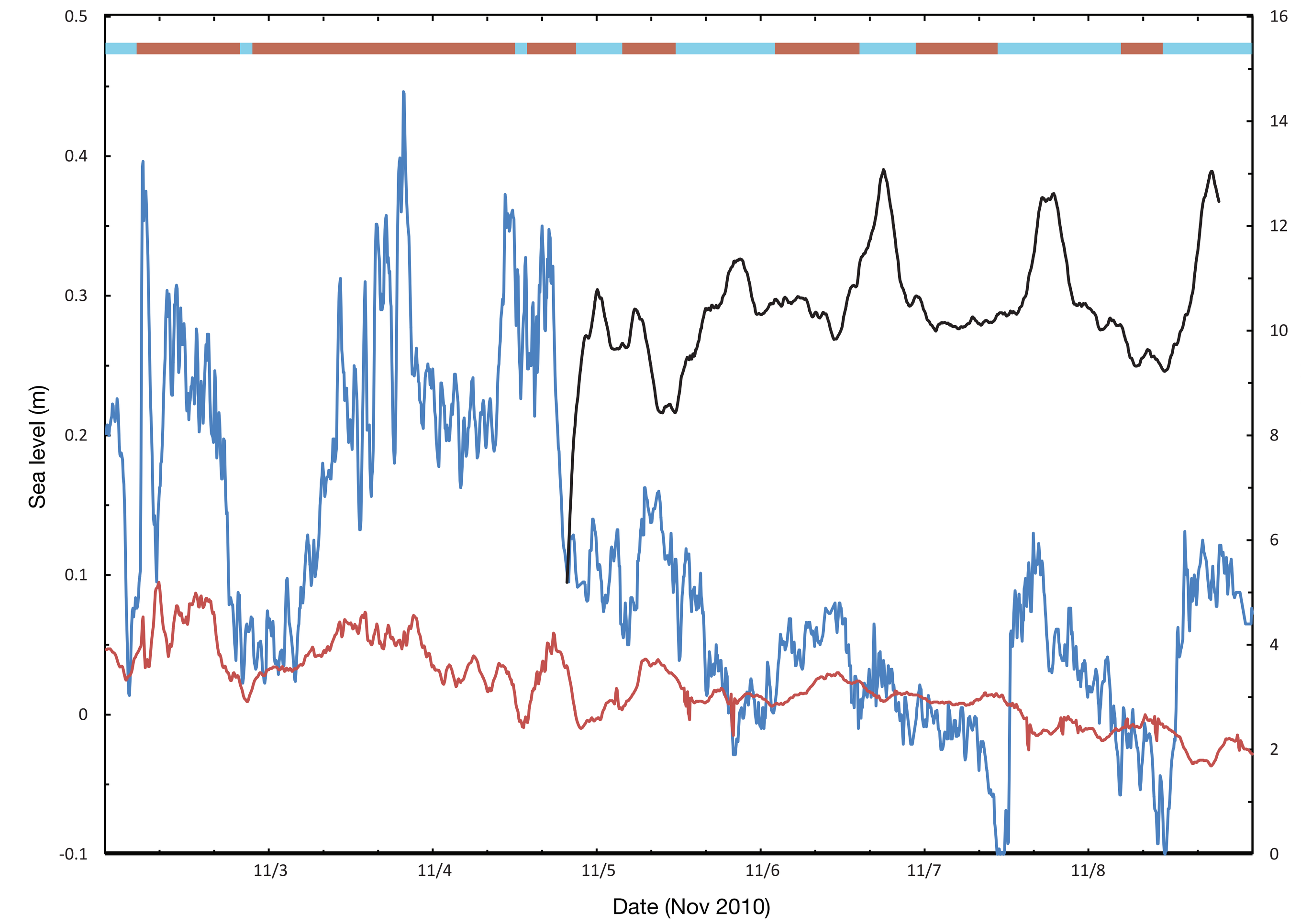

Figure 2. Comparison of wind speed (blue line), bay mouth tide (red line) and upper baytidal data (black line) Colored bar (top) indicates when wind direction raises tide in (blue shade) and when wind direction lowers tide (red shade). Note delayed periodic peaks (~4:00 PM) between wind speed and upper bay tide correlating with favorable wind direction and increased wind speed.

