The Evolution of Paleoindian Geochronology and Typology on the Great Plains

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The Great Plains contain many of the best-known Paleoindian sites in North America, and a number of these localities were key to determining the chronology of Paleoindian occupations in the years before, during, and since the development of radiocarbon and other chronometric dating methods. Initial attempts at dating were based on correlation with extinct fauna, the "geologic-climatic" dating method, and stratigraphic relationships of artifacts within sites. By the time radiocarbon dating was developed (1950), the basic Paleoindian sequence (oldest to youngest) was: Clovis-Folsom-unfluted lanceolates (such as Plainview, Eden, and Scottsbluff). Initial applications of radiocarbon dating in the 1950s did little to further resolve age relationships. In the 1960s, however, largely through the efforts of C. V. Haynes, a numerical geochronology of Paleoindian occupations on the Great Plains began to emerge On the Southern Great Plains the radiocarbon-dated artifact chronology is: Clovis (11,600–11,000 yr B.P.); Folsom and Midland (10,900–10,100 yr B.P.); Plainview, Milnesand, and Lubbock (10,200–9800 yr B.P.); Firstview (9400–8200 yr B.P.); St. Mary's Hall, Golondrina, and Texas Angostura (9200–8000 yr B.P.). The chronology for the Northern Great Plains is: Clovis (11,200–10,900 yr B.P.); Goshen (ca. 11,000 yr B.P.); Folsom (10,900–10,200 yr B.P.); Agate Basin (10,500–10,000 yr B.P.); Hell Gap (10,500–9500 yr B.P.); Alberta, Alberta-Cody (10,200–9400 yr B.P.); Cody (Eden-Scottsbluff) (9400–8800 yr B.P.); Angostura, Jimmy Allen, Frederick, and other parallel-oblique types (9400–7800 yr B.P.). Fifty years after the development of radiocarbon dating, the basic typological sequence has not changed significantly except for the realization that there probably was significant temporal overlap of some point types, and that the old unilinear sequence does not account for all the known typological variation. The chronology has been continually refined with the determination of hundreds of radiocarbon ages in recent decades. © 2000 John Wiley & Sons, Inc.

INTRODUCTION

A fundamental issue in and perhaps a characteristic of archaeology is chronology (e.g., O'Brien and Lyman, 1998:1). "How old is it" or "is it older than or younger than" something else are routine and recurring questions. Geoarchaeology has long been one method for answering these sorts of questions. Throughout the history of archaeology, geoscientists were (and still are) involved in applying basic stratigraphic principles as a means of dating, and in the past four or five decades, geoscientists have applied various numerical geochronologic methods in archaeology (e.g., Zeuner, 1958; Taylor and Aitken, 1997). In North American archaeology, perhaps no other cultural period has been dominated by the question of "how old is

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it?" than Paleoindian. In part, this is due to its great antiquity and due to historic debates on the peopling of the new world (e.g., Haynes, 1992; Meltzer, 1993). There has also been considerable interest in relating if not linking the Paleoindian record to dramatic events of the terminal Pleistocene and early Holocene such as climate changes, the waning of ice sheets, and megafauna extinction.

Within North America, the Great Plains contain many of the best-known Paleoindian sites (e.g., Wormington, 1957; Hofman, 1989, 1996; Frison, 1991; Holliday, 1997). Moreover, many of these sites played important roles in establishing our views, accurate or otherwise, of the subsistence, mobility, and artifact types of these earliest occupants of North America. A number of Great Plains sites were also key to determining the chronology of Paleoindian occupations in the years before, during, and since the development of radiocarbon and other chronometric dating methods (Mandel, in press). This article focuses on the evolution of Paleoindian research in terms of relative and numerical artifact chronologies on the Great Plains, application of geoarchaeology and the radiocarbon method to research on the chronology, current views on Paleoindian chronology, and continuing problems regarding this chronology as well as the application of numerical dating methods to these problems. These discussions are warranted because of the role of Great Plains Paleoindian studies in North American archaeology and because issues of chronology, association, and sampling continue to be important and often problematic in Paleoindian and late Quaternary research on the Plains and elsewhere.

