Investigating carbon reservoir effects through time in fluvial–bay systems of the Gulf Coast

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Research objective: Identify the source and quantify the amplitude of carbon reservoir in fluvial/bay systems that span an arid-humid climatic gradient and which drain variable areas of Cretaceous carbonate substrate. An accurate correction will allow a comparison of the ages of flooding/backstepping events in multiple fluvial/bay systems and provide additional insight into forcing mechanisms that control stratigraphy.

Introduction:

The Rice Gulf Research Group has investigated and compiled valuable information concerning the Holocene evolution of a suite of small coastal plain fluvial-bay systems that span a climatic gradient and drain a range of geological substrates to extract the relative effects of sea level, antecedent topography, and sediment supply (climate) on stratigraphic architecture (Rodriguez *et. al.*, 2004; Simms, 2004; Maddox, 2005, Milliken, in progress).

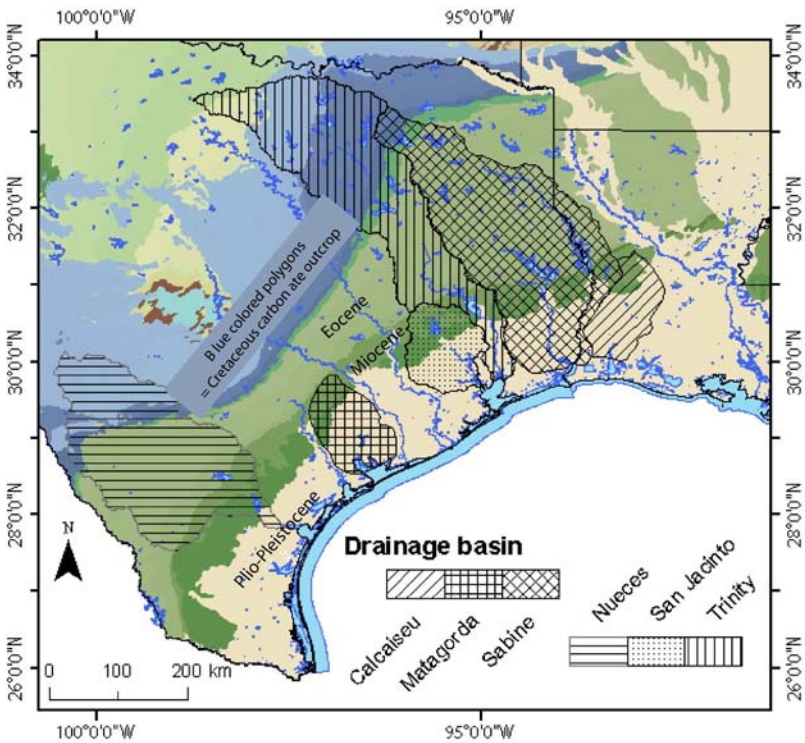

Figure 1. Drainage basins of studies fluvial–bay systems overlain on 1974 King and Biekman United States geologic map (Scruben *et. al.*, 1994). In the Gulf Coast region, Cretaceous carbonates outcrop is shown in blue colors with Tertiary to Pleisocene clastic sediments cropping out basinward and illustrated in green and tan.

Tools utilized include high resolution boomer and chirp seismic data coupled with continuous drill and vibracores (up to 20 m length) and radiocarbon dating of key surfaces to document the timing of each system's backstepping and progradation and relate to the appropriate controlling mechanism. The next step entails comparing and contrasting all systems to determine which flooding events are synchronous across this area of the Gulf versus which events are unique to individual systems. This can further aid in quantifying the effects of sea level rise, sediment supply variations, and antecedent topography on depositional environments and sediment flux. In order to accomplish this goal, the dating method pitfalls must be negated through successful calibration of radiocarbon years to calendar years.

For the Holocene and latest Pleistocene, the radio – 14C isotope (with a 5380 year half-life) is a useful tool for constraining the timing of depositional events and constructing a chronostratigraphy for fluvial, bay, and marine systems. Moreover, Accelerator Mass Spectrometry (AMS) dating allows the submission of very small sample size (1 to 4 mg) of carbonate shell and wood or plant material which produces very accurate and precise dating of flooding and depositional events within a sedimentary system. Calibration to calendar years is necessary in order to compare carbonate ages with wood or plant ages and determine accurate sediment flux rates through time. This is possible using the Calib04 (Stuvier, 2004) calibration curves and software program.

The dominant complication of radiocarbon age dating involves variable reservoir effects in different materials (Figure 2; for complete description see Aten, 1983; Appendix A). For instance, pelecypods such as *Rangia* sp. extract carbon from the *in situ* water which may contain a proportion of old 'dead' radiocarbon. This commonly occurs when the fluvial system drains Cretaceous age carbonate. Plants extract carbon directly from the atmosphere so should reflect the relative atmospheric proportions of carbon isotopes (accounting for appropriate biological fractionation) and should not sequester an old carbon reservoir signal.

