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Stratigraphy of the Younger Dryas Chronozone and paleoenvironmental implications: Central and Southern Great Plains

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ABSTRACT

The Great Plains of the United States was the setting for some of the earliest research in North America into patterns and changes in the character of late Pleistocene environments and their effects on contemporary human populations. Many localities in the region have well-stratified records of terminal Pleistocene and early Holocene human (Paleoindian) activity and past environments. These have proven important in debates over the character of the Younger Dryas Chronozone (YDC; 11,000–10,000 ^{14}C BP; 12,900–11,700 cal BP) in the continental interior. This paper reviews the lithostratigraphic record of the YDC on the Central and Southern Great Plains and summarizes paleobiological records (largely isotopic). The goal is to determine if there is any uniformity in the timing, character, direction and/or magnitude of changes in depositional environments or broader geomorphic systems before, during or after the YDC in order to address the question of the character of environments through this time. The stratigraphic records of the late Pleistocene to early Holocene transition, and in particular, the stratigraphic records of the YDC vary through time and space. The data clearly show that a host of geomorphic processes produced the terminal Pleistocene and early Holocene stratigraphic records of the Great Plains. Moreover, the YDC is not necessarily manifest as a distinct lithostratigraphic or biostratigraphic entity in these different types of deposits and soils. The various geomorphic systems of the Great Plains did not behave synchronously in response to any common climate driver. These stratigraphic records reflect local environmental conditions and probably a complex response to the reorganization of mid-latitude climates in the terminal Pleistocene and early Holocene.

1. Introduction

The Great Plains was the site of some of the earliest research in North America into patterns and changes in the character of late Pleistocene environments and their effects on contemporary human populations (Mandel, 2000; Meltzer, 2006a). This is, in part, a result of the work and interests of individuals such as Ernst Antevs, Kirk Bryan, C.V. Haynes, and Fred Wendorf (e.g., Haynes, 1990; Holliday, 2000a, 2000b), but also because of the nature of the geological records. Many localities on the Central and Southern Great Plains have well-stratified records of terminal Pleistocene and early Holocene human (Paleoindian) activity and past environments (Mandel, 2000), and these have proven important in debates over the environmental character of the Younger Dryas in the continental interior (Haynes, 1991, 2008; Holliday, 2000c; Mandel, 2008; Mason et al., 2008; Meltzer and Holliday, 2010). This paper, drawn in part from a recently published review (Meltzer and Holliday, 2010), focuses in particular on the stratigraphic record of the YDC on the Central and Southern Great Plains and a few localities in the neighboring Central Lowlands and Coastal Plain. This paper uses the term "Younger Dryas" in a strictly chronostratigraphic and temporal sense, i.e., the Younger Dryas Chronozone (YDC), dated to 11,000–10,000 ^{14}C BP (Mangerud et al., 1974). The Pleistocene/Holocene boundary is 10,000 ^{14}C BP, i.e., at the close of the YDC (Pillans, 2007).

A recent, high-resolution analysis – using isotopic analyses of deuterium excess and ^{18}O as indicators of past ocean surface and air temperatures, respectively – indicates that Younger Dryas cooling began 12,900 calendar years before present, with the warming starting 11,700 calendar years before present (Steffensen et al., 2008: table 1; in that study, the year 2000 was designated as the 'present'). Dates in this paper are presented in Radiocarbon Years Before Present (^{14}C BP) with calibration in parentheses (cal BP) where age control is based on radiocarbon dating.

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Although there is little doubt that there were abrupt and dramatic shifts in climate at the onset and end of the YDC over Greenland, as evidenced in ice core data (e.g., Ruddiman and McIntyre, 1981; Broecker et al., 1989; Alley et al., 1993; Mayewski et al., 1993; Taylor et al., 1997; Yu and Wright, 2001; for summaries, including more recent evidence, see Alley, 2007; Hald et al., 2007), how or even whether this climatic "event" was translated through various components of the lithosphere and biosphere across North America is far from clear (Meltzer and Holliday, 2010). The Younger Dryas has been described as a return to full glacial climatic conditions, but even in the core areas of YDC cooling (Greenland and the North Atlantic), it was not a rerun of the Last Glacial Maximum (LGM). Moreover, as Alley and Clark (1999, p.174) observed, the changes accompanying the Younger Dryas might have been "large and rapid around the North Atlantic, [but were] probably smaller and slower elsewhere." Indeed, some regions show minimal YD-age cooling while others provide no evidence of climate change (e.g., Meltzer and Holliday, 2010).

This paper examines lithostratigraphic records that include deposits dated to the YDC. To provide a broader context, slightly older late Pleistocene and early Holocene records will also be summarized. The goal is to examine both similarities and differences in the stratigraphic records of the YDC within and between regions and to identify possible mechanisms (both internal and external) that may have driven the geomorphic and sedimentologic processes that created the records. Understanding these mechanisms will aid in environmental reconstructions. The specific focus is on lithostratigraphic records to determine if there is any uniformity in the timing, character, direction and/or magnitude of changes in depositional environments or broader geomorphic systems before, during or after the YDC in order to address the question of the character of environments through this time. Put another way, Can the Younger Dryas Chronozone be recognized as a distinct lithostratigraphic entity? Does that indicate evidence for an abrupt environmental change 11,000–10,000 ^{14}C BP?

At the outset, however, an important point about field data must be made. Many of the best-studied, best-dated stratigraphic localities are archaeological sites, and many of these have well-established paleoenvironmental records. However, archaeological sites are often by their very nature not representative of larger regions. They may be locales of past human activity (such as camping of hunting) precisely because they are unique settings, such as easily accessible and well-watered valleys or fresh-water springs (e.g., the Clovis, NM, and Lubbock Lake, TX, sites on the Southern High Plains). The degree to which generalizations can be drawn from these data is accordingly limited.

Before presenting the stratigraphic data in detail, the relatively meager paleoenvironmental records for each region are summarized in order to establish an independent "standard" against which to compare the lithostratigraphy. Continuous paleoenvironmental records across the YDC are relatively rare for the Great Plains. Records of stable isotopes from the late Pleistocene and early Holocene are becoming more common, however. Stable-carbon (stable-C) isotopes provide a means of reconstructing major plant communities (warm-season vs cool season) to make inferences about temperature and especially temperature change through time. Stable-oxygen (stable-O) isotopes can sometimes aid in reconstructing sources of moisture and moisture variation over time (Nordt, 2001).

2. Setting

The Great Plains and adjacent Central Lowlands and Coastal Plain are formally defined physiographic regions (Fenneman, 1938; Graf, 1987; Holliday et al., 2002). The Great Plains physiographic province is the vast, generally level and minimally dissected terrain east of the mountains of the Rocky Mountains and the Basin and Range (Fig. 1), and broadly underlain by Cenozoic and Mesozoic rocks. The eastern margin of these rocks, identifiable in many areas by an east-facing escarpment, marks the boundary with the Central Lowlands (Fig. 1). The Central Great Plains extends south from the Pine Ridge Escarpment in southern South Dakota to the Canadian River in the Texas Panhandle. It includes the Northern High Plains, Colorado Piedmont, and the Raton Volcanic field. The Southern Great Plains extends south from the Canadian River to the Balcones Escarpment in central Texas. It includes the Southern High Plains, the Pecos Valley, and the Edwards Plateau. The Central Lowlands physiographic province is the heavily dissected, low-relief landscape east of the Great Plains and dominated by the central Mississippi River drainage system (Fig. 1). The Edwards Plateau is bordered to the east and south by the generally low-relief landscape of the Coastal Plain.

3. YDC stratigraphy and paleoenvironments of the Central and Southern Great Plains

YD-age stratigraphic records on the Great Plains and in neighboring regions are preserved in valleys, closed basins, and on uplands; the same settings where most Paleoindian sites are reported (Holliday and Mandel, 2006). Many of the stratigraphic records presented here were reviewed and discussed by Holliday and Mandel (2006) and Meltzer and Holliday (2010). The following discussion proceeds north to south, from the Central Great Plains to the Edwards Plateau.

Continuous records with plant fossil evidence for terminal Pleistocene and early Holocene environments (i.e., pollen and phytoliths) on the Great Plains are rare. Stable-carbon isotopes and some phytolith assemblages from soils provide regional but low-resolution records of shifting grassland composition from the late Pleistocene into the early Holocene (e.g., Nordt et al., 2008; Cordova et al., 2011), though, as discussed below, a few site-specific records are available. Overall, grassland composition in the late Pleistocene was dominated by plants adapted to cooler and wetter conditions relative to modern composition. Nordt et al. (2008, Fig. 5a) illustrate a distinct shift to cooler conditions before the YDC followed by a general warming until the end of the YDC. Grassland communities rapidly changed to warm-season and more arid-adapted grasslands in the early Holocene. The modern shortgrass prairie of the Southern Great Plains was in place by ~9000 ^{14}C BP (~10,200 cal BP); the modern mixed- and tallgrass-prairie had a more complex evolution but was in place by ~6000 ^{14}C BP (~6800 cal BP) (Cordova et al., 2011).

Most other continuous records of fossil plant assemblages (largely pollen) spanning the YDC are from the Plains periphery such as lakes in formerly glaciated terrains, bogs near the Edwards Plateau or in the Rocky Mountains. Meltzer and Holliday (2010, p. 14–21) examined evidence from the North American Pollen Data Base for clues to YDC environments of the region. There are a number of limitations to the data, but they nevertheless allow some general observations to be made. First, although vegetation changed throughout the YDC, these changes were subtle and primarily visible at longer time scales. Thus, the most significant changes occurred on a 500-year temporal scale, and instances of significant vegetation change were less frequent on the 200 and 100 year time scales. Moreover, most of the significant changes did not coincide with the onset or the end of the YDC, except when viewed across a longer (e.g., 500 year) span of time. Instead, the majority of the significant changes in vegetation occur in the middle centuries of the Younger Dryas Chronozone and then again in the centuries after the YDC. The timing of these changes suggests

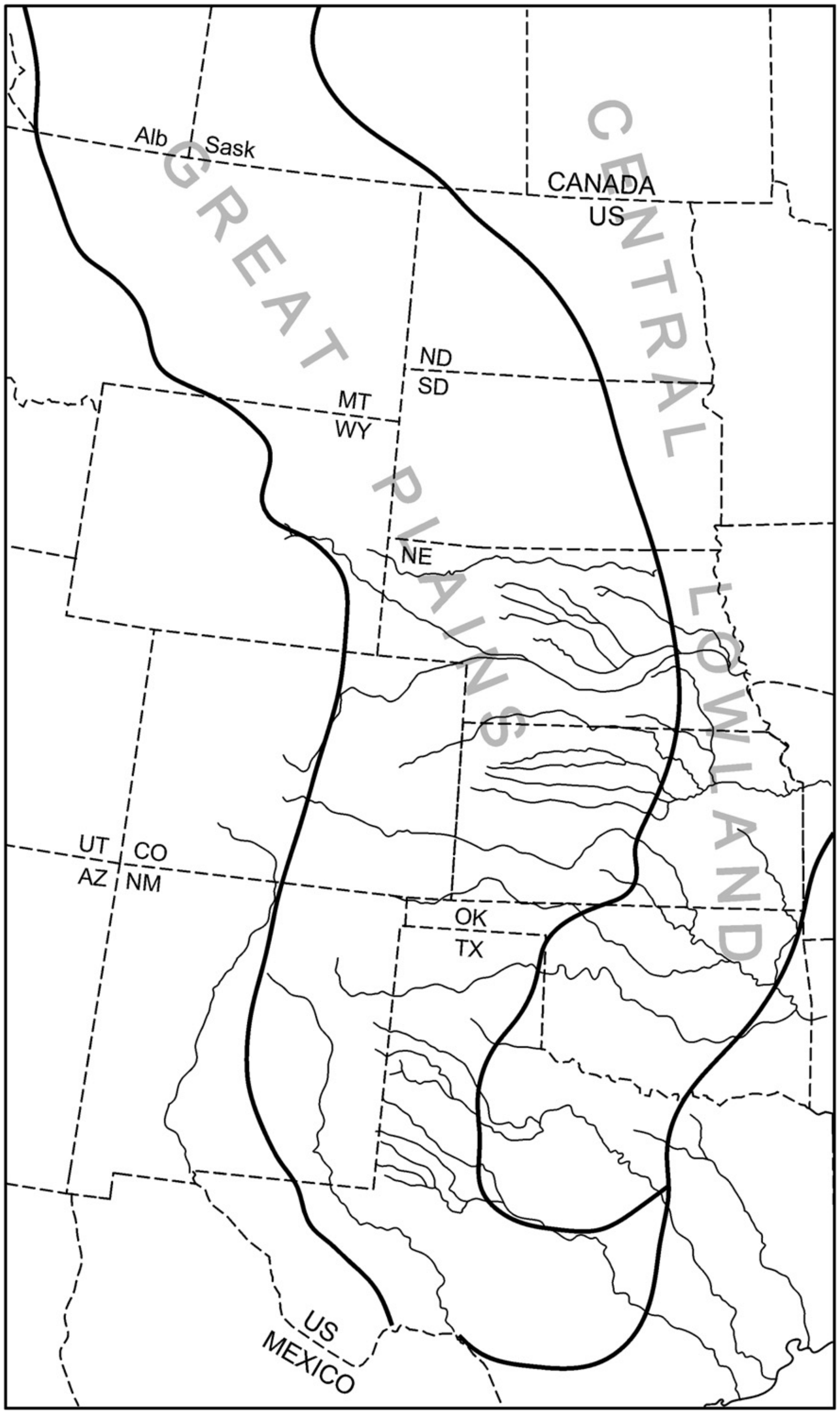

Fig. 1. The west-central U.S. and northwest Mexico, with locations of physiographic provinces and regions mentioned in the text, and major drainages identified in Figs. 2 and 5.