Setting

- Baffin Bay is the LGM flooded incised valley of the Los Olmos, San Fernando, and Petronilla Creeks.
- Water depths in the open bay range from 3 - 4 m with upper bay shallowing to depths of typically 1 m
- Evaporation is greater than preecipitation with avgerage annual rainfall at 66 - 76 cm/yr
- San Fernando creek average stream flow is 0.64 m^3/s with a low of 0.03 m^3/s and high of 3.53 m^3/s
- Astronomical tidal range is < 0.1 m
- Upper bay tidal range ~ 0.3 m
- Average summer wind speed is 15 to 24 mph
- Prevailing southeast winds from spring to autumn and northwest winds from late autumn to early spring dominate upper bay water levels

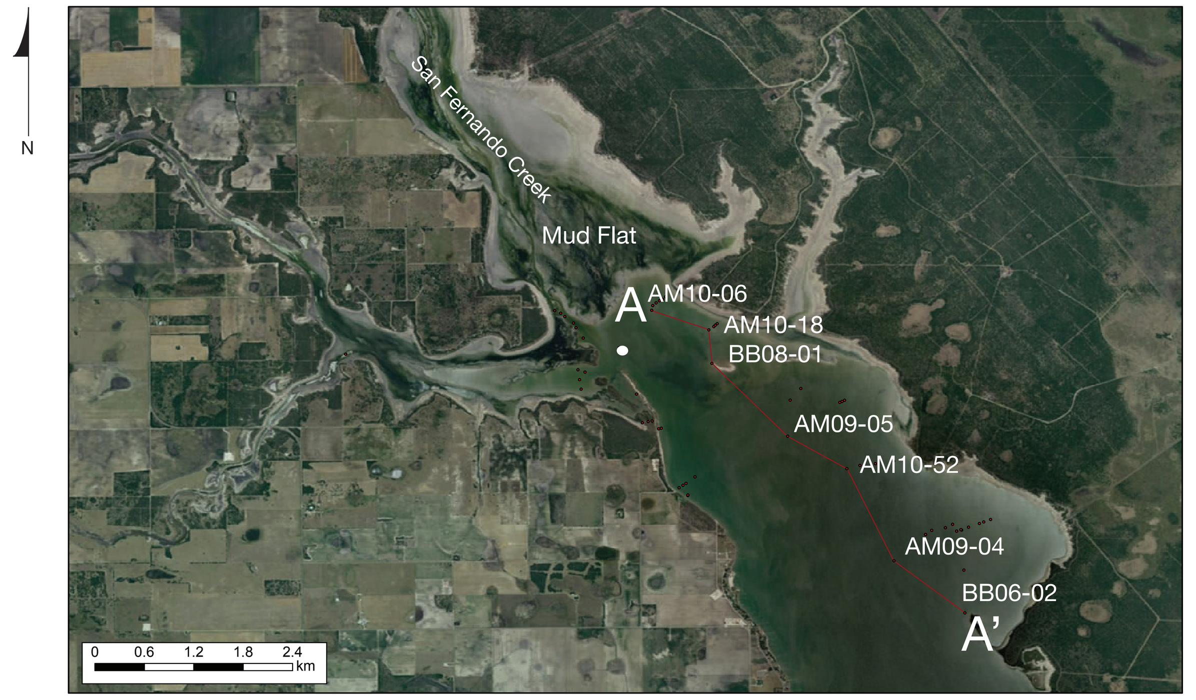

Figure 3. Upper Baffin Bay. Red dots indicate core locations; upper bay tide gauge (white dot) ; transect A to A' (red line). Note mud flat in place of bay-head delta, shelly spit, and shelly internal barrier island. See Fig. 1 for inset location. Cores BB08_01 and BB06_02 from Simms et al. (2010).

Method

- 55 vibra-cores and 6 jackhammer cores were taken
- Sediment in core was compared to modern environ ments to create facies model
- 5 sediment traps were deployed in Nov. 2010 to quan- tify sedlimentation rates on mud flat
- Upper bay tide gauge data, wind speed, and wind direction were compared to analyze the affect of winds on tidal regime
- Radiocarbon dating of microbial mats and articulated bivalves allow for chronostratigrpahic control

Sedimentary facies of upper bay

Table 1. Sedimentary facies and their interpretation.

