A Potomalogical Study into the Pleistocene Fluvial Terraces of the Red River of the South, Southern Oklahoma and Northern Texas

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Introduction

The Red River of the South is a highly understudied fluvial system with limited mapping. Early work, however, did map four fluvial terraces along the flanks of the modern river valley. These terraces record a period of time in which the ancestral Pleistocene Red River was a continent-scale river, sourcing from the Rockies and the volcanic uplands of New Mexico and depositing into the Gulf of Mexico. The ages of these terraces, though, are poorly understood. With these four known terraces, spanning the "terrace zone" (a ~5 km radius from the modern valley), and with surface areas of the terraces ranging between ~3 km^2 and ~8.8 km^2—there exists the potential to document the deposits of these four distinct periods of lateral migration—as well as to characterize various paleochannels and other fluvial features preserved within these terraces through hand auger sampling.

I aim to track the evolution of the Red River both physiologically and geochronologically, utilizing allostratigraphic methods to reconstruct some of the River's past through the floodplain's lithology and optically stimulated luminescence (OSL) dating of preserved terraces. I aim to construct detailed cross-sections of the valley fill by sampling the deposits of each of the various ancient terraces, as well as the modern floodplain, running roughly perpendicular to the axis of the current stretch of the Red River. Ideally, I would encounter paleochannels while drilling so as to potentially assess the features of the paleochannel belt. To maximize the likelihood of encountering paleochannels and related assemblages, I have begun to process and analyze Lidar and satellite data in an effort to identify remnants of these paleo-structures. I will collect sealed samples containing silica grains to send for OSL dating. In doing so, I can ascertain definitive dates on when the deposits associated with specific terraces were laid down.

Background

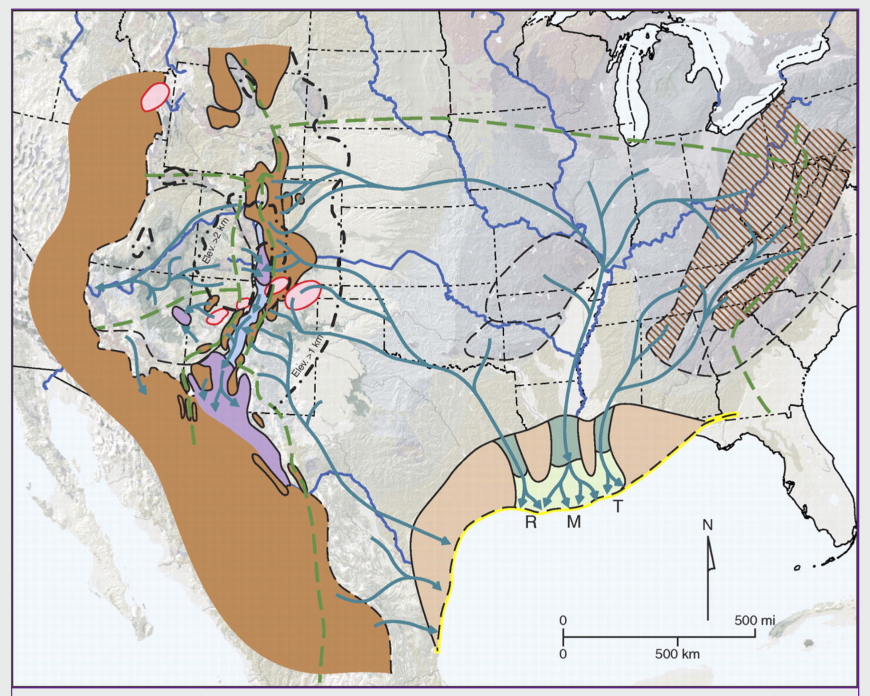


Figure 1. Major Pliocene depocenters in the Gulf of Mexico detailing the continent-scale size of the ancestral Red River. (Galloway et al., 2011).