that there was a temporal lag in vegetation response, in turn suggesting that critical thresholds for change took longer to emerge, or (in the latter instance), a response to general insolation-driven growing-season warming.

Such general conclusions, however, are based on the limited pollen records available in this region. To supplement these data, Meltzer and Holliday (2010) followed Yu and Wright's (2001, p.351) suggestion of also using paleoclimatic information from other deposits, such as loess, sand dunes, and soils. This paper follows that approach as well.

3.1. Central Great Plains

The stratigraphy across the YDC is well illustrated in alluvial and eolian stratigraphic records on the Central Great Plains. The valleys include those that head on the Plains proper and those with headwaters in the Rocky Mountains. Mandel (2008) presents a comprehensive regional record from 49 dated localities from 37 stream valleys, draws, and fans in the Kansas and Arkansas drainage systems which head on the High Plains (Fig. 2). Streams were initially quasi-stable in incised positions in the late Pleistocene,

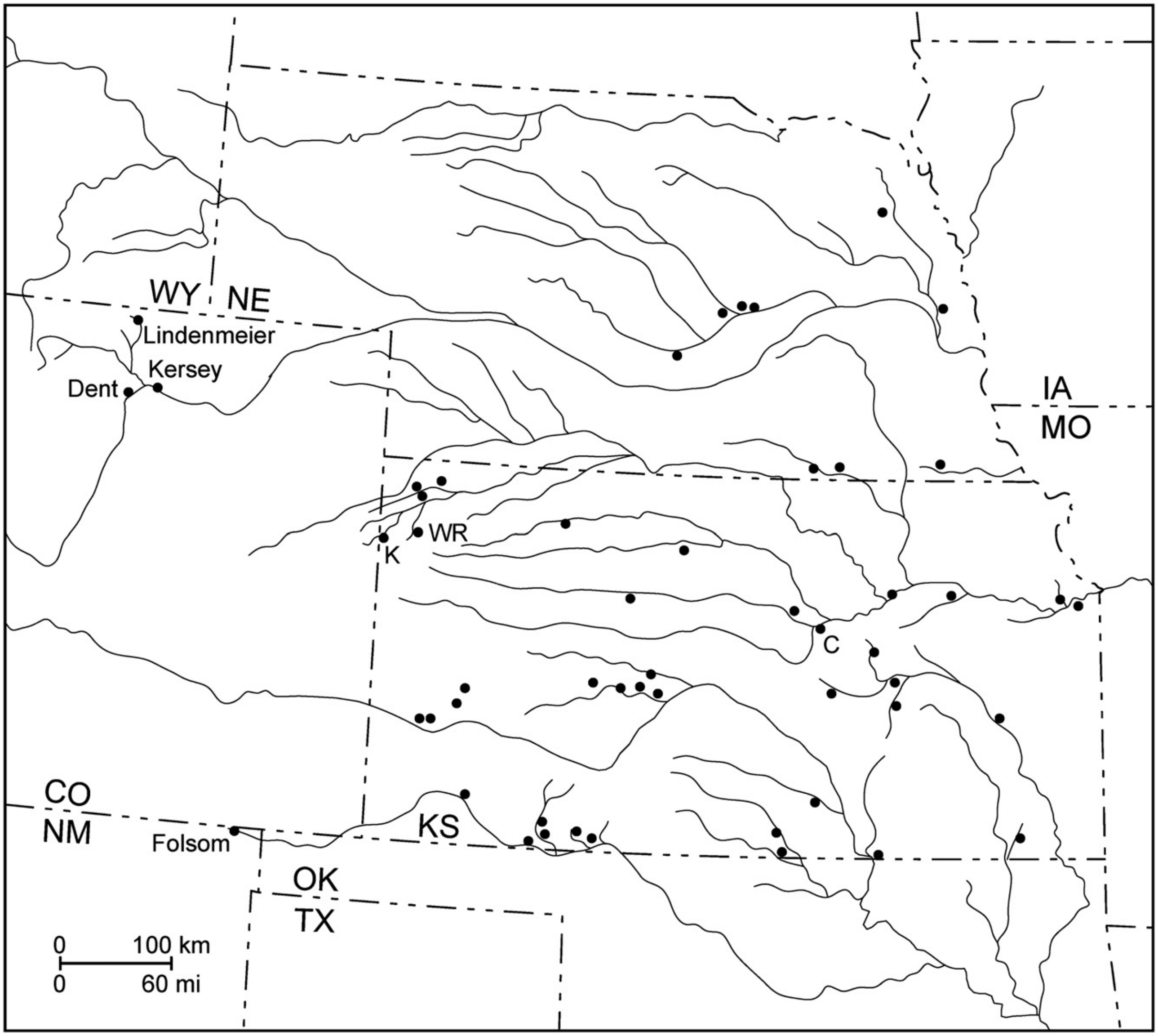

Fig. 2. The Central Great Plains showing key drainages, sites studied by Mandel (2008) (dots) in Kansas and Nebraska, and archaeological sites mentioned in the text (WR = Willem Ranch; K = Kanorado; C = Clemance).

meandering across the floors of their respective valleys. Active meandering eventually waned and the floodplains became more stable except for incremental additions of flood deposits. The result was development of an over-thickened (up to 2 m) A horizon that forms a distinct stratigraphic marker (Fig. 3A). Stabilization and soil cumulization began as early as ~13,300 ^{14}C BP (~15,800 cal BP) but was under way in most sections between ~11,400 and ~11,000 ^{14}C BP (13,300 and 12,900 cal BP); hence the onset of this process was time-transgressive. The cumulic soils were buried by flood deposits, interpreted to represent the onset of high-magnitude flooding. This shift in depositional environment was likewise time-transgressive, varying from ~10,000 to ~9,000 ^{14}C BP (~11,400 to ~10,200 cal BP). The soil-stratigraphic record in the draws of western Kansas indicates slow aggradation punctuated by episodes of landscape stability and pedogenesis beginning as early as ~13,400 ^{14}C BP (~16,000 cal BP) and spanning the Pleistocene–Holocene boundary (Fig. 3B). The stratigraphic record of alluvial fans in western Kansas is similar to the record in the draws; slow aggradation was punctuated by multiple episodes of stability and soil development between ~13,000 and ~9000 ^{14}C BP (~15,400 and ~10,200 cal BP). In eastern Kansas and Nebraska, development of alluvial fans was common during the early and middle Holocene, but evidence shows fan development as early as ~11,300 ^{14}C BP (~13,200 cal BP). Buried soils dating between ~11,500 and ~9000 ^{14}C BP (~13,300 and ~10,200 cal BP) were documented in fans throughout the region.

Analysis of the stable δ^{13}C isotope record from organic matter of buried soils at the Willem Ranch alluvial fan on the High Plains of northwest Kansas was used to assess vegetative change, and make paleoclimatic inferences, during the YD and into the middle Holocene (Fig. 4). The section exposes a prominent buried soil with a thick, dark gray, cumulic A horizon (Akb2 in Fig. 4). The duration of soil genesis (~10,800–10,400 ^{14}C BP; ~12,800–12,500 cal BP) overlapped the YDC. The δ^{13}C values determined on organic carbon from all but the upper 10 cm of the buried soil range between −22.7‰ and −19.5‰. These are the most depleted δ^{13}C values in the record at the Willem Ranch fan, with the lowest levels exhibited as a spike that probably predates the YDC and suggest

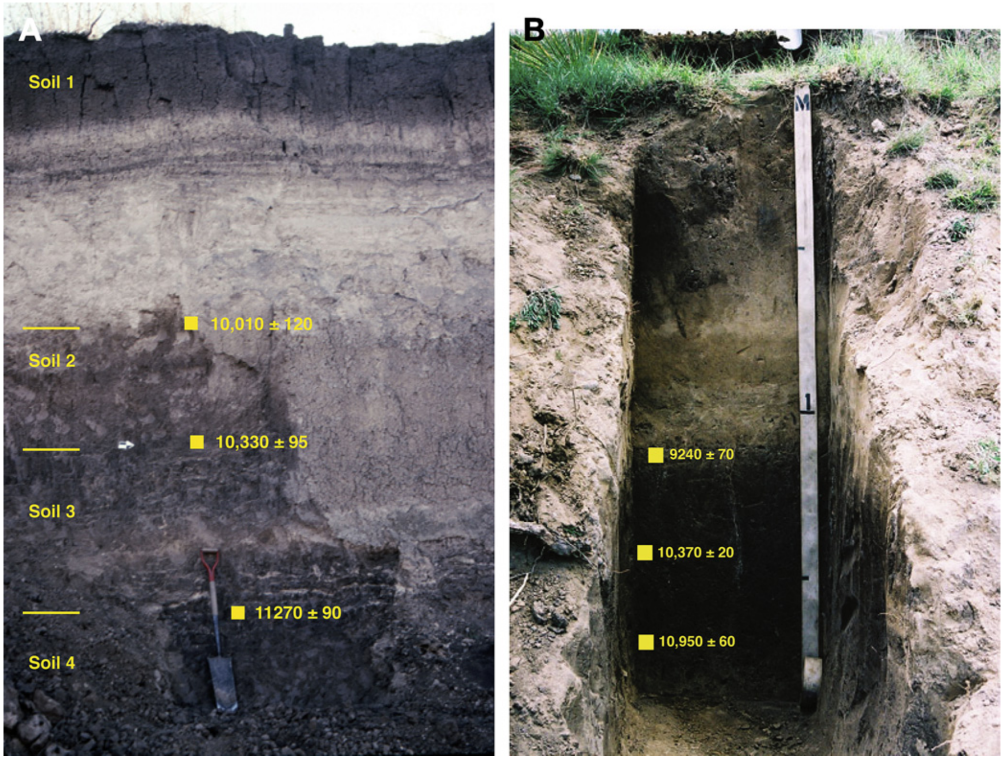

Fig. 3. Examples of alluvial-stratigraphic sections from the Central Great Plains with radiocarbon dated late Pleistocene and early Holocene buried soils. A. At the Clemance Section in the lower Smoky Hill River valley of east-central Kansas (Fig. 2), three buried soils 2, 3, and 4) characterized by thick, cumulic, organic-rich horizons span the YDC. The radiocarbon ages were determined on total soil organic matter (photo by R.D. Mandel). B. A single buried soil at the Kanorado site in northwestern Kansas contains stratified Clovis-age and Folsom cultural deposits. The lower two radiocarbon ages were determined on collagen from bison bone and the uppermost age was determined on total soil organic matter (photo by R.D. Mandel).

that a mixed C3/C4 plant community dominated the local ecosystem before and during most of the YD (Fig. 4). The values suggest that the YD was the coldest climatic episode during the entire period of fan development. The $\delta^{13}C$ values become significantly heavier, however, in the upper 20 cm of the YD soil (−17.7−17.4‰), indicating an increase in the carbon contribution of C4 plants. This shift most likely represents a trend towards warmer and probably drier conditions by ~10,400 ^{14}C BP (~12,300 cal BP) (Fig. 4).