This article provides a look at the key sites and studies that contributed to our understanding of the Paleoindian chronology. For discussion of Paleoindian geoarchaeology on the Great Plains, see Mandel (in press). Much of the emphasis in this article is on artifact (mainly projectile point) typology and chronology, which is typical of Paleoindian studies because there are few other diagnostic traits (e.g., Wormington, 1957; Hofman, 1989, 1996; Frison, 1991). Some of the discussion also focuses on issues of site stratigraphy. As outlined below, the basic Paleoindian chronology of the Great Plains was established prior to the development of radiocarbon dating. Instead, it was based on the most fundamental archaeological and geological principles, stratigraphy, including both the stratigraphic relationships of artifact types as well as the association of artifacts with fauna, and correlation of these to glacial/interglacial cycles. Almost 50 years after the initial development of radiocarbon dating, basic stratigraphic associations of artifact types within and between archaeological sites is still at the heart of chronology building.

There have been a number of compilations of Paleoindian date lists going back to the earliest days of the radiocarbon method (e.g., Roberts, 1951). Some of the date lists focus on specific subregions or states on the Great Plains (e.g., Greiser, 1985; Hofman, 1989, 1996; Frison, 1991), and others deal with specific subperiods of the Paleoindian occupation of North America (e.g., Haynes, 1992, 1993; Haynes et al., 1992a). A few compilations have attempted coverage of most dated sites or most subperiods throughout the continent (Haynes, 1967; Bonnichsen et al., 1987). The compilation presented here is unique in that it focuses on the entire Great

Plains and is an attempt to organize all published, reliable radiocarbon ages from Paleoindian occupations.

This article includes discussion of the developments in Paleoindian chronology on the Great Plains from the Folsom discovery to the 1960s, when the basic outline of the typological sequence was established, a summary of the chronology as it stands today, and concludes with comments on problems and issues remaining in further refining the chronology. Several tables (I–XI) were prepared to facilitate the discussion. Table I lists excavations by site that contributed to an understanding of the Paleoindian chronology. It is not a review of all Paleoindian research, but a listing of the work that provided either relative or numerical age control. Primary references to specific radiocarbon ages are given in Tables II–XI. Most assays from the 1950s and 1960s appeared in date lists published by the laboratories (usually in *Science* or *Radiocarbon*). By the 1970s, however, many radiocarbon laboratories ceased publishing date lists, and some of the laboratories involved in Paleoindian studies ceased functioning altogether. Tracking down primary references and pertinent data for specific radiocarbon ages is more difficult for dates published in the 1970s and later. Several tables (II, IIIA, IVA, V, VIA, VIC, VIIIA, IXA) were assembled to provide context for an assessment of the chronology as it stood in the 1960s. Tables IIIB, IVB, IVC, VIB, VII, VIIIB, X, and XI provide the basis for a current interpretation of the Paleoindian chronology. With a few exceptions, the acceptance or rejection of specific radiocarbon ages is based on the interpretations of the principal investigators and the geochronologists involved in dating the sites. Radiocarbon ages determined on problematic materials (e.g., bone not dated by AMS using specific amino acids, shell in limestone landscapes, solid carbon in the original Libby method) are not included. Only sites on the Great Plains (as defined below) are included, that is, no sites in the mountains immediately to the west (e.g., Indian Creek, Anzick, and MacHaffie in Montana, Owl Cave in Idaho, Sandia in New Mexico) are included.

For the purposes of this article, the Great Plains is defined more broadly than is usual in a strict physiographic sense (e.g, Hunt, 1974; Osterkamp, 1987). The term Great Plains will refer to the Great Plains proper (Fenneman, 1931), extending from the Edwards Plateau in the south, through the High Plains to the Missouri Plateau (Figure 1), the Wyoming Basin, and the western Rolling Plains section of the Central Lowlands (west of the Mississippi River) (Figure 1).

HISTORICAL PERSPECTIVE

Paleoindian studies on the Great Plains of North America are rooted in issues of chronology. The initial question was: Were humans in North America during the late Pleistocene or were they relative late-comers, preceding Europeans by just a few millennia? Once that issue was solved, most Paleoindian research focused on the stratigraphic relationships of artifacts types, environmental reconstructions of Paleoindian sites and periods, and numerical age estimation of sites and artifact

Table I. Archaeological investigations on the Great Plains that influenced the development of the Paleoindian chronology, 1926–1980 (see Figure 1 for site locations).