By the Early Miocene, the ancestral Red River was fully established and flowed to the Gulf of Mexico at the Texas-Louisiana state line (Galloway et al., 2011; Shen et al., 2012) (**Figure 1**). By the Late Pliocene and into the early Pleistocene, the river underwent multiple stages of extensive meandering and eventual denudation, resulting in the establishment of large aggradational fill-terrace deposits, some of which were identified by Frye and Leonard (1963) and are detailed in profile in **Figure 2** (Galloway et al., 2011).

Deltaic strata of the paleo-Red River was last deposited ~100,000 ka within the Late Pleistocene (Shen et al., 2012). By this time, the Red River ceased to flow directly into the Gulf and was likely captured by the Mississippi following rapid floodplain aggradation, roughly correlating to the collapse of the Younger Dryas (Shen et al., 2011; Palacios et al., 2020; Anderson & Holbrook, 2021).

Following the rapid buildup of sediment, a significant crevasse splay triggered the avulsion of the Red, which then pirated an abandoned channel of the Mississippi, resulting in its capture by the Mississippi. Later, the Atchafalaya would capture the Red River, resulting in the current Red-Atchafalaya-Mississippi River confluence zone (Saucier, 1994; Galloway et al., 2011).

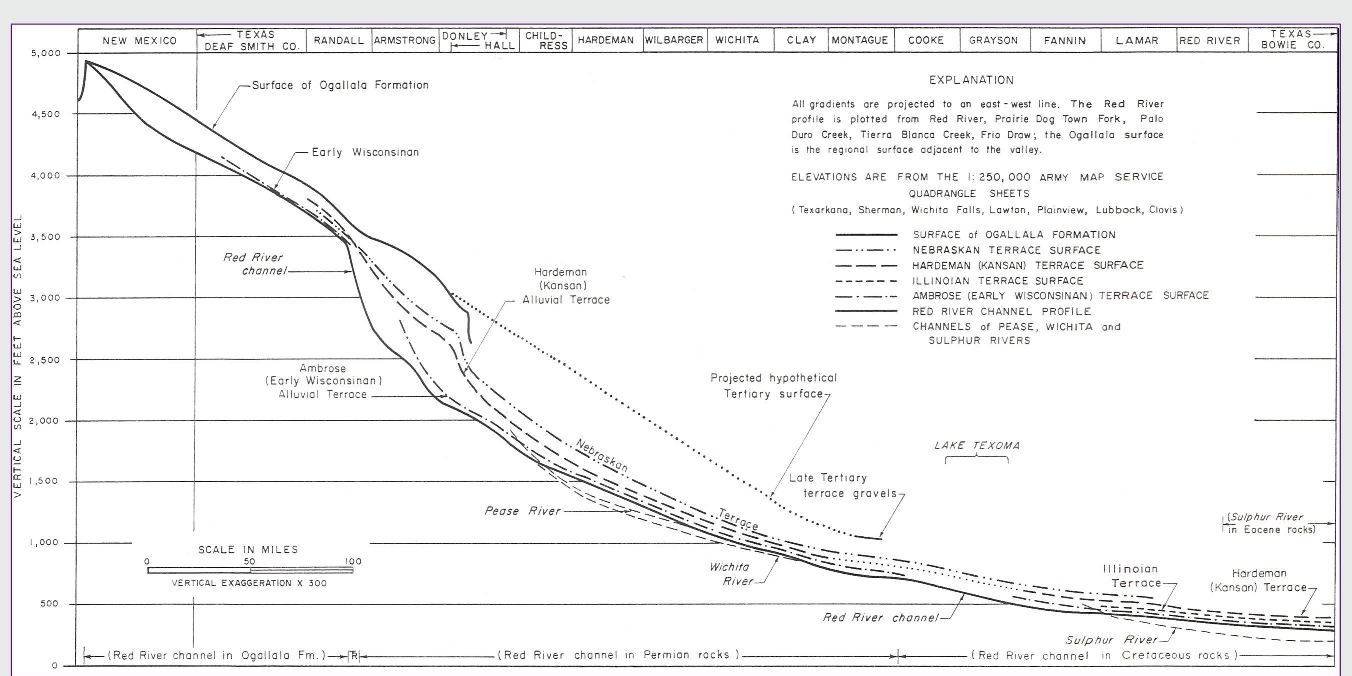


Figure 2. Profile of the modern Red River and identified terrace deposits, most notably, the "Late Tertiary" (Pleistocene) gravels, "Nebraskan," "Kansan," and "Wisconsinan"—all of which appear to be preserved in various locations in the study area. (Frye and Leonard, 1963)

Study Area

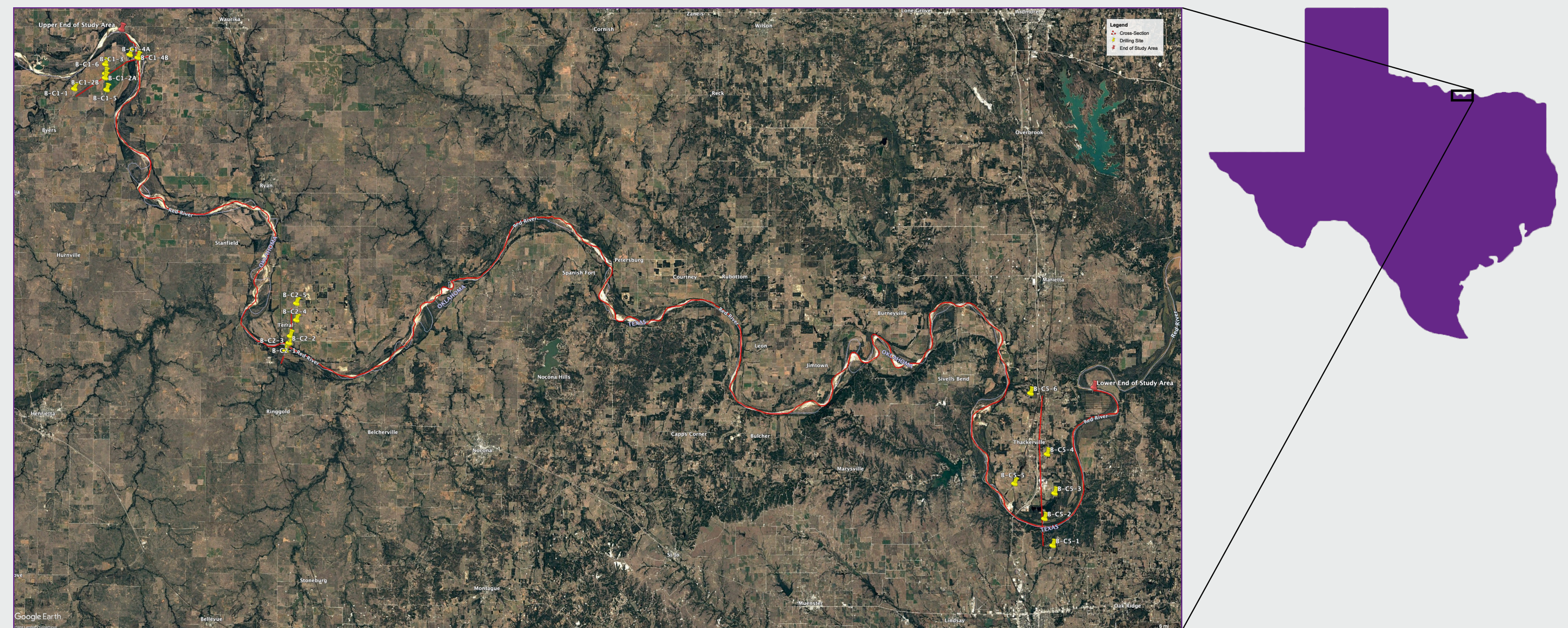


Figure 3. Google Earth satellite image detailing the study area, focused along the stretch of the Red River roughly between Byers, TX and Thackerville, OK. Moving west to east are Cross-Sections 1, 2, and 3.