The changes in alluvial regimes along the Kansas and Arkansas drainages in the late Pleistocene were almost certainly related to declining discharges or at least declines in stream energy. The period of alluvial stability, concomitant soil cumulization, and the onset of subsequent warming includes the Younger Dryas chronozone, but is not exclusive to it. Shifting geomorphic responses along these valleys, therefore, cannot be linked to the onset and demise of Younger Dryas cooling.

Bull Creek, a tributary of the Beaver River in the Oklahoma Panhandle, provides a dated, stratified alluvial record that also yielded abundant paleoenvironmental indicators (stable-C isotopes, pollen, and phytoliths) (Bement et al., 2007; Bement and Carter, 2008). The drainage was dominated by alluviation during the late Pleistocene until ~11,000 ^{14}C BP (~12,900 cal BP). The period ~11,000 to ~9800 ^{14}C BP (~12,900 to ~10,300 cal BP) was characterized by episodic alluviation and colluviation along with stability and soil formation. Eolian silt dominated the depositional environment through the early Holocene. The paleoenvironmental proxies are interpreted to indicate a shift toward cooler but also drier conditions ~11,000 ^{14}C BP, then fluctuations between cooler and warmer environments into the Holocene when warming became dominant. The isotope samples are not directly linked to the lithostratigraphy or the radiocarbon samples, however. Further, the dates and many of the samples for environmental proxies are from buried A horizons, which have inherent problems of "averaging" organic carbon and other organic input. The results of the dating and other analyses, therefore, provide only a general approximation of the timing and degree of environmental changes through the YDC.

The headwaters of the South Platte are in the Front Range of the Rocky Mountains and offer a dramatic contrast to the above described stratigraphic records in drainages heading on the Central Plains. The upper reaches of the South Platte on the plains northeast of Denver yielded some of the first Paleoindian localities, including the Dent Site, which produced fluted points associated with mammoth bones (Figgins, 1933). The Dent bone-bed, dated ~10,990 ^{14}C BP (~12,900 cal BP) (Waters and Stafford, 2007), is in the upper alluvium of the Kersey/Broadway terrace (Haynes et al., 1998). That date provides an approximation for the end of Kersey alluviation. If the bones were redeposited (Brunswig, 2007), the alluviation must have continued somewhat later. Incision of the Kersey surface was followed by formation of the next lower surface, the Kuner (Holliday, 1987; McFaul et al., 1994; Haynes et al., 1998). A date of ~10,105 ^{14}C BP (~11,650 cal BP) from fill below the Kuner surface (Haynes et al., 1998) shows that abandonment of the Kersey terrace, incision, and the start of the next cycle of alluviation took place sometime between ~11,000 and ~10,105 ^{14}C BP (~12,900 and ~11,400 cal BP); i.e., the YDC was expressed by geomorphic instability. The headwaters of the South Platte and its tributaries in the Front Range may have been subjected to glaciation during the YDC (Menounos and Reasoner, 1997; Benson et al., 2007), but the South Platte out on the Plains apparently was undergoing geomorphic adjustment, perhaps in response to pre-YDC deglaciation that

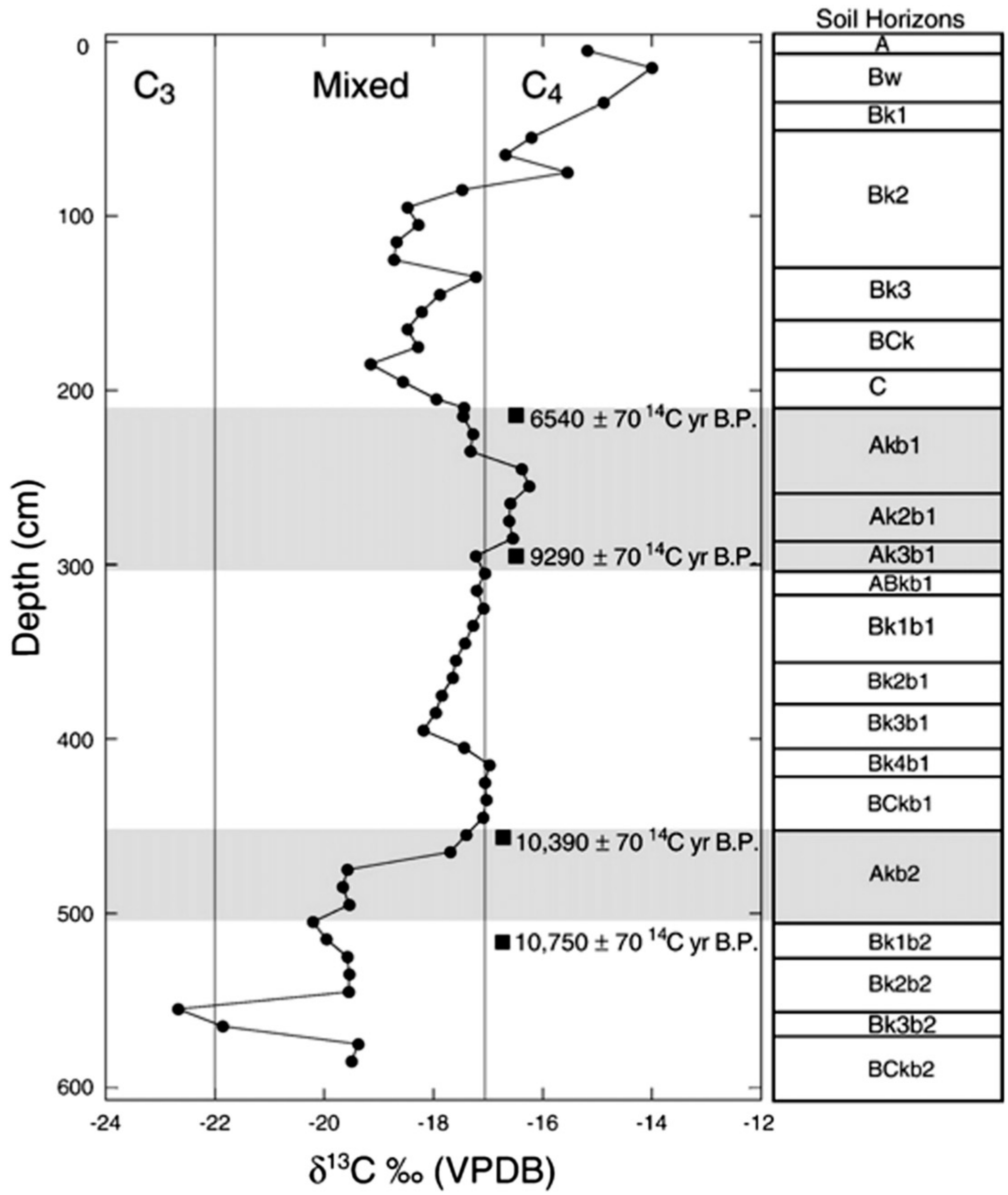

Fig. 4. Stratigraphic section of the Willem Ranch Fan, along a tributary of Beaver Creek, Kansas (Fig. 2), with radiocarbon dating of buried A horizons and the stable-C data through the section (from Mandel, 2008, Fig. 12).

introduced tremendous quantities of meltwater and sediment into the South Platte. The Arkansas River, also heading in the Rockies, appears to have a similar record of alluviation and incision in eastern Colorado (Painter et al., 1999: 13–21), but that record is poorly documented.

The Lindenmeier and Folsom archaeological sites offer further stratigraphic contrasts to the mainstreams. Both are in proximity to the eastern flank of the Rockies and are in lower-order tributaries of alluvial systems that cross the Great Plains. The Lindenmeier site (Bryan and Ray, 1940; Haynes and Agogino, 1960; Haynes et al., 1992; Haynes, 2003, 2008; C.V. Haynes, personal communication, 2009, 2010; VTH unpublished notes) is in an isolated dry valley that drains into Boxelder Creek, an ephemeral tributary of the Cache la Poudre River that is, in turn, a tributary of the South Platte River. The oldest dated deposit at the site (stratum B) is a calcareous silt dated to ~12,170 ^{14}C BP (~14,100 cal BP) (Haynes, 2008, Table 2). Lithologically and chronologically it correlates with the Peoria Loess, which is wide spread in the area. A well-developed soil (Btk–Bt profile) formed in the loess. Locally a layer of sand and gravel (stratum C) rests on stratum B. The top of the soil and stratum C apparently were truncated by erosion (Z4). Above the unconformity is a dark brown to black silty, deposit with localized lenses of gravel (stratum D). Stratum D is the compound A horizon of a soil that formed across the valley following Z4 erosion. The thickness of the horizon, dark–light–dark color variation (top, middle, bottom of stratum D, respectively), and the presence of gravel lenses are indicative of soil cumulization as sedimentation more or less kept pace with pedogenesis, resulting in a cumulic soil that slowly aggraded on the valley floor. Across the top of D is an erosional unconformity (Z5).

The base of Stratum D produced charcoal dated to an average of ~10,660 ^{14}C BP (~12,700 cal BP). Middle D dates to ~10,040 ^{14}C BP (~11,400 cal BP). Upper D is dated ~9690 ^{14}C BP (~11,100 cal BP). A deep channel (Z6) was cut and then filled by ~8310 ^{14}C BP (Haynes et al., 1992; Haynes, 2003). Just before the YDC, the Lindenmeier Valley was stable with soil formation on B. This stability was interrupted by erosion (Z4) then slow cumulization of the valley floor beginning early in the YDC and continuing beyond the YDC. The early Holocene was characterized by erosion and rapid alluviation.

The Folsom type site is in the headwaters of the Dry Cimarron River. It heads in the high relief landscape of the Clayton-Raton volcanic field, before crossing the Plains and Central Lowlands. The headwaters include a series of arroyos that expose the late Quaternary stratigraphic record. Research there includes geoarchaeological investigations at the Folsom type site along Wild Horse Arroyo, in the far upstream headwaters (Meltzer, 2006b), as well as along other tributary reaches of the Dry Cimarron (Mann and Meltzer, 2007). The drainages were dominated by aggradation from ~11,000 to ~10,000 ^{14}C BP (~12,900 to ~11,400 cal BP; i.e., during the YDC), but the style and chronology of filling varied dramatically from site to site. Along the mainstream, alluviation occurred before 10,200 ^{14}C BP (~11,900 cal BP) (Mann and Meltzer, 2007). However, at the Folsom site proper, alluviation or colluviation took place <~12,400 ^{14}C BP but >~10,500 ^{14}C BP (between ~14,600 and ~12,500 cal yrs BP), followed by eolian sedimentation until ~10,000 ^{14}C BP (~11,400 cal BP) (Meltzer, 2006b: 112–153). Along channel floors, incision ensued after ~10,000 ^{14}C BP, while uplands were stable (Mann and Meltzer, 2007). Late Pleistocene (and YD-age) geomorphic processes in the upper Cimarron varied through time and space. Thus, the stratigraphic manifestation of the YDC in the upper Cimarron varies significantly depending on location even within a drainage system.

At the lower elevation (2109 m asl) of the Folsom site, the Paleoindian bone-bed yielded nearly a dozen species of snails that today only live at or well above the elevation of the site, and whose oxygen isotopes hint at summer temperatures lower by several degrees (Balakrishnan et al., 2005; Meltzer, 2006b). Although temperatures were cooler, it was not cold enough for long enough for alpine or subalpine plants to move into the area. Younger Dryas-age pollen and charcoal recovered from the bone-bed and from nearby Bellisle Lake on Johnson Mesa came from trees that grow in the region today (Meltzer, 2006b). Likewise, stable isotopic evidence from bison and snail remains point to drier conditions, as well as to a strong C_4 signature in regional grasslands (Meltzer, 2006b: 200–203; Koch et al., 2004; Nordt et al., 2007, 2008). These data support the inference of cooler and generally drier conditions on the Great Plains (Mann and Meltzer, 2007), and likely also reflect higher summer insolation.