Facies #	Description	Interpretation	Munsell color
1	Laminated L-Bl & Gn silts with Wh (1-3mm) clay interlams and microbial mats	Mud flat	5PB 6.5/1;N8;10G 6/1
2	Mottled L-Bl and Gn clay with organic matter and lenticular lamination	Pro-mud flat	10Y 6.5/1
3	Gn and Blk clays with sandy bioturbation & abundant plant fragments	Back-spit lagoon/grassflat	5GY 4.5/1
4	Clayey shell hash grading into shelly clay	Shelly spit/shelly internal island	N6.5;10B 5.5/1
5	3-6 cm erosive shelly sandy clay	Erosive lag	10B 5.5/1
6	Bl and L-Bl mottled clay with sandy burrowing w/ (~0 - 15 %) shell fragments	Upper bay mud	10B 5/1
7	Bl (2-6 cm) and Wh (2-3 cm) interbedded clays	Open bay mud	10B 5.5/1; N9
8	Clayey fine sand with clay/silt infilled burrows and flaser bedding; few 1-2 cm lithics	Channel sand	5PB 7/1
9	Stiff Gn to Brn clay with plant fragments	Floodplain	10Y 7/1
10	Interlocking worm tubes composed of calcium carbonate	Serpulid worm tube reef	N8;10B 5.5/1
11	Bioturbated clayey sand with few shell fragments	Valley margin sand	10Y 6.5/1
12	Clayey Gn sand with plant fragments and flaser lamination	Bay-head delta	10Y 7/1
13	Stiff dewatered Ol bioturbated clayed sand and sandy clay w/ in-situ caliche	Pleistocene (undifferentiated)	10Y 6/2