Only portions of the river incising into Cenozoic alluvium and poorly lithified Permian sandstone will be studied, as these stretches exhibit traits of an alluvial river, which allows for well-developed floodplains and terrace preservation. Due to incision into the Cretaceous Fort Worth Limestone, Pawpaw Formation, and Woodbine—which effectively constricts the modern channel into a deeper valley with minimal conservation of the Pleistocene terraces— the study area begins ~86 km updip of Lake Texoma and is only "viable" following the confluence with the Wichita River (**Figure 3**).

Moreover, the area downdip of Lake Texoma is considered too altered due to the retention of 98% of the Red's sediment within the Lake Texoma reservoir, even though much of the lower section of the river flows over unlithified High Plains deposits.

Previous Studies and Purpose

The few investigations into the upper Red River Basin were attempting to identify terracing within the ancestral Red River (Frye & Leonard, 1963) or identify the transition point between fluvial patterns (Schwartz, 1977; 1978). Additional surficial studies have been conducted; existing almost purely as surficial, modern data collection for various government agencies or are employing data and superficial characteristics within their papers to discuss analogous systems (Shen et al., 2012, Wang & Bhattacharya, 2018). Except for these papers and maps, the Red River has seen no systematic examination in the targeted study reach.

Through the work of Galloway et al. (2011) and Shen et al. (2012), it is recognized that the Red River was once a continent-scale river and produced one of the largest deltas in the Gulf of Mexico, likely surpassing the Mississippi before the collapse of the Younger Dryas (Galloway et al., 2011; Anderson & Holbrook, 2021). With the work of Leonard and Frye (1963), the extensive Pleistocene terraces were identified and dated using rudimentary methods, but very little is known about the Red River, ancient or modern.

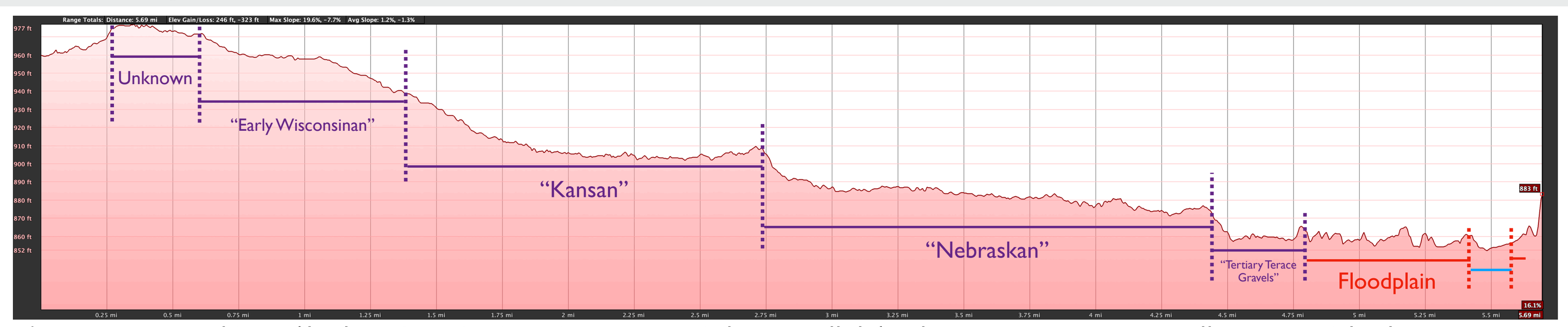


Figure 4a. Topographic profile along Cross-Section 1 in Byers, TX. At least 4 well-defined terraces are present, as well as a potential unknown terrace, and an extensive modern floodplain.