The upland stratigraphy on the Central Great Plains also illustrates time-transgressive changes in deposition environments from the late Pleistocene into the early Holocene. The best-known and most extensive deposits are eolian silts or loess. Eolian sand in dunes is common across the region, but these deposits are all Holocene in age, and primarily accumulated in the late Holocene (e.g., Madole, 1995; Muhs et al., 1996; Muhs and Zarate, 2001; Bettis et al., 2003; Busacca et al., 2004). Silt from the LGM referred to as Peoria Loess forms the most extensive loess deposit in North America and the thickest LGM loess in the world (Bettis et al., 2003; Roberts et al., 2003). The Peoria Loess is locally buried by Holocene silt referred to as the Bignell Loess (Bettis et al., 2003). At the top of the Peoria Loess where it is buried by the Bignell is the distinctive Brady Soil (Bettis et al., 2003). Where the Peoria Loess is not buried, this soil is the regional Mollisol of the Great Plains (Jacobs and Mason, 2005, 2007).

Formation of the Brady Soil has been linked to Younger Dryas climate (Haynes, 2008), but dating clearly shows pedogenesis began before the YDC and continued afterwards (Mason et al., 2008). Soil formation was initiated as a result of landscape stability from ~12,400 to ~11,300 ^{14}C BP (~14,600 to ~13,300 cal BP), as loess deposition waned, allowing more effective pedogenesis. Stability also may have been linked to higher effective precipitation possibly from a somewhat cooler climate. Dating suggests that stability and the beginning of Brady Soil formation was time-transgressive across the region, "ranging from just before the B-A [Bølling-Allerød] into the early YD" (Mason et al., 2008: 1776). The soil was buried by silt remobilized from nearby dune fields during episodes of early Holocene aridity (generally ~9400 to ~9000 ^{14}C BP; ~10,700 to ~10,200 cal BP) (Mason et al., 2003).

Stable-carbon isotopes show that a warming trend began as Peoria Loess deposition ended and the warming continued through pedogenesis (Johnson and Willey, 2000; Feggestad et al., 2004; Miao et al., 2007). At some time between 11,000 and 10,000 ^{14}C BP (12,900 and 11,400 cal BP; i.e., during the YDC) effective precipitation declined and drying began, probably due to the warming. The aridity of the early Holocene probably represented a culmination of the drying trend (this was the summer insolation maximum) and crossing of a geomorphic threshold (Mason et al., 2008).

This geomorphic and paleoenvironmental scenario for development of the Brady Soil has been applied to the Leonard Paleosol buried within the Oahe Formation on the Northern Great Plains (Mason et al., 2008). An important point here is that the Brady and Leonard soils are distinct stratigraphic entities due to eolian processes, driven by abundant sediment supply in the late Pleistocene and aridity in the early Holocene, and "a broad peak of high effective moisture across the late Pleistocene to Holocene boundary, rather than well-defined climatic episodes corresponding to the Bolling-Allerod and Younger Dryas in the North Atlantic region" (Mason et al., 2008: 1772). Thus, the Peoria-Brady-Bignell stratigraphic sequence is a result of a series of factors having to do with regional sedimentological and geomorphic processes, with no obvious relationship to high latitude cooling in the YDC.

Lithostratigraphy, soil-stratigraphy, and dating of playas formed in the Peoria Loess on the High Plains of western Kansas indicate that at least some of these upland basins were stable during the Pleistocene–Holocene transition. The radiocarbon chronology supporting this interpretation is, however, based on relatively few samples. Nevertheless, radiocarbon ages determined on organic carbon from buried soils at the Sullivan and Knudsen playas (Mandel, 2008) and at the Winger site, a Late Paleoindian bison bone-bed sealed in playa sediments (Mandel and Hofman, 2003), indicate cumulic soil development in playa basins ~12,500–9000 ^{14}C BP (~14,800–10,200 cal BP).

To summarize, on the Central Plains deep incision destabilized the loess mantled uplands and the valleys aggraded with redeposited silt. Alluvial aggradation slowed by the YDC and the depositional environment shifted to one of slowly and episodically aggrading floodplains. The onset and end of this floodplain cumulization process varied through time, however. The early Holocene was characterized by more rapid alluviation, probably reflecting the onset of episodic flooding. Stable-carbon isotopes show a general warming trend from the late Pleistocene into the early Holocene. Warming apparently was relatively rapid just before the YDC followed by a brief reversal to somewhat cooler conditions at roughly 11,500 to 10,500 ^{14}C BP (~13,400 to ~12,500 cal BP), and then a return to the warming trend.

3.2. Southern Great Plains

Depositional environments with stratigraphic records that intersect the YDC on the southern Great Plains include valleys, lake basins, rock shelters, and upland dunes. Valleys include those with perennial streams on the Edwards Plateau and in the Pecos Valley, and dry drainage-ways or "draws" on the Southern High Plains (Fig. 5). The Pecos Valley above its lower reaches, however, has no published late Pleistocene or early Holocene stratigraphic record.

Drainages throughout the Southern Great Plains were subjected to incision in the late Pleistocene (~17,000 to ~10,000 ^{14}C BP; ~21,000 to ~11,400 cal BP; varying from drainage to drainage) (Kochel et al., 1982; Patton and Dibble, 1982; Blum and Valastro, 1989, 1992, 1994; Blum et al., 1994; Nordt et al., 1994; Holliday, 1995; Nordt, 1995). On the Southern High Plains of west/northwest Texas and eastern New Mexico, the draws have vertically and laterally continuous stratigraphic records of the late Pleistocene and early Holocene. The drainages represent the headwaters of the Brazos and Colorado rivers though they have no perennial flow today. Holliday (1995) gathered stratigraphic data from 110 localities along 10 draws (Fig. 5). These localities included the Clovis type site (aka Blackwater Draw Locality 1) along Blackwater Draw (Haynes and Agogino, 1966; Haynes, 1995) and the Lubbock Lake site along Yellowhouse Draw (Holliday, 1985). As on the Central Plains, the valleys of the Southern High Plains contained streams in equilibrium (neither incising nor aggrading) in the terminal Pleistocene (~17,000–11,000 ^{14}C BP; ~21,000–12,900 cal BP), meandering across the valley floors. Locally, this process ended abruptly at ~11,000 ^{14}C BP (~12,900 cal BP) when water ceased to flow and valley floors switched to palustrine and lacustrine settings (Fig. 6). These lake and marsh conditions locally persisted until as late as ~8500 ^{14}C BP (~9400 cal BP). In other reaches of some draws, water continued to flow for centuries or even millennia after 11,000 ^{14}C BP (~12,900 cal BP) (e.g., the base of the overlying lacustrine sediments at the Mustang Springs site is dated to ~10,200 ^{14}C BP; ~11,900 cal BP [Meltzer, 1991]). Where adequate radiocarbon control is available, the data suggest that the abrupt contact between the alluvium and palustrine/lacustrine deposits is time-transgressive downstream, perhaps following a water table that was dropping due to the onset of aridity (Holliday, 1995). Stable-carbon isotopes and microvertebrates (Johnson, 1986, 1987a,b; Holliday, 1995, 2000c) suggest a warming and drying trend along the draws through and after Younger Dryas time.

The uplands of the Southern High Plains contain two different stratigraphic records that encompass the YDC: dune fields and playa basins. Several dune fields cross the region: the oldest layers of sand are Folsom (i.e., Younger Dryas) or late Paleoindian age (Holliday, 2000c, 2001). Evidence for Clovis-age sedimentation is rare. The implied record of wind erosion beginning ~11,000 ^{14}C BP (~12,900 cal BP) is believed to be an upland geomorphic manifestation of the drying trend recorded in the draws, described above (Holliday, 2000c). Playa basins are relatively small (most

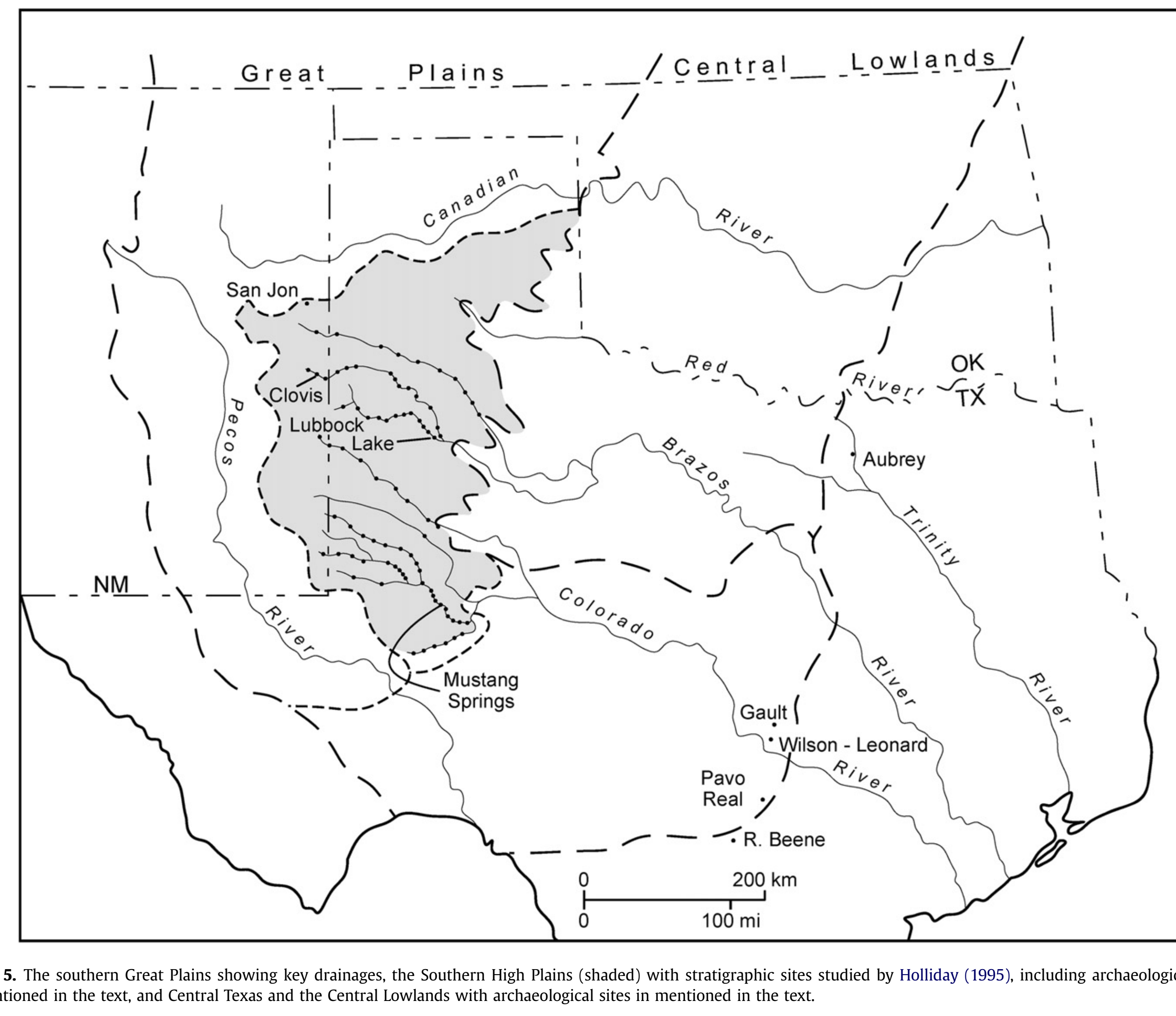

Fig. 5. The southern Great Plains showing key drainages, the Southern High Plains (shaded) with stratigraphic sites studied by Holliday (1995), including archaeological sites mentioned in the text, and Central Texas and the Central Lowlands with archaeological sites in mentioned in the text.

Fig. 6. Excavations at the Lubbock Lake site, Texas (Fig. 5) showing the YD-age laminated diatomite (stratum 2A; ~11,000 to ~10,000 BP) resting on clayey alluvium (1C; >~11,000 BP) and buried beneath mud (2B, ≤10,000 BP) (photo by V.T. Holliday; modified from Holliday, 1997b, fig. 3.28).