Years	Site	References[a]
1926–1928[b]	Folsom, NM	Cook, 1927, 1928; Figgins, 1927
1930–1931	Yuma Co., CO	Renaud, 1931, 1932
1932, 1973, 1992	Dent, CO	Figgins, 1933; Haynes, 1974; Haynes et al., 1998
1932–1935	Scottsbluff, NE	Barbour & Schultz, 1932 Schultz & Eiseley, 1935
1933–1937, 1949–1950, 1953–1957, 1958, 1961–1964[c], 1983–1984	Clovis, NM	Cotter, 1937, 1938; Haynes, 1975, 1995 Haynes & Agogino, 1966; Hester, 1972 Howard, 1935a,b; Sellards, 1952
1934–1940	Lindenmeier, CO	Bryan & Ray, 1940; Haynes & Agogino, 1960 Roberts, 1935, 1936, 1937, 1938, 1941[d] Wilmsen & Roberts, 1978
1934, 1937, 1990	Miami, TX	Holliday et al, 1994; Sellards, 1938, 1952
1939, 1946, 1988–1991	Lipscomb, TX	Barbour & Schultz, 1941; Hofman, 1995 Hofman et al., 1989; Schultz, 1943
1930s,[e] 1998–present	Nall, OK	Baker et al., 1957; LaBelle, 1999
1940, 1941, 1946, 1947[f]	Finley, WY	Hack, 1943; Howard, 1943; Moss, 1951 Satterthwaite, 1957
1941, 1943, 1947,[f] 1961–1962, 1993–1998	San Jon, NM	Harbour, 1975; Hill et al., 1995; Judson, 1953 Roberts, 1942
1942, 1959,[g] 1961, 1972, 1975–1980	Agate Basin, WY	Agogino, 1972; Agogino & Frankfortner, 1960 Frison & Stanford, 1982; Roberts, 1961
1945	Plainview, TX	Holliday, 1997; Sellards et al., 1947
1947–1949[h]	Allen, NE	Bamforth, 1991; Holder & Witke, 1949
1947, 1949, 1950[h]	Lime Creek, NE	Davis, 1953, 1962; Bamforth, 1991
1947, 1949, 1952[h]	Red Smoke, NE	Davis, 1953; Bamforth, 1991
1948, 1949, 1950, 1985, 1987, 1992	Ray Long, SD	Hannus, 1986; Hughes, 1949 Wheeler, 1954, 1995
1948, 1950, 1951, 1959, 1960, 1973–present	Lubbock Lake, TX	Green, 1962; Johnson, 1987; Sellards 1952
1949, 1950, 1951, 1953, 1977, 1978	Horner, WY	Frison & Todd, 1987; Jepson, 1953
1951, 1953, 1954	James Allen, WY	Mulloy, 1959
1953, 1995, 1996	Milnesand, NM	Holliday, 1997; Sellards, 1955 Warnica & Williamson, 1968
1953, 1954, 1955, 1989–1991	Midland, TX	Holliday & Meltzer, 1996 Wendorf & Krieger, 1959; Wendorf et al., 1955
1953, 1975	Claypool, CO	Dick & Mountain, 1960 Stanford & Albanese, 1975
1956	Lewisville, TX	Crook & Harris, 1957, 1958
1958, 1960	Olsen-Chubbuck, CO	Wheat, 1972
1959, 1960, 1974	Levi Rockshelter, TX	Alexander, 1963, 1982
1959, 1961–1962, 1967	Devil's Mouth, TX	Johnson, 1964; Sorrow, 1968
1960s, 1970s[i]	Horn Shelter, TX	Forrester, 1985; Redder, 1985; Watt, 1978
1959–1966[i]	Hell Gap, WY	Haynes, 1967; Irwin-Williams et al., 1973
1960, 1961	Sister's Hill, WY	Agogino & Galloway, 1965 Haynes & Grey, 1965

Table I. *(Continued)*

Years	Site	References[a]
1961, 1962, 1980, 1981	Lamb Spring, CO	Rancier et al., 1982; Stanford et al., 1981 Mandryk, 1998
1962	Domebo, OK	Leonhardy, 1966
1962, 1976	Baker Cave, TX	Hester, 1982; Word & Douglas, 1970
1963, 1982–1984	Bonfire, TX	Bement, 1986; Dibble & Lorraine, 1968
1963, 1964, 1975, 1987, 1988	Fletcher, Alberta	Forbis, 1968 Vickers & Beaudoin, 1989
1966, 1967	Frazier, CO	Wormington, 1984
1968, 1970	Jurgens, CO	Wheat, 1979
1968, 1978	Loeve, TX	Prewitt, 1982
1968	Sutter, KS	Katz, 1971, 1973
1971	Casper, WY	Frison, 1974
1971–1975, 1976	Hudson-Meng, NE	Agenbroad, 1978
1973, 1975	Hanson, WY	Frison & Bradley, 1980
1973–1975	Jones-Miller, CO	Stanford, 1978, 1984
1974–1977	Lake Theo, TX	Harrison & Killen, 1978; Harrison & Smith, 1975 E. Johnson et al., 1982
1976–1977	Carter/Kerr-McGee	Frison, 1984
1979, 1980	Frasca, CO	Fulgham & Stanford, 1982
1980, 1984	Lange-Ferguson, SD	Hannus, 1989, 1990
1988–1989	Aubrey, TX	Ferring, 1995
1982–1984, 1992	Wilson-Leonard, TX	Collins et al., 1993; Masson & Collins, 1995
1990–1991	Richard Beene, TX	Thoms, 1992, 1993; Thoms & Mandel, 1992
1991, 1992, 1993	Waugh, OK	Hofman, 1995; Hill & Hofman, 1997
1992	Horace Rivers, TX	Mallouf & Mandel, 1997
1992, 1993	Norton, KS	Hofman et al., 1995; Hofman, 1996
1994, 1995	Hausman Road, TX	Tennis, 1996