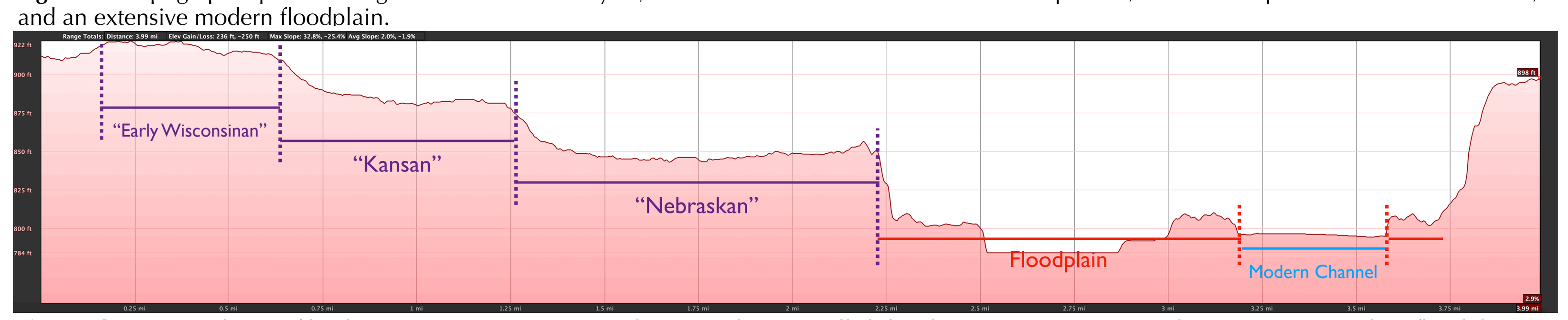


Figure 4b. Topographic profile along Cross-Section 2 in Terral, OK. At least 3 well-defined terraces are present with an extensive modern floodplain.

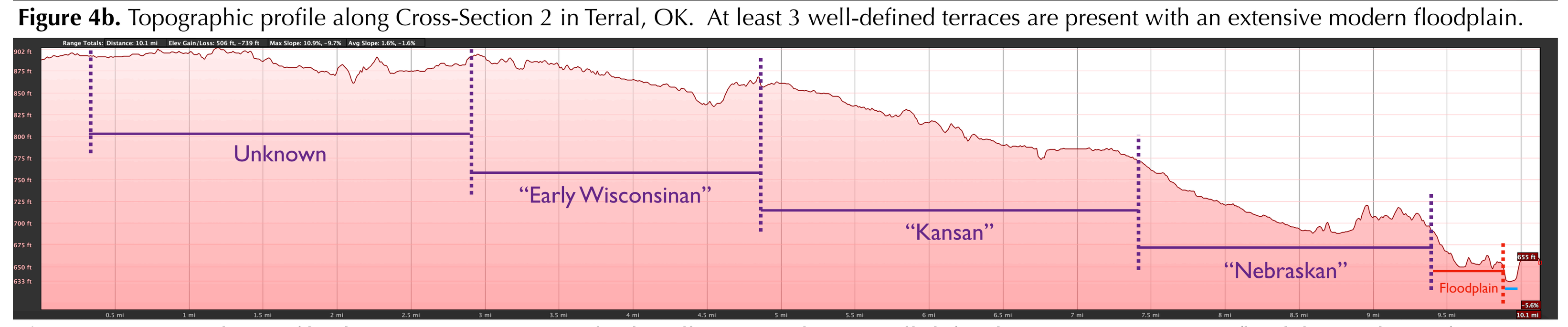


Figure 4c. Topographic profile along Cross-Section 3 in Thackerville, OK. At least 3 well-defined terraces are present, a floodplain with significant scroll bars, and a potential fourth terrace. The terraces here have undergone extensive erosion.

Objectives

At the three cross-sectional areas I have selected, as depicted in **Figure 3**, I aim to track the evolution of the Red River—architecturally and through time, utilizing allostratigraphic methods to reconstruct some of the River's past through the floodplain's lithology.