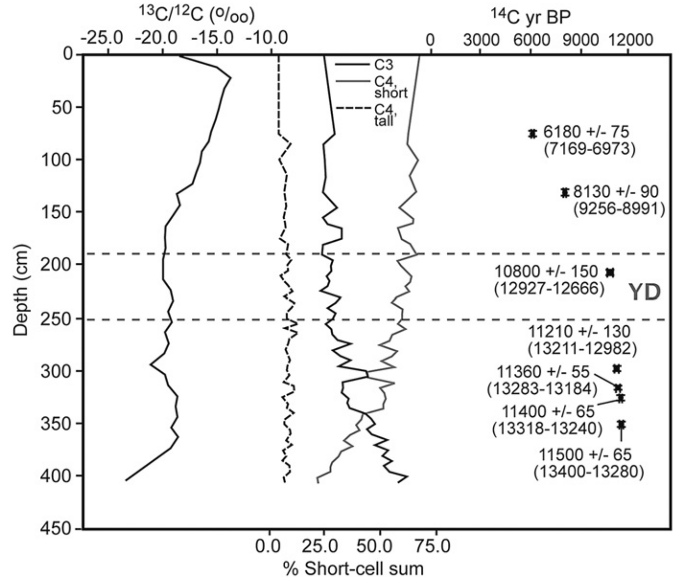

Fig. 7. Stable-carbon isotope trend for the late Quaternary from the San Jon site, northeastern New Mexico (Fig. 5) (modified from Holliday et al., 2008, Fig. 7).

<1.5 km^2), roughly circular depressions on the High Plains surface (Holliday et al., 1996, 2008). All radiometric dating shows that the basins predate the YDC by at least a few millennia and were filling before Clovis time (Holliday et al., 1996, 2008). Most formed by wind deflation and contain several meters of dark gray mud that accumulated continuously after the basins formed. The fills encompass the Younger Dryas Chronozone, but they exhibit no obvious YDC marker bed.

Lunettes are isolated dunes formed on the leeward side of ~5% of the playa basins in the region (Sabin and Holliday, 1995; Holliday, 1997a). The dunes contain carbonate sediment derived from lacustrine marl formed in the playa basins and sand deflated during basin formation (or enlargement) or from sand deposited in the basin. Buried soils are common in the lunettes, indicative of lunette stability. Lunette accretion is likely a function of dryer conditions, allowing deflation of the basin sediments. Stability and soil formation in the lunette sediments is probably related to more moist conditions when the playa is wet and more dense vegetation takes hold on the dune. The carbonate was deposited in the playa basins sometime between ~25,000 and ~15,000 ^{14}C BP (~20,000 and ~18,200 cal BP) (Holliday et al., 1996, 2008; Holliday, 1997a) under wetter conditions. Lunette formation ensued episodically ~15,000 to 8,000 ^{14}C BP (~18,200–~8900 cal BP), suggesting fluctuations between wetter and dryer conditions, but no clear pattern at any one time (Holliday, 1997a). Isotopes from soils buried in lunettes broadly suggest a warming trend ~15,000 to ~11,000 or ~10,000 ^{14}C BP (~18,200 to ~11,400 cal BP), with a return to cooler conditions in the early Holocene (Holliday, 1997a).

Stable-carbon isotopes and phytoliths from a section at the San Jon playa are indicative of warming and perhaps drying through the YDC (Fig. 7) (Holliday et al., 2008). Sometime before ~11,500 ^{14}C BP (~13,500 cal BP), δ^{13}C values increase from −23‰ to −19‰, while C_3-type short-cell phytoliths decrease from 60% to 40%. Between 11,500 and 10,800 ^{14}C BP (13,500 and 12,800 cal BP), δ^{13}C values of soil organic matter (SOM) are between −20‰ and −19‰ (~50–60% C_4 contributions to SOM), while C_4-type short-cell phytoliths increase from ~40% to over 60%, remarkably similar to C_4 contributions to SOM calculated using δ^{13}C values. The gradual increase in C_4-type short-cell phytoliths beginning >11,500 ^{14}C BP (>13,300 cal BP) until just prior to ~10,800 ^{14}C BP (~12,800 cal BP) indicate gradual warming. The δ^{13}C values range from −20‰ to −19‰, indicating approximately equal contributions of C_3 and C_4 plants to SOM and interpreted to reflect only seasonal inundation of the playa. Within the apparent warming trend, however C_4-type phytolith content decreases and δ^{13}C values decrease (from −19‰ to −21‰) between ~11,400 and ~11,200 ^{14}C BP (~13,200 and ~13,100 cal BP) (Fig. 7), interrupting the warming trend just prior to the YDC. Between ~11,200 and ~10,800 ^{14}C BP (~13,100 and ~12,800 cal BP), C_4-type phytoliths increase from less than 50% to about 60%, considered to reflect a return to the warming trend recognized prior to 11,200 ^{14}C BP (~13,100 cal BP). Between ~10,800 and ~8130 ^{14}C BP (~12,800 and ~9000 cal BP), δ^{13}C values increase from −20‰ to −17‰, while C_4-type phytoliths gradually increase to about 63%, likely representing a decrease in duration of playa inundation associated with drying during the latest Pleistocene and early Holocene.

The thick limestone of the Edwards Plateau is dissected by large rivers such as the Brazos, Colorado, and Pecos, and their tributaries (Fig. 5), along with a number of smaller drainages that head on the plateau. In the canyons of the southwestern Edwards Plateau, the dominant depositional process on the lower Pecos and lower Devils Rivers in the early Holocene was aggradation of fine-grained sediment (Collins, 1976; Kochel et al., 1982; Patton and Dibble, 1982; Gustavson and Collins, 1998). Otherwise, little is known about the late Pleistocene/early Holocene stratigraphic record of the region. In the eastern part of the Edwards Plateau, reported late Pleistocene/early Holocene stratigraphic sections (which tend to be archaeological sites) are in generally similar settings: low-order tributaries incised into the limestone bedrock and in proximity to springs. Besides their setting, both Wilson-Leonard (Bousman, 1998; Collins, 1998a,b; Bousman et al., 2002) and Gault (Collins and Brown, 2000; Collins, 2007) (Fig. 5) exhibit remarkably similar stratigraphic sequences: multiple Paleoindian occupations in thick (>1 m), well-stratified sediments; a fining-upward sequence of alluvium during the Early Paleoindian period from ~11,500 to ~10,000 ^{14}C BP (~13,500 to ~11,400 cal BP); stability and soil formation beginning ~10,000 ^{14}C BP and lasting ~500–1000 radiocarbon years, then colluvial and alluvial deposition coincident with late Paleoindian and Early Archaic occupations. Pavo Real (Fig. 5) is in a similar setting and contains multiple Paleoindian zones, but they are compressed into relatively thin (<1 m), mixed deposits (Collins et al., 2003).

Two sites in alluvial settings beyond the margin of the Great Plains, Richard Beene and Aubrey (Fig. 5), provide stratigraphic contrasts with the Southern Great Plains record. The Richard Beene site, along the Medina River in southcentral Texas (on the margin o the Coastal Plain immediately south of the Edwards Plateau), provided a rare look at the late Pleistocene/early Holocene transition in a continuous, fine-grained alluvial-stratigraphic sequence that spans the past 35,000 years (Mandel et al., 2007). A period of slow aggradation punctuated by stability and soil development ~13,000–11,500 ^{14}C BP (~15,500–13,400 cal BP) was followed by rapid aggradation that continued until ~10,500 ^{14}C BP Alluviation slowed ~10,500–9000 ^{14}C BP (~12,400–10,200 cal BP), and floodplain stability and concomitant pedogenesis occurred ~9000–8600 ^{14}C BP (~10,200–9550 cal BP), resulting in the development of the Perez paleosol.

The δ^{13}C values of SOM at the Richard Beene site (Fig. 8) show large and rapid fluctuations from ~15,000 to 10,000 ^{14}C BP (~18,700–11,500 cal BP), coincident with episodic floodplain accretion (Nordt et al., 2002). Distinct periods of low relative C_4 productivity occurred between ca. 15,500 and 14,000 ^{14}C BP (~18,700–17,000 cal BP) and between ~13,000 and ~11,000 ^{14}C BP (~15,550 and ~12,900 cal BP), which correlates with two well-documented episodes of glacial meltwater flux from the Laurentide ice sheet into the Gulf of Mexico via the Mississippi River (Kennett et al., 1985; Leventer et al., 1982; Spero and Williams, 1990). Cold water inputs into the Gulf of Mexico apparently resulted in cooler climatic conditions at least as far inland as the Richard Beene site, thereby reducing the relative productivity of C_4 grasses during the two meltwater episodes. A distinct period of high relative C_4 productivity occurred during the first half of the YDC (~11,000–10,500 ^{14}C BP; ~12,900–12,400 cal BP), a time when rapid alluviation was occurring. The increase in C_4 productivity, implying warmer temperatures, corresponds precisely with significant reduction in cold meltwater flow into the Gulf of Mexico (Broecker et al., 1989; Spero and Williams, 1990; Teller, 1990) and perhaps to greater summer monsoonal precipitation and temperatures (COHMAP, 1988). Between 10,500 and 9000 ^{14}C BP (12,400 and 10,200 cal BP), when aggradation was slowing down, relative C_4 productivity initially decreased, then increased slightly. However, between 9000 and 8600 ^{14}C BP (~10,200 and 9550 cal BP), which was the period when the Perez paleosol developed, δ^{13}C values of soil carbon become lighter, suggesting an increase in relative C_3 productivity and, therefore, cooler temperatures.

The Aubrey site in the Central Lowlands of north central Texas provides a significant contrast in YDC alluvial stratigraphy compared to the Central Great Plains, just to the north, and the Southern Great Plains, not far to the west and southwest. The Aubrey site is along the upper Trinity River (Ferring, 1995, 2001a). Deep valley incision (~20 m) began sometime after ~26,000 cal BP (Ferring, 2001a: 30, 37), followed by aggradation of coarse-grained mainstream alluvium. Alluviation ceased >15,000 ^{14}C BP (18,200 cal BP). Landscape stability with localized ponding and deflation occurred ~11,500–11,000 ^{14}C BP (~13,500–12,900 cal BP). Fine-grained overbank alluviation and burial of the Clovis occupation surface began sometime between ~11,000 and ~10,500 ^{14}C BP (~12,900 and ~12,500 cal BP) and continued through the early Holocene (Ferring, 2001a: 37–54). The shift in style of alluvial processes from the late Pleistocene into the early Holocene is clearly indicative of