[a] References refer to Paleoindian investigations at the respective sites; references to specific radiocarbon ages are in Tables II–XI. Additional references on most of these sites are presented by Frison (1991), Frison et al. (1996), Hofman (1989, 1996), and Holliday (1997).

[b] Additional geoarchaeological investigations were conducted 1970–1971 by Anderson and Haynes (1979), and collection of radiocarbon samples occurred sporadically in the years that followed, resulting, for example, in the radiocarbon ages reported by Haynes et al. (1992a).

[c] Sporadic excavations by G. Agogino and students from Eastern New Mexico University were conducted at Clovis from 1964 until the early 1970s.

[d] These are a few of a number of papers on the Lindenmeier excavations by Roberts; see Wilmsen and Roberts (1978) for a complete list.

[e] An extensive collection of artifacts was acquired from the surface of the site over a period of some years.

[f] The 1947 work at Finley and the 1943 and 1947 work at San Jon were only geologic.

[g] The 1959 work was at the Brewster site; the Agate Basin type was formalized by Wheeler (1954).

[h] Further paleoenvironmental, geoarchaeological, and geochronological investigations of the Medicine Creek sites were carried out 1989–1994 (Bamforth, 1991; unpub. data).

[i] The Horn Shelter work was carried out by local avocational archaeologists working on weekends over a period of some years.

[j] Work was renewed at Hell Gap in the late 1990s, largely focused on understanding the stratigraphy and the results of the initial investigations (G. Frison, pers. commun., 1997).

Figure 1. The Great Plains with the locations of all Paleoindian sites mentioned in text and tables, the location of selected cities (A Austin; D Denver; DC Dodge City; NP North Platte; OC Oklahoma City; R Rapid City), and principal physiographic features and provinces. Archaeological sites are numbered from north to south, grouped by state: *Montana* 1 Mill Iron; Fletcher, in Alberta, Canada, is ~650 km northwest of Mill Iron; *Wyoming* 2 Horner, 3 Hanson, 4 Colby, 5 Little Canyon Creek Cave, 6 Sister's Hill, 7 Carter/Kerr-McGee, 8 Casper, 9 Agate Basin (including Sheaman and Brewster), 10 Hell Gap, 11 Finley, 12 James Allen; *South Dakota* 13 Ray Long, 14 Lange-Ferguson; *Nebraska* 15 Hudson-Meng, 16 Scottsbluff, 17 Medicine Creek (including Lime Creek, Red Smoke, and Allen); *Colorado* 18 Lindenmeier, 19 Frasca, 20 Frazier, 21 Jurgens, 22 Dent, 23 Lamb Spring, 24 Claypool, 25 Jones-Miller, 26 Olsen-Chubbuck (area indicated with broken line is Yuma County); *Kansas* 27 Norton, 28 Sutter; *New Mexico* 29 Folsom, 30 San Jon, 31 Clovis, 32 Anderson Basin; *Oklahoma* 33 Nall, 34 Waugh, 35 Domebo; *Texas* 36 Lipscomb, 37 Horace Rivers, 38 Miami, 39 Plainview, 40 Lake Theo, 41 Ryan, 42 Lubbock Lake, 43 Midland, 44 Aubrey, 45 Lewisville, 46 Horn Shelter, 47 Wilson-Leonard, 48 Loeve, 49 Levi, 50 Bonfire Shelter, 51 Baker Cave, 52 Devil's Mouth, 53 Hausman Road, 54 Richard Beene.

types, three issues that often were closely linked (see historical discussions by Hofman, 1989, 1996; Frison et al., 1996; Mandel, in press). The advent of numerical dating methods, radiocarbon in particular, allowed chronological issues to be addressed independently from paleoenvironmental or typological ones. Many fundamental questions about the Great Plains Paleoindian chronology remain. The following sections present a sketch of the evolution of the Great Plains Paleoindian chronology. Table I lists all sites mentioned, the years field work was conducted, and key references. This information is not specifically referred to in the text, but provides the historical context for the discussion which follows.