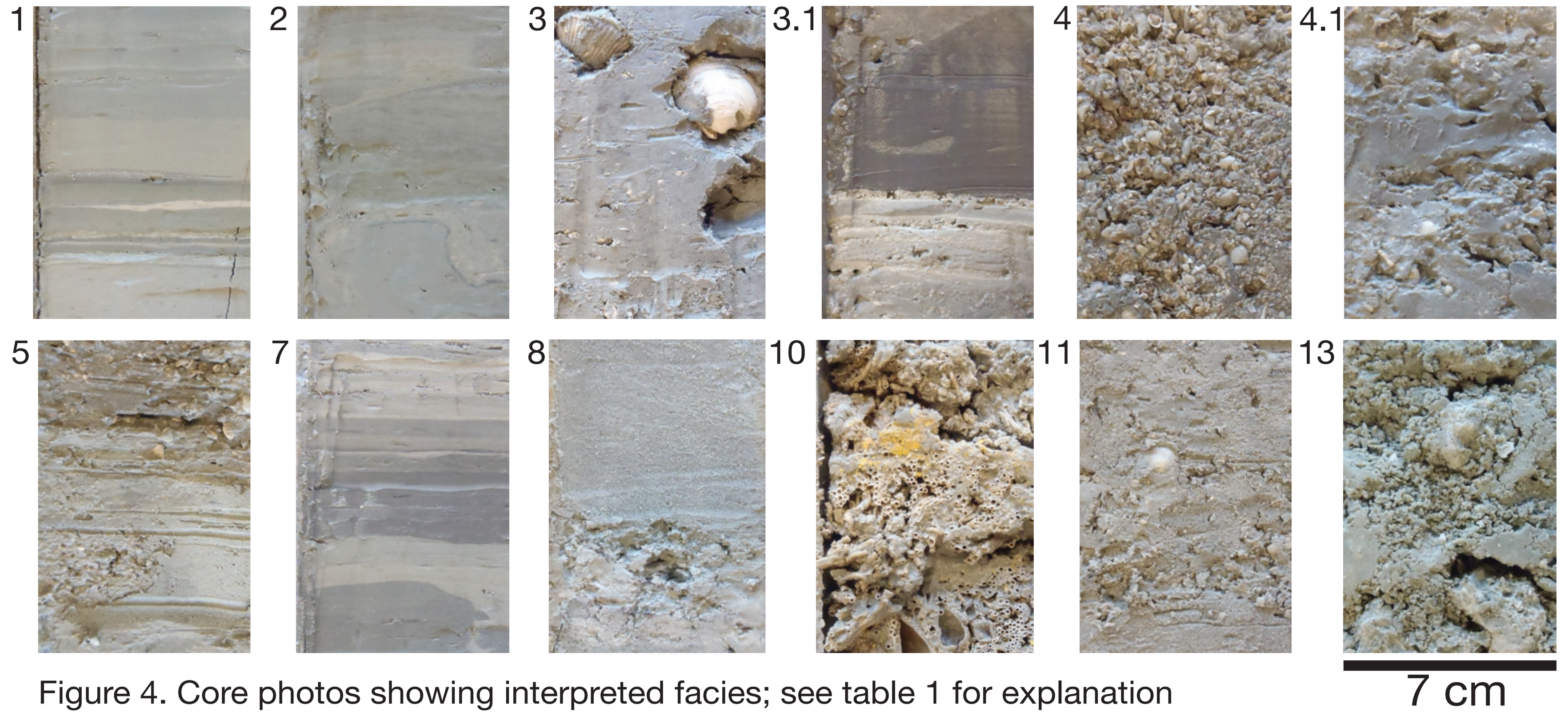

Figure 4. Core photos showing interpreted facies; see table 1 for explanation

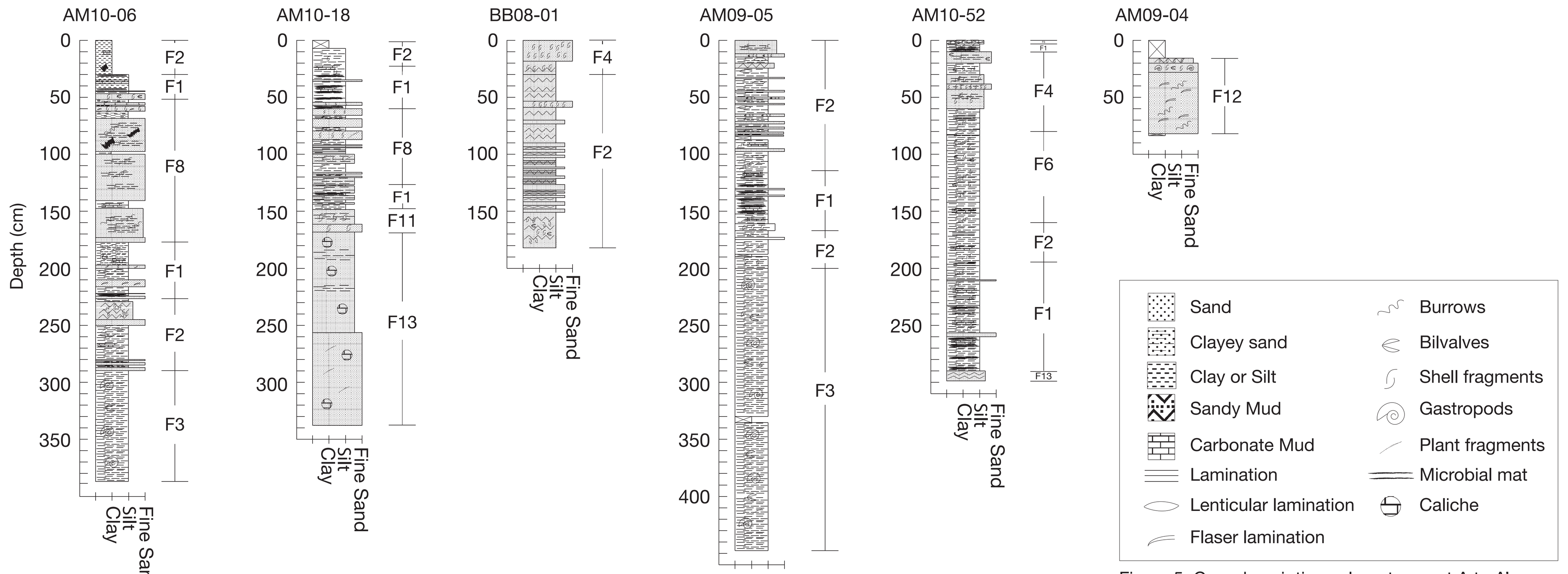

Figure 5. Core descriptions along transect A to A'
See Table 1 for facies i.d. and Fig 3 for core locations

