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Channel and Floodplain Response to Baselevel Change: Case Study of the Brazos River, along the East Texas Coast

Understanding the effects of climate and base level rise on fluvial aggradation and channel avulsion has implications for both petroleum exploration (connectivity of reservoir rock) (Bridge and Leeder, 1979) and societal dependence on stable river routes (Slingerland and Smith, 1998). For the last 18 ka, the Gulf of Mexico has experienced a rise in sea level (Fairbanks *et al.*, 1989, Bard *et al.*, 1996) with variability noted in fluvial response to this rise along the east Texas coast (Blum and Price, 1998 for the Colorado river, Smyth, 1991 for the Trinity river, and current study for the Brazos river).

Along the east Texas coast, fluvial systems tend to aggrade in response to base level rise. The three fluvial systems along the east Texas coast which debouche into the Gulf of Mexico are, from south to north, the Colorado, Brazos, and Trinity.

Blum and Price (1998) developed a strong chronostratigraphic framework for the alluvium of the lower Colorado valley over the last 20 ka by using both paleosols and radiocarbon dates. Cross cutting relations between paleosols, which are backed by radiocarbon dates, led Blum and Price (1998) to determine that the Colorado valley had undergone both episodes of aggradation and incision since base level began to rise from 18 ka to the present. Episodes of incision were correlated with shifting climates and the influence climate levers on sediment supply. Thus Blum and Price (1998) concluded that, for the Colorado fluvial system, the idea of constant aggradation of the alluvial and coastal plains during base level rise is oversimplified and climate, by effecting channel incision, exerts a strong influence on alluvial architecture.

The Brazos river is adjacent to the Colorado and shares a similar climate (www.wrcc.dri.edu/pcpn/tx.gif) and almost identical drainage basin size (Leblanc and Hodgson, 1959, and current study using GIS). Yet, so far as this current studied has determined, the lower Brazos alluvium (from 100 km inland, down to the present coast) has only undergone aggradation since sea level began to rise, with no concomitant incision. This study seeks to better understand why these two adjacent fluvial systems respond in different ways to base level rise. Differences between the surface geology of each drainage basin much further inland (400-700 km) is believed to play a large role by effecting the grain size and sediment yield. The Brazos drainage basin contains large exposures of clay-rich Permian redbeds, which leads to a suspended load dominated river. This is in contrast to the Colorado drainage basin which has smaller exposures of Permian redbeds and flows over a Precambrian granitic province (Llano Uplift) which supplies abundant bed load sediment. As a result the Colorado is a mixed load dominated fluvial system, and does not yield as much sediment overall. Admittedly it is hard to determine exactly what percent of a fluvial system's grain size transport is suspended load vs. bed load because of difficulties gauging bed load transport under normal conditions (Bloom, 1998) and difficulty assessing sediment yield during floods (when large quantities of suspended load sediment are sequestered on the floodplains) (Allison et al., 1998). But by using approximately 10 km of water well drillers' core descriptions for the lower Brazos alluvial valley (cores from Fort Bend and Brazoria counties), more accurate long-term ratios of suspended load vs. bed load sediment have been calculated. This in turn may help explain the differences in alleviation history between the lower Brazos and Colorado valleys ever since transgression began (Nanson, 1986, Nanson and Croke, 1992). What is missing is better chronostratigraphy (to be discussed below).

This study also seeks to better understand the circumstances which lead to avulsions during aggradation. If the Brazos has not undergone episodes of aggradation and incision since the last transgression began, this provides a more controlled natural laboratory for understanding how aggradation (in this case continuous aggradation) controls avulsion. The conditions leading to avulsions (wholesale movement of a meandering channel to create a new meander belt within an alluvial valley) have not as yet been distilled accurately enough to allow for prediction (Allen, 1978; Bridge and Leeder, 1979; Pizzuto, 1987; Smith *et al.*, 1989; Bryant *et al.*, 1995; and Slingerland and Smith, 1998). Sediment supply, variable distribution of sediment on the floodplains, and total rates of vertical aggradation are all important factors controlling avulsion, and have been assessed over the short term (single-large floods to 300 yrs duration) for various large fluvial systems around the globe (Kesel *et al*, 1974; Mertes, 1994; Gomez *et al*., 1995; and Allison *et al*., 1998). Tornqvist (1994) analyzed avulsion over a longer period of time (approx. 8 ka) for the distributaries of the Rhine-Meuse delta. But these numerous studies do not allow the degree of control needed to understand the mechanics necessary to predict recurrent avulsions, either because their duration of observation is too short, or in the case of Tornqvist

(1994) the fluvial system has multiple distributaries, varying between 5 and 12 over the last 8 ka, which provides too many unknowns to solve individual avulsion events. This is where the current long term analysis of the Brazos alluvial valley, with its single trunk stream, allows for a more thorough assessment of the interplay between floodplain aggradation and channel avulsion.

A large database has already been gathered to understand the Brazos system. Below is a list of the data either collected by us or gathered from previous studies:

- 17 terrestrial cores (collected)
- 5 offshore cores (collected)
- 22 radiocarbon dates (collected)
- 24 radiocarbon dates (gathered from previous studies)
- Marine seismic (collected along the Intracoastal Canal)
- Land seismic (collected with a shear wave streamer with geophones mounted on sleds and tethered to a truck)
- Ground penetrating radar (collected several km of data along the coastal and alluvial plain)
- US Army Core of Engineers' core descriptions (from studies along the Intracoastal Canal)
- Core descriptions from water wells in Brazoria county (8.8 km of core description from the surface to the Stage 2 sequence boundary--as interpreted from this study)
- Core descriptions from water wells in Fort Bend County (2.0 km of core description from surface to the Stage 2 sequence boundary--as interpreted from this study)

This data has been integrated using GIS software (Rockworks Inc. and ESRI's Arcmap). In addition, the history and distribution of avulsions have been analyzed using digital elevation models (DEM's) with this software and backed by radiocarbon dates.

From the numerous radiocarbon dates a good chronostratigraphic framework for the Brazos alluvium from the present coast to a distance 100 km inland has be developed over the last 10 ka. This includes both radiocarbon control (terrestrial gastropods and organic material) on vertical floodplain aggradation and Brazos channel avulsions (as recorded by point bar deposits).

Presently no chronostratigraphic control between 10 ka and 18 ka exists for the Brazos alluvium. A previous core taken in the Brazos floodplain (approximately 60 km from the coast) was studied for grain size changes in floodplain aggradation, and yielded three successful radiocarbon dates to constrain aggradation rates. Both the grain size analysis and radiocarbon dates were correlated with other cores updip and downdip. This core only penetrated

48 ft (16.5 m) and the age of the floodplain sediment at the base has been dated as 6,500 cal. B.P. At this location the base of the floodplain deposits (Stage 2 sequence boundary) are believed to lie at a depth of 90 ft (27.4 m). **We hope to collect the remainder of this core**. If it is possible to collect the remainder of this core, it should **provide important information on when aggradation commenced** at this location (did it actually start at 18 ka, or was there a time lag), **and what the aggradation rates were that occurred between the start of aggradation and 10 ka**. This data can be tied into known avulsion events to provide a better model for the cause and effect relationship between variable aggradation (as driven be changing rates of sea level rise) and avulsion of a single trunk stream.

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