1926–1950

Debate over the antiquity of humans in North America raged among geologists, paleontologists, and anthropologists in the decades of the late 19th and early 20th centuries (Meltzer, 1983, 1991, 1994). The issue was finally resolved with excavations at the Folsom site, New Mexico (Table I, Figure 1), in the late 1920s (Table I). Work at that site demonstrated that humans had been in North America since late Pleistocene times by clearly documenting the association of artifacts with extinct bison. The site also gave its name to the distinctive, finely made, fluted, lanceolate Folsom projectile points found with the bone.

Antiquity of the Folsom site was demonstrated on the basis of criteria first formally articulated by T. C. Chamberlin (1903) but most forcefully applied by physical anthropologist Aleš Hrdlička, a leading figure in the debate over early human occupation in North America. He argued that the antiquity of human remains must be based, in part, on "indisputable stratigraphical evidence" (Hrdlička, 1907:98), or "that the specimens were found in geologically ancient deposits whose age is confirmed by the presence of paleontological remains" (Hrdlička, 1912:2) along with other criteria (also see Meltzer, 1983, 1994). Although Hrdlička, who focused his attention on the antiquity of human skeletal remains, came to distrust geological evidence of antiquity in favor of criteria such as fossilization and morphometrics (Meltzer, 1994:13), his demands for solid stratigraphic evidence and clear paleontologic associations became the basis for confirming the age of Folsom and remained an important component of dating Paleoindian finds for decades.

Additional incontrovertible support for the association of human artifacts with Pleistocene fauna appeared repeatedly in the years from 1927 to the early 1940s. Indeed, the initial discoveries of many Paleoindian sites were by paleontologists who first recognized extinct megafauna and then found associated artifacts. Fluted points were found with the bones of extinct bison at the Lindenmeier site, Colorado, the Clovis site, New Mexico, and the Lipscomb site, Texas (Table I, Figure 1). Moreover, fluted projectile points also were discovered in association with the remains of extinct mammoth, first at the Dent site, Colorado, then at the Clovis site, New Mexico, and the Miami site, Texas (Table I, Figure 1), and well-made, lanceolate, but unfluted projectile points were found associated with extinct bison at the Meserve and Scottsbluff sites, Nebraska, Finley, Horner, and Agate Basin sites, Wyoming, and San Jon, New Mexico (Table I, Figure 1). In addition, large collections of fluted and unfluted lanceolate points came to light from extensive surface sites in Yuma County, northeastern Colorado (Table I). The typology of these artifacts and the recovery of some remains of extinct fauna all suggested some antiquity, although none were found in firm stratigraphic contexts.

With the rapid appearance of these varied artifact types and faunal associations came the vexing problem of sorting out the cultural and age relationships of the artifacts and the sites. Some of these problems remain, as noted below, but several fundamental typological and chronological patterns emerged. The initial issue was the relationship between the fluted and unfluted variants, the so-called "Folsom-Yuma problem" (e.g., Howard, 1943). Beginning with the Folsom discovery and through the 1930s, most fluted points were referred to as "Folsom," "Folsom-like," "Folsomoid," or "Generalized Folsom" (Wormington, 1957:30). By the late 1930s, however, the typological and chronological distinctions between Clovis and Folsom were all but formalized, based on excavations at the Clovis site.

> [I]t is evident that the...points associated...with mammoth bones were typically long and heavy for the Folsom pattern, with very slight channeling at the base. ...finds made in the [overlying]...clay associated with bison bones were typically of a slighter design, with and without channeling." (Cotter, 1938:117).

The various unfluted lanceolate artifacts were first identified by the catch-all term "Yuma" on the basis of the finds in Yuma County, Colorado (Renaud, 1931, 1932). A subsequent study of these extensive collections led to the proposal of three categories, based on flaking characteristics: "oblique Yuma," "collateral Yuma," and "indeterminate Yuma" (Wormington, 1939). The age of the Yuma artifacts remained unclear for some time, however, and as late as the mid 1940s some believed the unfluted lanceolate points to span the Holocene and "their presence in a collection may mean little from the standpoint of age" (Roberts, 1944:407).