Discussion

- The mud flat back-stepped 4.5 km from 5.5 ka to 4.3 ka, prograded 2.0 km between 4.3 ka to 1.4 ka, and back-stepped 2.0 km to its present lo cation (Fig 6)
- Aerial photographs from 1989,1995, 2002, and 2010 indicate the mudflat has remained stable for last 21 years
- Mud flat possibly responding to rapid changes in sediment supply, climate, and/or accomadation space
- Comparison of tidal data and wind speed suggest wind tides are primary process controlling tidal regime (Fig 2)
- Given low flow rates into upper bay (0.64 m^3/s) seasonal winds are likely dominant proccess acting on upper bay sedimentation

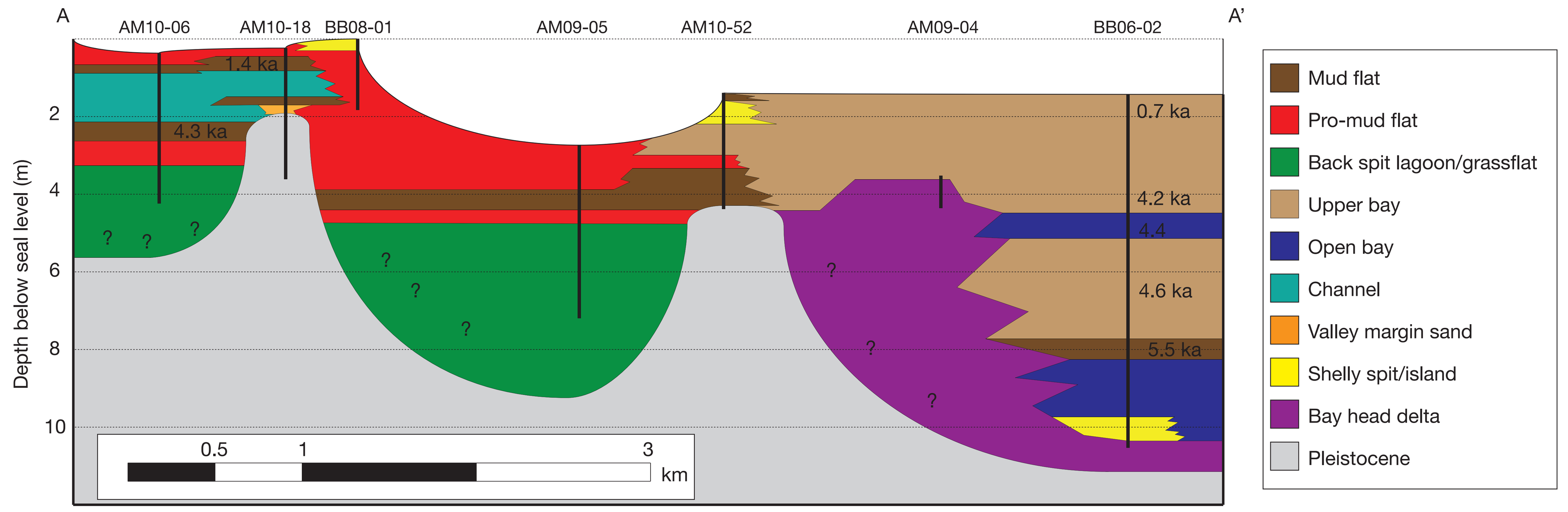

Figure 6. Facies dip profile along transect A to A'; see Figure 3 for core locations; Dates from core BB06-02 (Simms et al. 2010)

References

SIMMS, A. R., ARYAL, N., MILLER, L. and YOKOYAMA, Y. (2010), The incised valley of Baffin Bay, Texas: a tale of two climates. Sedimentology, 57: 642–669

Meteorlogical data from Division of Nearshore Research at http://lighthouse.tamucc.edu/TCOON/HomePage

Acknowledgements

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