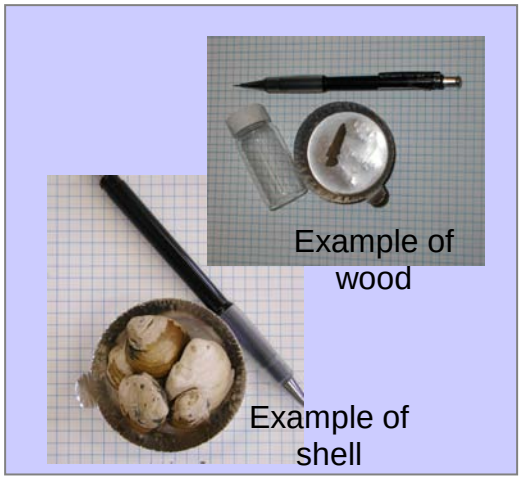

Figure 2: Examples of datable material which contain variable carbon reservoirs.

The fluvial – bay systems studied northeast to southwest include Calcasieu – Calcasieu, Sabine, and Neches – Sabine, Trinity-Galveston, Lavaca-Matagorda, and Nueces-Corpus Christ (Figure 1). Present day climate ranges from humid, subtropical in the Calcasieu system to semi-arid, subtropical in the Nueces system. The fluvial

systems also traverse variable geological substrates from Cretaceous carbonates to Tertiary fluvio-delatic sediments. Calcasieu is a small drainage basin which traverses only tertiary clastics. The Sabine and Neches highest tributaries drain Cretaceous carbonate rocks, but greater than 90% of the drainage basin resides in tertiary fluvio-deltaics. The sub-humid Trinity fluvial system also has tributaries that flow through Cretaceous carbonates. The semi-arid Lavaca system resides only in Tertiary clastics but has documented soil carbonate which may be several thousand years old and could provide a carbonate reservoir (Blum and Price, 1998). The Nueces drainage basin has a significant portion within the Cretaceous carbonate and also rests in a semi-arid climate so likely has soil carbonate.

Dates from a series of *Rangia* sp. – charcoal pairs from shell middens in the Trinity, Lavaca, and Sabine River drainages show significant variations in carbon reservoir (Aten, 1983; Ensor, 1999). These results suggest that the carbon reservoir ranges from almost zero in Sabine to 225 years in Trinity to 650 to 1240 years in Lavaca. Simms (2005) dated a wood – barnacle pair in the Nueces system and found a 700 year correction. My hypothesis states that the carbon reservoir of shell dates can be attributed to area of drainage basin which drains Cretaceous carbonates. Nueces-Corpus Christi system should have the greatest correction, the Calcasieu system should have no correction with the other systems somewhere in between.

Methods

Continuing of from data collected by Simms (2004) in Corpus Christi bay, I propose age dating additional wood/peat – shell pairs in each system to document the reservoir. This includes Sabine, Matagorda, Calcasieu, and Trinity for a total of six dates to augment existing dates. Additionally, I would like to collect one radiocarbon sample from each bay to assess the modern carbon signature. This would include a live organism sample to obtain an inorganic carbon AMS date. (total - 5 organism samples)

Results

This study aims to extend the previous datasets in both space and time (Aten, 1983, Ensor, 1999, Simms, 2005). Aten (1983) and Ensor (1999) focused on surface samples and a relatively young carbon reservoir effects. With the cores obtained in all the bays, I can investigate the change of carbon reservoir through time. For instance, if the Lavace – Matagorda system drains no Cretaceous age carbonates, but does drain potentially thousand year old soil carbonates, the carbon reservoir could change through time if the soil carbonate amounts expanded or diminished. Additionally, Calcasieu resides in a humid climate without soils that hold carbonate as nodules, but could the soils have been different during the altithermal, 5000 years ago (Delcourt and Delcourt, 1985; Bense, 1994; Toomey *et. al.*, 1993)

Anticipated results include a knowledge of both present and past variations of radiocarbon reservoir and the ability to correct the dates to calendar years. This will enable me to compare the various systems and document environmental changes that occur across all the bays versus individual bays. The ultimate goal is to construct a climate history for the Holocene coastal areas from central Texas to west Louisiana when sea level and antecedent topography are taken into account.

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2005 Funding results

Previous funding from the Ed Picou fellowship augmented existing funding and allowed Kristy to extend the dataset to include age constraints of key surfaces within the Holocene sedimentary fill of the Calcasieu incised valley. A paper in preparation as a result of this funding entitled: Flooding history of Calcasieu Lake and fluvial system with implications for controlling factors on deposition is scheduled to be submitted later this month.

Biography

Kristy T. Milliken is a PhD student in the Earth Science department of Rice University in Houston, TX. Her current research interests include understanding the Holocene and Late Pleistocene stratigraphic and climatic evolution of two estuaries in the northern Gulf of Mexico. Kristy received her BS in Environmental Studies with a Geology emphasis from the University of Nebraska in 1998 and her MS in Geology from the University of Oklahoma in 2000.

Past research interests include Holocene sea level change and preserved stratigraphy of a back barrier system of North Padre Island, Texas; and early Permian glacio-climatic fluctuations preserved in paleosols of the Maroon Formation loessite,

Colorado. Her previous work experience includes 3 years with Marathon Oil Company as an exploration geologist.

Publications to date include a first authored paper in GSA Bulletin, co-authored paper in an upcoming GSSEPM special publication (eds., H., Posamentier, and R., Davis) and 8 abstracts. Additionally, Kristy has three papers in preparation which relate to the Holocene evolution of coastal Gulf of Mexico.