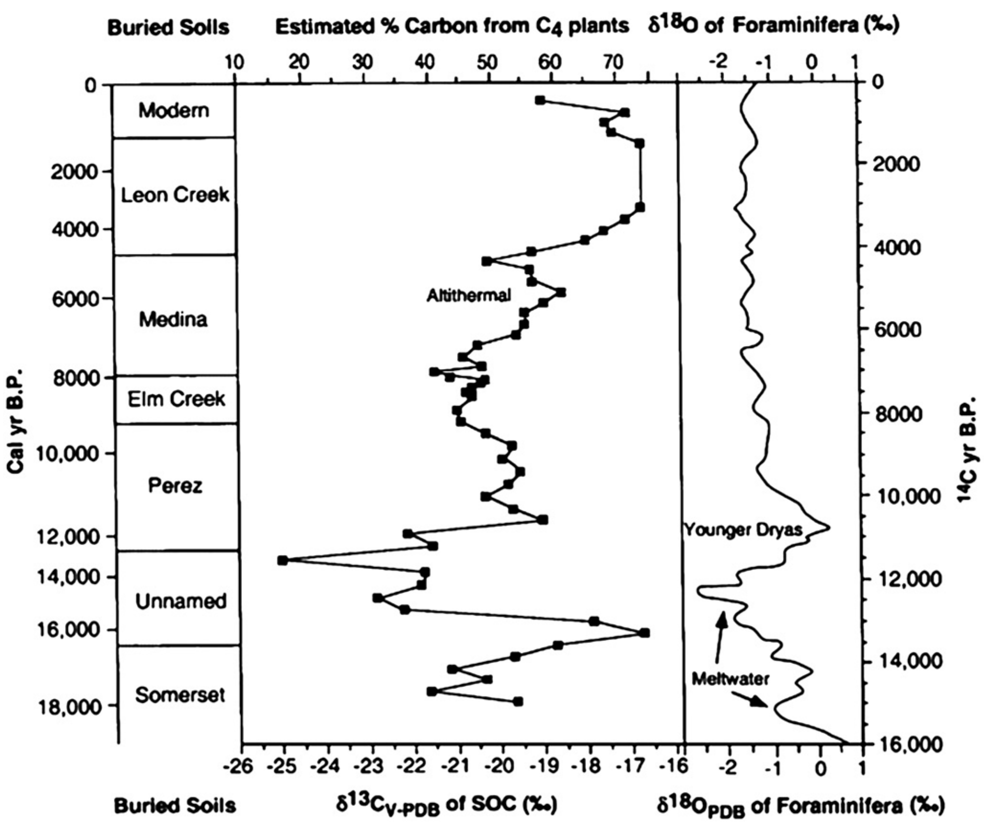

Fig. 8. Stable-carbon isotope values of soil organic carbon (SOC) from buried soils at the Richard Beene site in southcentral Texas (modified from Nordt et al., 2002, Fig. 3). Values are shown with respect to buried soil, calendar years (left axis), radiocarbon years (right axis), and δ^{18}O PDB values of foraminifera in the Gulf of Mexico (values from Leventer et al., 1982, for core EN32-PC, with chronology modified by Flower and Kennett, 1990). The proportion of organic carbon derived from C4 plant production (top axis) was estimated by mass balance calculations.

decreasing discharge through the late Pleistocene (i.e., high energy to low energy deposits) and also probably related to increased sediment yield from the drainage (i.e., the long term aggradation of fine sediments) basin following the Clovis occupation and on into the Holocene (i.e., the long term aggradation of fine sediments). These sedimentological and hydrological characteristics are typical of many large streams (Brown, 1997: 17–44; Ferring, 2001b; Gladfelter, 2001; Huckleberry, 2001) but other than an overlap in time, there is no obvious chronostratigraphic correlation between depositional processes at Aubrey and the YDC.

Stable-C isotopes from the Aubrey sediments ~11,000 ^{14}C BP and younger provide additional paleoenvironmental information (Humphrey and Ferring, 1994). Pedogenic carbonate suggests a strong shift toward lighter δ^{13}C values (indicative of more cool season grasses) beginning ~11,000 ^{14}C BP (~12,900 cal BP) and peaking at ~10,000 ^{14}C BP (~11,400 cal BP) (i.e., peak cooling at the end of the YDC) (Humphrey and Ferring, 1994, Fig. 8A). This shift reversed toward heavier isotopes (indicative of warm-season grasses) very rapidly immediately after ~10,000 ^{14}C BP.

In summary, on the Southern High Plains, late Pleistocene alluviation shifted to lacustrine or palustrine sedimentation beginning ~11,000 ^{14}C BP (12,900 cal BP), but this change in depositional environments was later along some draws, especially in downstream reaches. The specific character of the lake/marsh conditions also varied: diatomaceous lake beds in some areas; muds in others; and hard water marshes in yet others. These conditions probably were controlled by local groundwater discharge (Holliday, 1995). These lake and marsh deposits have eolian facies. On the uplands the oldest eolian sands contain Folsom and equivalent-age artifacts; i.e., they are YDC age. Eolian sedimentation increasingly dominated depositional environments into the early Holocene. The playa basins slowly filled with mud from the last millennia of the Pleistocene on into the early Holocene. The depositional trends as well as stable isotope data suggest that the region was subjected to a warming and drying trend through the YDC. On the Edwards Plateau, following late Pleistocene incision, aggradation commenced by the time of the Clovis occupation of the region ~11,500 BP and continued on into the Holocene, but the character and timing of depositional processes varied.

Arroyos and low-order tributaries throughout the Plains exhibit variable stratigraphic records for the YDC. Most were aggrading in the late Pleistocene and through the YDC. The uppermost Cache La Poudre drainage with the Lindenmeier site filled with loess, then some alluvium followed by erosion just before the YDC. A quasi-stable setting with some slopewash additions through the YDC resulted in development of a cumulic soil. In the Upper Dry Cimarron in and around the area of the Folsom site the YDC is characterized by aggradation, but 1) in some tributaries the deposition was under way well before the YDC; and 2) the local depositional environments varied from alluviation to colluviation to eolian sedimentation.

4. Discussion and conclusions

The stratigraphic records of the late Pleistocene to early Holocene transition on the Central and Southern Great Plains, and, in particular, the stratigraphic records of the Younger Dryas Chronozone vary through time and space. Some broad trends are apparent, however. Valleys that head on the Plains went through entrenchment in the late Pleistocene, followed by aggradation through the YDC and into the early Holocene. The character and driving mechanisms of the aggradation varied, however. The YDC depositional environments of the Great Plains were largely ones of slow sediment accumulation or stability and soil formation. Valleys that head on and only drain the Great Plains were aggrading (at various rates and with varying depositional systems) through the YDC. The mainstreams heading in mountainous regions apparently were both stable and incising at some point during the YDC. Low-order tributaries, including arroyo systems, were also aggrading during this time. The playas of the High Plains were likely wetter than today, but drying through the YDC. Two dominant environmental trends are warming and declines in effective moisture, best reflected in evidence for declining surface runoff and declining water tables, and evidence for increased wind erosion and eolian sedimentation.

An important point when considering these apparent environmental trends is the nature of the various stratigraphic records. Some settings on the Central Great Plains and the Southern High Plains (e.g., Holliday, 1995; Mann and Meltzer, 2007; Mandel, 2008; Mason et al., 2008) have been subjected to systematic investigation of late Quaternary stratigraphy, geomorphology, and environments Other settings, particularly the South Platte and Arkansas systems deserve much more attention to better understand the role of glacial activity in the headwaters in driving cycles of cutting, filling, and stability from the late Pleistocene into the early Holocene. Elsewhere, much of the research has focused on one or a few localities (typically archaeological). The late Quaternary records of most of the mainstreams (Canadian, Red, upper Trinity, and Pecos) are woefully understudied. However, local environmental records may be better preserved in low-order tributary systems.

The driving mechanisms for the broad array of post-LGM late Pleistocene environmental changes have been debated for decades. One of the latest additions to this list of drivers is the hypothesis that North America was subjected to some sort of "extraterrestrial event" at ~11,000 ^{14}C BP (12,900 cal BP), possibly a comet impact or possibly some sort of airburst. The end result is hypothesized continent-wide grass and forest fires, extinction of late Pleistocene fauna, extinction of the Clovis occupation of the continent, and melting of the glaciers and subsequent cooling of the North Atlantic that resulted in the onset of the Younger Dryas (Firestone et al., 2006, 2007). All attempts to test and replicate this claim or to confirm aspects of this hypothesis (Buchanan et al., 2008; Marlon et al., 2009; Gill et al., 2009; Holliday and Meltzer, 2010) or reproduce data (Surovell et al., 2009; Paquay et al., 2009; Daulton et al., 2010; Haynes et al., 2010; Scott et al., 2010) have not been successful, raising serious concerns about the veracity of the claim (see summary and discussion by Pinter et al., in press). The debate rages. Such a catastrophic event should have had an obvious and noticeable impact on geomorphic systems, and yet the stratigraphic record summarized above (and other aspects of the environment, discussed by Meltzer and Holliday, 2010) likewise provide no evidence of an extraterrestrial impact. Uniform sedimentation or time-transgressive changes in sedimentary styles across the lower boundary of the YDC (at 12,900 cal BP) combined with the inability to reproduce data used to support the impact hypothesis or to confirm predictions generated by the hypothesis argue that if indeed some sort of extraterrestrial body collided with North America or exploded in the atmosphere above the continent it left behind only chemical or microscopic physical markers. But then, those have not been detected either (Pinter et al., in press).

The data clearly show that a host of geomorphic processes produced the terminal Pleistocene and early Holocene stratigraphic records of the Great Plains. Moreover, the Younger Dryas interval is not necessarily manifest as a distinct lithostratigraphic or biostratigraphic entity in these different types of deposits and soils. The various geomorphic systems of the Great Plains did not behave synchronously in response to any common climate driver. These stratigraphic records reflect local environmental conditions and probably a complex response to the reorganization of mid-latitude climates in the terminal Pleistocene and early Holocene.