I intend to construct detailed cross-sections of the ancient and modern valley fill by sampling the deposits of each of the various ancient terraces preserved along the modern channel.

Ideally, paleochannels will be encountered so that I can somewhat diagnose the dimensions of the channel fill deposits while drilling to potentially assess the features of the paleochannel belt and characterize the lithologies and settings during deposition (**Figure 5**).

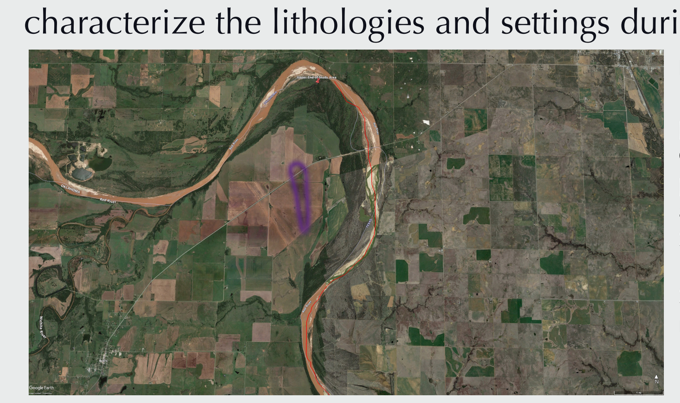
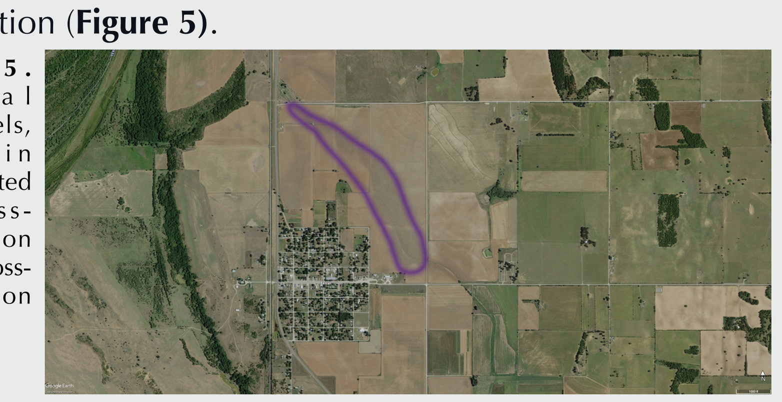


Figure 5. Potential paleochannels, outlined in purple, located along Cross-Section 1 (on left) and Cross-Section 2 (on right).



Methodology

Beginning with the identification of accessible drill sites, at least 2 locations are selected on each of the ancient terraces—roughly perpendicular to the axis of the river—with additional consideration given to any relict fluvial structures seen within the terraces through Lidar and satellite imaging (**Figure 5**).

We drill the sites using the Dutch auger method (**Figures 6a, 6b**)—sampling every 10 cm and using the soil texture ternary diagram and the Munsell Soil Color Chart to describe the sediment and soil. Sedimentary structures and lithologic variations are recorded as continuous core. This data is recorded on uniform, standardized log sheets.

Additional augering with a sealed sampler will take place to secure samples with quartz grains for optically stimulated luminescence (OSL) testing (**Figures 6c, 6d**). These sealed OSL samples will then be sent to the University of Nebraska Luminescence Lab, where they will be dated within 0 - 500 years of initial burial.

With the physical logs, I will characterize the deposits of the floodplain so that I can illustrate a cross-section of the ancient terraces and modern river. With this information, we can begin to better understand the nature and morphology of the ancestral Red River.

Figure 6a. The method of turning the auger; **6b.** Extending the auger rods; **6c.** A close-up of the OSL sampler—a sealed tube that allows for the auger to secure with quartz grain-bearing sediment to be later dated to identify the last moment sunlight last touched the grain; **6d.** The process of carefully labeling the capped tube to be sent off. This is critical as it will ensure the sediment remains unspoiled.

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