Quaternary Research 85 (2016) 118–132

Contents lists available at ScienceDirect

Quaternary Research

journal homepage: www.elsevier.com/locate/yqres

Geomorphic and sedimentary responses of the Bull Creek Valley (Southern High Plains, USA) to Pleistocene and Holocene environmental change

Hanna M. Arauza [a], Alexander R. Simms [a,*], Leland C. Bement [b], Brian J. Carter [c], Travis Conley [c], Ammanuel Woldergauy [d], William C. Johnson [e], Priyank Jaiswal [d]

[a] Department of Earth Science, University of California, Santa Barbara, 1006 Webb Hall, Santa Barbara, CA 93106, USA
[b] Oklahoma Archeological Survey, Norman, OK, USA
[c] Department of Plant and Soil Sciences, Oklahoma State University, Stillwater, OK, USA
[d] Boone Pickens School of Geology, Oklahoma State University, Stillwater, OK, USA
[e] William C. Johnson Department of Geography, University of Kansas, Lawrence, KS 66045, USA

ARTICLE INFO

Article history:
Received 2 April 2015
Available online 21 December 2015

Keywords:
Great Plains
Arroyo
Loess
Streams
Sediments
Rivers

ABSTRACT

Fluvial geomorphology and stratigraphy often reflect past environmental and climate conditions. This study examines the response of Bull Creek, a small ephemeral creek in the Oklahoma panhandle, to environmental conditions through the late Pleistocene and Holocene. Fluvial terraces were mapped and their stratigraphy and sedimentology documented throughout the course of the main valley. Based on their elevations, terraces were broadly grouped into a late-Pleistocene fill terrace (T3) and two Holocene fill-cut terrace sets (T2 and T1). Terrace systems are marked by similar stratigraphies recording the general environmental conditions of the time. Sedimentary sequences preserved in terrace fills record the transition from a perennial fluvial system during the late glacial period and the Younger Dryas to a semiarid environment dominated by loess accumulation and punctuated by flood events during the middle to late Holocene. The highest rates of aeolian accumulation within the valley occurred during the early to middle Holocene. Our data provide significant new information regarding the late-Pleistocene and Holocene environmental history for this region, located between the well-studied Southern and Central High Plains of North America.

Introduction

Geomorphologic and environmental changes recorded in the Southern Great Plains of North America have provided valuable insights into both the climate of North America (Forman et al., 1995; Holliday, 1997, 2000b; Mann and Meltzer, 2007; Forman et al., 2008; Cordova et al., 2011) and the manner in which early people responded to stresses (Haynes and Agogino, 1966; Meltzer, 1999; Waters and Stafford, 2007; Meltzer, 2009; Bement and Carter, 2010; Meltzer and Holliday, 2010; Ballenger et al., 2011). In the absence of widespread and long-lived perennial lakes within this region, many researchers have turned to records of fluvial stratigraphy as a means of reconstructing past environmental conditions across the Southern Great Plains (Mann and Meltzer, 2007; Meier et al., 2014a,b). Bull Creek, Oklahoma (Fig. 1) is a fluvial system with a well-developed stratigraphy preserved within terrace deposits of late Quaternary through Holocene age (Bement et al., 2007).

We investigated the evolution of the Bull Creek Valley by mapping and characterizing terraces and their deposits within the valley. Constrained by radiocarbon ages, the stratigraphic character and timing of geomorphic change within the valley are compared to the environmental history of the region. The study provides important insights into the timing and character of landscape change in this region, one that is within the transition from the Southern High Plains to the fluvially dissected plains border of the Central High Plains.

Background

Study area

Bull Creek, located in Beaver County of the Oklahoma Panhandle within the Central High Plains (Fig. 1), is a northwest draining 18-km-long ephemeral tributary of the eastward flowing Beaver River (also known as the North Canadian River) (Bement et al., 2007; Woldearegay et al., 2012). Channel flow in Bull Creek occurs only during thunderstorms and the modern low-flow channel is currently largely vegetated with intermittent spring-fed pools. However, the stream retains a meandering planform at the larger scale (Fig. 2). Upstream the channel

* Corresponding author.
E-mail address: asimms@geol.ucsb.edu (A.R. Simms).