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References

Alley, R., 2007. Wally was right: predictive ability of the North Atlantic Conveyor Belt hypothesis for abrupt climate change. Annual Review of Earth and Planetary Sciences 35, 1–72.
Alley, R., Clark, P., 1999. The deglaciation of the northern hemisphere. Annual Review of Earth and Planetary Sciences 27, 149–182.
Alley, R., Meese, D., Shuman, C., Gow, A., Taylor, K., Grootes, P., White, J., Ram, M., Waddington, E., Mayewski, P., Zielinski, G., 1993. Abrupt increase in Greenland snow accumulation at the end of the Younger Dryas event. Nature 362, 527–529.
Balakrishnan, M., Yapp, C., Meltzer, D.J., Theler, J., 2005. Paleoenvironment of the Folsom site $\sim$10,500 ^{14}C years B.P. as inferred from the stable isotope composition of fossil land snails. Quaternary Research 63, 31–44.
Bement, L.C., Carter, B.J., 2008. A Younger Dryas signature on the southern plains. Current Research in the Pleistocene 25, 193–194.
Bement, L.C., Carter, B.J., Varney, R.A., Cummings, L.S., Sudbury, J.B., 2007. Paleoenvironmental reconstruction and bio-stratigraphy, Oklahoma Panhandle, USA. Quaternary International 169-170, 39–50.
Benson, L., Madole, R., Kubik, P., McDonald, R., 2007. Surface-exposure ages of Front Range moraines that may have formed during the Younger Dryas, 8.2 cal ka, and Little Ice Age events. Quaternary Science Reviews 26, 1638–1649.
Bettis, E.A., Muhs, D.R., Roberts, H.M., Wintle, A.G., 2003. Last Glacial loess in the conterminous USA. Quaternary Science Reviews 22, 1907–1946.
Blum, M.D., Toomey III, R.S., Valastro Jr., S.S., 1994. Fluvial response to late Quaternary climatic and environmental change, Edwards Plateau, Texas. Palaeogeography, Palaeoclimatology, Palaeoecology 108, 1–21.
Blum, M.D., Valastro Jr., S.S., 1989. Response of the Pedernales River of Central Texas to late Holocene climatic change. Annals of the Association of American Geographers 79, 435–456.
Blum, M.D., Valastro Jr., S.S., 1992. Quaternary stratigraphy and geoarchaeology of the Colorado and Concho rivers, west Texas. Geoarchaeology 7, 419–448.
Blum, M.D., Valastro Jr., S.S., 1994. Late Quaternary sedimentation, lower Colorado River, Gulf Coastal Plain of Texas. Geological Society of America Bulletin 106, 1002–1016.
Bousman, C.B., 1998. Late Paleoindian archeology. In: Collins, M.B. (Ed.), Wilson-Leonard: An 11,000-year Archeological Record of Hunter-gatherers in Central Texas; Volume I: Introduction, Background, and Synthesis. Archeology Studies Program, Report 10. Texas Department of Transportation, Environmental Affairs Division, Austin, pp. 161–210.
Bousman, C.B., Collins, M.B., Goldberg, P., Stafford, T., Guy, J., Baker, B.W., Steele, D.G., Kay, M., Kerr, A., Fredlund, G., Dering, P., Holliday, V., Wilson, D., Gose, W., Dial, S., Takac, P., Balinsky, R., Masson, M., Powell, J.F., 2002. The Palaeoindian–Archaic transition in North America: new evidence from Texas. Antiquity 76, 980–990.
Broecker, W.S., Kennett, J., Flower, B., Teller, J., Trumbore, S., Bonani, G., Wolfli, W., 1989. Routing of meltwater from the Laurentide ice sheet during the Young Dryas cold episode. Nature 341, 318–323.
Brown, A.G., 1997. Alluvial Geoarchaeology: Floodplain Archaeology and Environmental Change. Cambridge University Press, Cambridge.
Brunswig, R.H., 2007. New interpretations of the Dent mammoth site. In: Brunswig, R.H., Pitblado, B.L. (Eds.), Frontiers in Colorado Paleoindian archaeology. University Press of Colorado, Boulder, pp. 87–121.
Bryan, K., Ray, L., 1940. Geologic Antiquity of the Lindenmeier Site in Colorado. Smithsonian Miscellaneous Collections 99, Washington, D.C.
Buchanan, B., Collard, M., Edinborough, K., 2008. Paleoindian demography and the extraterrestrial hypothesis. Proceedings of the National Academy of Sciences 105, 11651–11654.
Busacca, A., Begét, J.E., Markewich, H.W., Muhs, D.R., Lancaster, N., Sweeney, M.R., 2004. Eolian sediments. In: Gillespie, A.R., Porter, S.C., Atwater, B.F. (Eds.), The Quaternary Period in the United States. Elsevier, New York, pp. 275–310.
COHMAP Project Members, 1988. Climatic changes of the last 18,000 years: observations and model simulations. Science 241, 1043.
Collins, M.B., 1976. Terminal Pleistocene cultural adaptations in southern Texas. In: Griffin, J.B. (Ed.), Habitats humains antérieurs a L'Holocène en Amérique. IXe Congrès, Union Internationale des Sciences Préhistoriques et Protohistoriques. France, Nice, pp. 102–135.
Collins, M.B. (Ed.), 1998a. Wilson-Leonard: An 11,000-year Archeological Record of Hunter-gatherers in Central Texas. Archeology Studies Program, Report 10 (5 volumes). Texas Department of Transportation, Environmental Affairs Division, Austin.
Collins, M.B., 2007. Discerning clovis subsistence from stone artifacts and site distributions on the Southern Plains periphery. In: Walker, R.B., Driskell, B.N. (Eds.), Foragers of the Terminal Pleistocene in North America. University of Nebraska Press, Lincoln, pp. 59–87.
Collins, M.B., 1998b. Early Paleoindian components. In: Collins, M.B. (Ed.), Wilson-Leonard: An 11,000-year Archeological Record of Hunter-gatherers in Central Texas; Volume I: Introduction, Background, and Synthesis. Archeology Studies Program, Report 10. Texas Department of Transportation, Environmental Affairs Division, Austin, pp. 123–159.
Collins, M.B., Brown, K.M., 2000. The Gault *gisement*: some preliminary observations. Current archeology in Texas. Texas Historical Commission 2, 8–11.
Collins, M.B., Hudler, D.B., Black, S.L., 2003. Pavo Real (41BX52): A Paleoindian and Archaic Camp and Work-shop on the Balcones Escarpment, South-central Texas. In: Studies in Archeology 41. Texas Archeological Research Laboratory, The University of Texas at Austin, Austin.
Cordova, C.E., Johnson, W.C., Mandel, R., Palmer, M., 2011. Late Quaternary environmental change inferred from phytoliths and other soil-related proxies: case studies from the central and southern Great Plains, USA. Catena 85, 87–108.
Daulton, T.L., Pinter, N., Scott, A.C., 2010. No evidence of nanodiamonds in Younger Dryas sediments to support an impact event. Proceedings of the National Academy of Sciences 107, 16043–16047.
Feggestad, A.J., Jacobs, P.M., Miao, X.D., Mason, J.A., 2004. Stable carbon isotope record of Holocene environmental change in the central Great Plains. Physical Geography 25, 170–190.
Fenneman, N.M., 1938. Physiography of Eastern United States. McGraw-Hill Book Company, New York.
Ferring, C.R., 1995. The late Quaternary geology and rchaeology of the Aubrey Clovis site, Texas. In: Johnson, E. (Ed.), Ancient Peoples and Landscapes. Museum of Texas Tech University, Lubbock, Texas, pp. 273–281.
Ferring, C.R., 2001a. The Archaeology and Paleoecology of the Aubrey Clovis Site (41DN479), Denton County, Texas. Center for Environmental Archaeology, Department of Geography, University of North Texas, Denton, Texas. 276 p.
Ferring, C.R., 2001b. Geoarchaeology in alluvial landscapes. In: Goldberg, P., Holliday, V.T., Ferring, C.R. (Eds.), Earth Sciences and Archaeology. Kluwer Academic Publishers, New York, pp. 77–106.
Figgins, J.D., 1933. A further contribution to the antiquity of man in America. Proceedings of the Colorado Museum of Natural History 12 (2), 4–8.
Firestone, R., West, A., Warwick-Smith, S., 2006. The Cycle of Cosmic Catastrophes: How a Stone-Age Comet Changed the Course of World Culture. Bear and Company, Rochester, Vermont.
Firestone, R.B., West, A., Kennett, J.P., Becker, L., Bunch, T.E., Revay, Z.S., Schultz, P.H., Belgya, T., Kennett, D., Erlandson, J.M., Dickenson, J., Goodyear, A.C., Harris, R.S., Howard, G.A., Kloosterman, J.B., Lechler, P., Mayewski, P.A., Montgomery, J., Poreda, R., Darrah, T., Que Hee, S.S., Smith, A.R., Stich, A., Topping, W., Wittke, J.H., Wolbach, W.S., 2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. Proceedings of the National Academy of Sciences 104, 16016–16021.
Flower, B.P., Kennett, J.P., 1990. The Younger Dryas cool episode in the Gulf of Mexico. Paleoceanography 5, 949–961.
Gill, J.L., Williams, J.W., Jackson, S.T., Lininger, K.B., Robinson, G.S., 2009. Pleistocene megafaunal collapse, novel plant communities, and enhanced fire regimes in North America. Science 326, 1100–1103.
Gladfelter, B., 2001. Humid alluvial systems. In: Stein, J., Farrand, W. (Eds.), Sediments in Archaeological Contexts. University of Utah Press, Salt Lake City, pp. 93–125.
Graf, W.L. (Ed.), 1987. Geomorphic Systems of North America. Centennial Special Volume 2. Geological Society of America, Boulder, Colorado, p. 643.
Gustavson, T.C., Collins, M.B., 1998. Geoarchaeological Investigations of Rio Grande Terrace and Floodplain Alluvium from Amistad Dam to the Gulf of Mexico. Technical Series 49. Texas Archeological Research Laboratory, The University of Texas, Austin. 43 p.
Hald, M., Andersson, C., Ebbesen, H., Jansen, E., Klitgaard-Kristensen, D., Risebrobakken, B., Salomonsen, G., Sarnthein, M., Sejrup, H.-P., Telford, R., 2007. Variations in temperature and extent of Atlantic water in the northern North Atlantic during the Holocene. Quaternary Science Reviews 26, 3423–3440.
Haynes Jr., C.V., 1991. Geoarchaeological and paleohydrological evidence for a Clovis-age drought in North America and its bearing on extinction. Quaternary Research 35, 438–450.
Haynes Jr., C.V., 1990. The Antevs-Bryan years and the legacy for Paleoindian geochronology. In: Laporte, L.F. (Ed.), Establishment of a Geologic Framework for Paleoanthropology. Special Papers 242. Geological Society of America, pp. 55–68.
Haynes Jr., C.V., 1995. Geochronology of paleoenvironmental change, Clovis type site, Blackwater Draw, New Mexico. Geoarchaeology 10, 317–388.
Haynes Jr., C.V., 2003. Dating the Lindenmeier Folsom site, Colorado, U.S.A., before the radiocarbon revolution. Geoarchaeology 18, 161–174.
Haynes Jr., C.V., 2008. Younger Dryas "black mats" and the Rancholabrean termination in North America. Proceedings of the National Academy of Sciences 105, 6520–6525.
Haynes Jr., C.V., Agogino, G.A., 1960. Geological Significance of a New Radiocarbon Date from the Lindenmeier Site. The Denver Museum of Natural History. Proceedings 9.
Haynes Jr., C.V., Agogino, G.A., 1966. Prehistoric springs and geochronology of the Clovis site, New Mexico. American Antiquity 31, 812–821.

Haynes Jr., C.V., Beukens, R.P., Jull, A.J.T., Davis, O.K., 1992. New radiocarbon dates for some old Folsom sites: accelerator technology. In: Stanford, D.J., Day, J.S. (Eds.), Ice Age Hunters of the Rockies. Denver Museum of Natural History and University Press of Colorado, Denver, pp. 83–100.

Haynes Jr., C.V., McFaul, M., Brunswig, R.H., Hopkins, K.D., 1998. Kersey-Kuner terrace investigations at the Dent and Bernhardt sites, Colorado. Geoarchaeology 13, 201–218.

Haynes Jr., C.V., Boerner, J., Domanik, K., Lauretta, D., Ballenger, J., Goreva, J., 2010. The Murray Springs Clovis site, Pleistocene extinction, and the question of extraterrestrial impact. Proceedings of the National Academy of Sciences 107, 4010–4015.

Holliday, V.T., 1985. Archaeological geology of the Lubbock Lake site, southern high plains of Texas. Geological Society of America Bulletin 96, 1483–1492.

Holliday, V.T., 1987. Geoarchaeology and late Quaternary geomorphology of the Middle South Platte River, Northeastern Colorado. Geoarchaeology: An International Journal 2, 317–329.

Holliday, V.T., 1995. Stratigraphy and Paleoenvironments of Late Quaternary Valley Fills on the Southern High Plains. In: Memoir 186. Geological Society of America Memoir, Boulder, Colorado.

Holliday, V.T., 1997a. Origin and evolution of lunettes on the High Plains of Texas and New Mexico. Quaternary Research 47, 54–69.

Holliday, V.T., 1997b. Paleoindian Geoarchaeology of the Southern High Plains. University of Texas Press, Austin. 297 p..

Holliday, V.T., 2000a. Vance Haynes and Paleoindian geoarchaeology and geochronology of the Great Plains. Geoarchaeology 15, 511–522.

Holliday, V.T., 2000b. Folsom drought and episodic drying on the Southern High Plains from 10,900–10,200 ^{14}C yr B.P. Quaternary Research 53, 1–12.

Holliday, V.T., 2000c. The evolution of Paleoindian geochronology and typology on the Great Plains. Geoarchaeology 15, 227–290.

Holliday, V.T., 2001. Stratigraphy and geochronology of upper Quaternary eolian sand on the Southern High Plains of Texas and New Mexico, United States. Geological Society of America Bulletin 113, 88–108.

Holliday, V.T., Mandel, R., 2006. Paleoindian geoarchaeology of the Great Plains, Central Lowlands, and Southwestern U.S. In: Ubelaker, D.H. (Ed.), Environment, Origins, and Populations, Volume 3 of the Handbook of North American Indians. Smithsonian Institution Press, Washington, D.C., pp. 23–46.

Holliday, V.T., Meltzer, D.J., 2010. The 12.9 ka impact hypothesis and North American Paleoindians. Current Anthropology 51, 575–585.

Holliday, V.T., Knox, J.C., Running IV, G.L., Mandel, R.D., Ferring, C.R., 2002. The Central Lowlands and Great Plains. In: Orme, A. (Ed.), The Physical Geography of North America. Oxford University Press, New York, pp. 335–362.

Holliday, V.T., Hovorka, S.D., Gustavson, T.C., 1996. Lithostratigraphy and geochronology of fills in small playa basins on the Southern High Plains. Geological Society of America Bulletin 108, 953–965.

Holliday, V.T., Mayer, J.H., Fredlund, G.G., 2008. Late Quaternary sedimentology and geochronology of small playas on the Southern High Plains, Texas and New Mexico, U.S.A. Quaternary Research 70, 11–25.

Huckleberry, G.A., 2001. Archaeological sediments in dryland alluvial environments. In: Stein, J., Farrand, W. (Eds.), Sediments in Archaeological Contexts. University of Utah Press, Salt Lake City, pp. 67–92.

Humphrey, J.D., Ferring, C.R., 1994. Stable isotope evidence for latest Pleistocene and Holocene climatic change in north-central Texas. Quaternary Research 41, 200–213.

Jacobs, P.M., Mason, J.A., 2005. Impact of Holocene dust aggradation on A horizon characteristics and carbon storage in loess-derived Mollisols of the Great Plains, USA. Geoderma 125, 95–106.

Jacobs, P.M., Mason, J.A., 2007. Late Quaternary climate change, loess sedimentation, and soil profile development in the central Great Plains: a pedosedimentary model. Geological Society of America Bulletin 119, 462–475.

Johnson, E., 1986. Late Pleistocene and early Holocene vertebrates and paleoenvironments on Southern High Plains, U.S.A. Géographie physique et Quaternaire 40 (3), 249–261.

Johnson, E., 1987a. Vertebrate remains. In: Johnson, E. (Ed.), Lubbock Lake: Late Quaternary Studies on the Southern High Plains. Texas A&M University Press, College Station, pp. 49–89.

Johnson, E., 1987b. Paleoenvironmental overview. In: Johnson, E. (Ed.), Lubbock Lake: Late Quaternary Studies on the Southern High Plains. Texas A&M University Press, College Station, pp. 90–99.

Johnson, W.C., Willey, K.L., 2000. Isotopic and rock magnetic expression of environmental changes at the Pleistocene-Holocene transition in the central Great Plains. Quaternary International 67, 89–106.

Kennett, J.P., Elmstron, K., Penrose, N., 1985. The last deglaciation in the Orca Basin, Gulf of Mexico: high-resolution planktonic foraminiferal changes. Palaeogeography, Palaeoclimatology, Palaeoecology 50, 189–216.

Koch, P.L., Diffenbaugh, N., Hoppe, K., 2004. The effects of late Quaternary climate and pCO_2 change on C4 p.ant abundance in the south-central United States. Palaeogeography, Palaeoclimatology, Palaeoecology 207, 331–357.

Kochel, R.C., Baker, V.R., Patton, P.C., 1982. Paleohydrology of southwestern Texas. Water Resources Research 18, 1165–1183.

Leventer, A., Williams, D.F., Kennett, J.P., 1982. Dynamics of the Laurentide ice sheet during the last deglaciation: evidence from the Gulf of Mexico. Earth and Planetary Science Letters 59, 11–17.

Madole, R.F., 1995. Spatial and temporal patterns of late Quaternary eolian deposition, eastern Colorado, U.S.A. Quaternary Science Reviews 14, 155–177.

Mandel, R.D. (Ed.), 2000. Geoarchaeology of the Great Plains: a Historical Perspective. University of Oklahoma Press, Norman, p. 306.

Mandel, R.D., 2008. Buried Paleoindian-age landscapes in stream valleys of the Central Plains, USA. Geomorphology 101, 342–361.

Mandel, R.D., Hofman, J.L., 2003. Geoarchaeological investigations at the Winger site: a late Paleoindian bison bonebed in southwestern Kansas, U.S.A. Geoarchaeology 18, 129–144.

Mandel, R.D., Jacob, J.S., Nordt, L.C., 2007. Geomorphic investigations. In: Thoms, A.V., Mandel, R.D. (Eds.), Archaeological and Paleoecological Investigations at the Richard Beene Site, South-central Texas, Vol. I: Paleoecological Studies, Cultural Contexts, and Excavation Strategies. Report of Investigations 8. Texas A&M University, Center for Ecological Archaeology, pp. 27–59.

Mangerud, J., Andersen, S.T., Berglund, B.J., Donner, J.J., 1974. Quaternary stratigraphy of Norden, a proposal for terminology and classification. Boreas 3, 109–128.

Mann, D.H., Meltzer, D.J., 2007. Millennial-scale dynamics of valley fills over the past 12,000 ^{14}C years, northeastern New Mexico, USA. Geological Society of America Bulletin 119, 1433–1448.

Marlon, J.P., Bartlein, J., Walsh, M.K., Harrison, S.P., Brown, K.J., Edwards, M.E., Higuera, P.E., Power, M.J., Anderson, R.S., Briles, C., Brunelle, A., Carcaillet, C., Daniels, M., Hu, F.S., Lavoie, M., Long, C., Minckley, T., Richard, P.J.H., Scott, A.C., Shafer, D.S., Tinner, W., Umbanhowar, C.E., Whitlock, C., 2009. Wildfire responses to abrupt climate change in North America. Proceedings of the National Academy of Sciences 106, 2519–2524.

Mason, J.A., Jacobs, P.M., Hanson, P.R., Miao, X.D., Goble, R.J., 2003. Sources and paleoclimatic significance of Holocene Bignell loess, central Great Plains, USA. Quaternary Research 60, 330–339.

Mason, J.A., Miao, X.D., Hanson, P.R., Johnson, W.C., Jacobs, P.M., Goble, R.J., 2008. Loess record of the last glacial-interglacial transition on the northern and central Great Plains. Quaternary Science Reviews 27, 1772–1783.

Mayewski, P.A., Meeker, L., Whitlow, S., Twickler, M., Morrison, M., Alley, R., Bloomfield, P., Taylor, K., 1993. The atmosphere during the Younger Dryas. Science 261, 195–197.

McFaul, M., Traugh, K.L., Smith, G.D., Doering, W., 1994. Geoarchaeologic analysis of South Platte River terraces: Kersey, Colorado. Geoarchaeology 9, 345–374.

Meltzer, D.J., Holliday, V.T., 2010. Would North American Paleoindians have noticed Younger Dryas age climate changes? Journal of World Prehistory 23, 1–41.

Meltzer, D.J., 1991. Altithermal archaeology and paleoecology at Mustang Springs, on the southern High Plains of Texas. American Antiquity 56, 236–267.

Meltzer, D.J., 2006a. History of research on the Paleo-Indian. In: Ubelaker, D.H. (Ed.), Handbook of North American Indians. Volume 3: Environment, Origins, and Population. Smithsonian Institution, Washington, D.C, pp. 110–128.

Meltzer, D.J., 2006b. Folsom: New Archaeological Investigations of a Classic Paleoindian Bison Kill. University of California Press, Berkeley.

Menounos, B., Reasoner, M., 1997. Evidence for cirque glaciation in the Colorado Front Range during the Younger Dryas Chronozone. Quaternary Research 48, 38–47.

Miao, X.D., Mason, J.A., Johnson, W.C., Wang, H., 2007. High-resolution proxy record of Holocene climate from a loess section in southwestern Nebraska, USA. Palaeogeography, Palaeoclimatology, Palaeoecology 245, 368–381.

Muhs, D.R., Zarate, M., 2001. Late Quaternary eolian record of the Americas and their paleoclimatic significance. In: Markgraf, V. (Ed.), Interhemispheric Climate Linkages. Academic Press, California, San Diego, pp. 183–216.

Muhs, D.R., Stafford, T.W., Cowherd, S.D., Mahan, S.A., Kihl, R., Maat, P.B., Bush, C.A., Nehring, J., 1996. Origin of the late Quaternary dune fields of northeastern Colorado. Geomorphology 17, 129–149.

Nordt, L.C., 1995. Geoarchaeological investigations of Henson Creek: a low-order tributary in central Texas. Geoarchaeology 10, 205–221.

Nordt, L.C., 2001. Stable carbon and oxygen isotopes in soils: applications for archaeological research. In: Goldberg, P., Holliday, V.T., Ferring, C.R. (Eds.), Earth Sciences and Archaeology. Kluwer Academic/Plenum Publishers, New York, pp. 419–448.

Nordt, L.C., Boutton, T.W., Hallmark, C.T., Waters, M.R., 1994. Late Quaternary vegetation and climate changes in central Texas based on isotopic composition of organic carbon. Quaternary Research 41, 109–120.

Nordt, L.C., Boutton, T.W., Jacob, J.S., Mandel, R.D., 2002. C_4 plant productivity and climate-CO_2 variations in south-central Texas during the late Quaternary. Quaternary Research 58, 182–188.

Nordt, L., Von Fischer, J., Tieszen, L., 2007. Late Quaternary temperature record from buried soils of the North American great Plains. Geology 35, 159–162.

Nordt, L., Von Fischer, J., Tieszen, L., Tubbs, J., 2008. Coherent changes in relative C4 p.ant productivity and climate during the Late Quaternary in the North American great Plains. Quaternary Science Reviews 27, 1600–1611.

Paquay, F.S., Goderis, S., Ravizza, G., Vanhaecke, F., Boyd, M., Surovell, T., Holliday, V.T., Haynes, C.V., Claeys, P., 2009. Absence of geochemical evidence for an impact event at the Bølling–Allerød/Younger Dryas transition. Proceedings of the National Academy of Sciences 106, 21505–21510.

Painter, M.W., Holmes, A., McFaul, M., Zier, C.J., 1999. Environmental setting. In: Zier, C., Kalasz, S.M. (Eds.), Colorado Prehistory: a Context for the Arkansas River Basin. Colorado Council of Professional Archaeologists, Denver, pp. 45–114.

Patton, P.C., Dibble, D.S., 1982. Archeologic and geomorphic evidence for the paleohydrologic record of the Pecos River in west Texas. American Journal of Science 282, 97–121.

Pillans, B., 2007. Chronostratigraphy. In: Elias, S.A. (Ed.), Encyclopedia of Quaternary Science. Elsevier, NY, pp. 2811–2819.

Pinter, N., Scott, A.C., Daulton, T.L., Podoll, A., Koeverl, C., Anderson, R.S., Ishman, S.E. The Younger Dryas impact hypothesis: A requiem. Earth-Science Reviews, in press. doi:10.1016/j.earscirev.2011.02.005.

Roberts, H.M., Muhs, D.R., Wintle, A.G., Duller, G., Bettis, E.A., 2003. Unprecedented last glacial mass accumulation rates determined by luminescence dating of loess from western Nebraska. Quaternary Research 59, 411–419.

Ruddiman, W.F., McIntyre, A., 1981. The mode and mechanism of the last deglaciation: oceanic evidence. Quaternary Research 16, 125–134.

Sabin, T.J., Holliday, V.T., 1995. Morphometric and spatial relationships of playas and lunettes on the Southern High Plains. Annals of the Association of American Geographers 85, 286–305.

Scott, A.C., Pinter, N., Collinson, M.E., Hardiman, M., Anderson, R.S., Brain, A.P.R., Smith, S.Y., Marone, F., Stampanoni, M., 2010. Fungus, not comet or catastrophe, accounts for carbonaceous spherules in the Younger Dryas "impact layer". Geophysical Research Letters 37, L14302. doi:10.1029/2010GL043345.

Spero, H.J., Williams, D.F., 1990. Evidence for seasonal low salinity surface waters in the Gulf of Mexico over the last 16,000 years. Paleoceanography 5, 963–975.

Steffensen, J.P., Andersen, K.K., Bigler, M., Clausen, H., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M., Johnsen, S., Jouzel, J., Masson-Delmotte, V., Popp, T., Rasmussen, S., Rothlisberger, R., Ruth, U., Stauffer, B., Siggaard-Andersen, M.-L., Sveinbjörnsdóttir, A., Svensson, A., White, J.W.C., 2008. High-resolution Greenland ice core data show abrupt climate change happens in few years. Science 321, 680–684.

Surovell, T., Holliday, V., Gingerich, J., Ketron, C., Haynes, C.V., Hilman, I., Wagner, D., Johnson, E., Claeys, P., 2009. An independent evaluation of the Younger Dryas extraterrestrial impact hypothesis. Proceedings of the National Academy of Sciences 106, 18155–18158.

Taylor, K., Mayewski, P., Alley, R., Brook, E., Gow, A., Grootes, P., Meese, D., Saltzman, E., Severinghaus, J., Twickler, M., White, J., Whitlow, S., Zielinski, G., 1997. The Holocene-Younger Dryas transition recorded at Summit, Greenland. Science 278, 825–827.

Teller, J.T., 1990. Volume and routing of late-glacial runoff from the southern Laurentide ice sheet. Quaternary Research 34, 12–23.

Waters, M.R., Stafford Jr., T.W., 2007. Redefining the age of Clovis: implications for the peopling of the Americas. Science 315, 1122–1126.

Yu, Z., Wright Jr., H.E., 2001. Response of interior North America to abrupt climate oscillations in the North Atlantic region during the last deglaciation. Earth-Science Reviews 52, 333–369.