http://dx.doi.org/10.1016/j.yqres.2015.11.006
0033-5894/

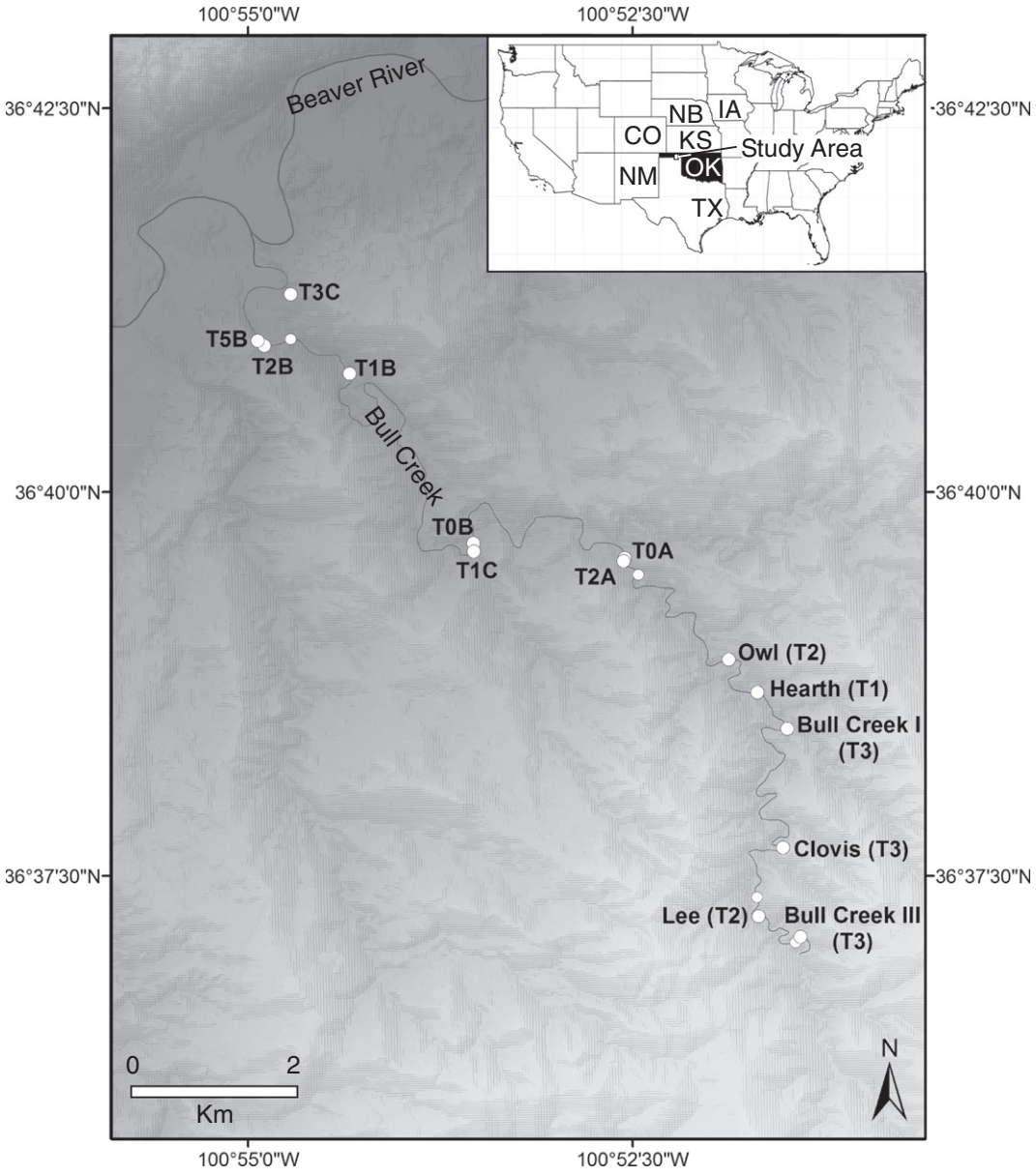

Figure 1. Bull Creek study area including the location of the terrace description sites mentioned in the text. Inset shows the location of the study area in relation to the USA and other states discussed in the text (CO = Colorado, NB = Nebraska, KS = Kansas, NM = New Mexico, TX = Texas, IA = Iowa). Elevations within the study area map range from a low of ~780 m near the Beaver River to a high of ~870 m along the interfluves above Bull Creek in the south portions of the map.

is largely confined to its incised channel but downstream it broadens and scroll bars are preserved on the inside bend of broad meanders (Fig. 2). Cattle have destroyed any primary bedforms along the modern channel floors but the grain size of the channel floor is largely coarse sands and gravels with very little fine-grained material (e.g., clays and silts) preserved in the valley and channel floors.

Bull Creek is commonly bound by bedrock highwalls on the west side of the valley (Fig. 2), while terraces are typically located to the east of the active channel. The highwalls are a result of entrenched meanders, common in areas with horizontal bedrock and low channel gradients, and are often related to base-level lowering (Harden, 1990). The highwalls of the Bull Creek valley contain late-Pleistocene and Holocene sediments overlying Permian and Neogene sedimentary rocks (Fig. 2). The three formations underlying the Bull Creek drainage basin are the Permian Cloud Chief and Doxey Formations and the Neogene Ogallala Formation (Stanley and Suneson, 2002). The Cloud Chief and Doxey Formations are part of an extensive suite of Permian red clay shales, fine sandstones, siltstones, and thin gypsums underlying much of the Texas Panhandle, western Oklahoma, and southwestern Kansas (Gould and Lonsdale, 1926; Johnson, 1972). The Ogallala Formation unconformably overlies the Cloud Chief Formation (Fig. 2D) and contains a heterogeneous assortment of lithified fluvial gravel, sand, and mud derived from the Rocky Mountains during the Neogene (Schoff, 1939; Duller et al., 2012). Within Bull Creek, the Ogallala Formation crops out as white, pink, or red gravelly sandstone beds in gullies, cut banks, and the stream bed of the upstream (southern) reach of the creek.

Unconsolidated fluvial and aeolian sediments deposited during the late Pleistocene and Holocene (Bement et al., 2007) overlie the Cloud Chief and Ogallala Formations (Fig. 2A and B). Aggradation followed by incision by Bull Creek created a series of fluvial terraces, with cut banks along the modern creek exposing the valley-fill stratigraphy (Carter and Bement, 2004; Bement et al., 2007; Woldearegay et al., 2012; Bement et al., 2014; Fig. 2A).

Aeolian sediments mantle much of the Bull Creek drainage and surrounding area. A loess (clayey-silt) mantle generally less than 50 cm thick but up to 1.5 m thick in some locations is present on the interfluves