In 1941 a symposium on Paleoindian artifact terminology and typology was held in Santa Fe, New Mexico, sponsored by the University of Pennsylvania Museum and the Laboratory of Anthropology (Ray, 1942; Howard, 1943; Wormington, 1948, 1949:51–53). One goal of the meeting was to differentiate the various fluted types; thus the Folsom and Clovis types were defined. The Santa Fe Conference also resulted in an early systematic attempt to differentiate the many unfluted lanceolate points. The catch-all "Yuma" category was discarded, and new classifications were designated on the basis of type collections. Among the "collateral Yuma" types, two specific types were identified: the ″Eden Yuma," named for artifacts from the Finley site, near Eden, Wyoming (Table I, Figure 1) and the "Scottsbluff Yuma," named for projectile points from the Scottsbluff site, Nebraska (Table I, Figure 1). Wormington (1948, 1949:51–53) subsequently proposed abandoning the term "Yuma" altogether, replacing it with "Parallel Flaked." The Eden Yuma became simply the Eden point, and likewise the Scottsbluff Yuma became the Scottsbluff point. Other specific types would be identified as appropriate type collections were found (e.g., Plainview and Jimmy Allen).

The finds at Folsom and elsewhere in the 1930s significantly expanded the time depth for the human occupation of the Americas, but stratigraphic relationships of artifact types and their numerical ages remained unclear. Prior to the development of radiocarbon and other numerical dating methods, there were essentially two basic approaches to dating Paleoindian sites: (1) paleontological correlation based on stratigraphy and the association of artifacts with extinct Pleistocene fauna (following the criteria of Chamberlin, 1903, and Hrdlička, 1907, 1912), and (2) stratigraphic or "geologic-climatic dating." The association of artifacts with extinct fauna provided the most common means of dating early sites. This was the method for initial dating of the Folsom site and most other Paleoindian localities in the 1930s and 1940s. Once the association of various fluted and unfluted points with extinct vertebrates was well established, these artifacts became "index fossils" themselves and were used to infer the age of other sites in the absence of paleontological associations (e.g., the Yuma County finds).

Geologic-climatic dating was applied to several Paleoindian sites on the Great Plains following the Folsom discoveries. Ernst Antevs, a key contributor in dating Pleistocene sections in the early decades of Paleoindian studies (Haynes, 1990), succinctly outlined the steps in geologic-climatic dating: "1) study of beds and geologic features, 2) climatic interpretation of beds and features, 3) assignment of the bed with the human record to a particular regional climatic age or phase, 4) correlation of the regional relative chronology with a dated climatic history" (Antevs, 1955:317; see also Zeuner, 1958:20–36; Oakley, 1964:51–57). This approach was viewed as most effective in settings where the stratigraphy or geomorphology could be directly traced to glacial deposits or landforms. The local glacial chronology was then correlated to a varve chronology defined for northeastern North America by Antevs (1925, 1928, 1931; summarized by Zeuner, 1958:33–36, and Haynes, 1990). The method, therefore, could not be applied in all situations. The Folsom site, for example, was not in a setting that lent itself easily to geologic-climatic dating; it is in a small tributary of an unglaciated stream (but see Bryan, 1937).

Perhaps the best known application of geologic-climatic dating is the classic study of Bryan and Ray (1940) attempting to date the Folsom occupations excavated by Frank H. H. Roberts at the Lindenmeier site (Table I, Figure 1) (see also Haynes, 1990:58–59, 1992:356–357). The site is in a small, dry, low-order tributary of the Cache La Poudre River, entering the river near its confluence with the South Platte. The strata at Lindenmeier could not be traced directly to the Cache La Poudre, so a correlation was made between the Folsom material in the site and the terrace of the South Platte that contained the fluted Clovis points and mammoth at the Dent site (at the time of their work, the typological and chronological distinction between Folsom and Clovis artifacts had not been made) (Figure 1). The workers then traced the terraces from the South Platte into the Cache La Poudre and up its valley to the glacial landforms and deposits in the headwaters of the drainage in the Rocky Mountain Front Range. They then correlated the local glacial sequence with Antevs' varve chronology. Based on these long distance correlations, they decided that the Folsom material at Lindenmeier was between 25,000 and 10,000 years old, most likely closer to the older age. Antevs (1941) disagreed with their correlations and believed that the Folsom material was closer to 10,000 years old.

Geologic-climatic dating was also used to date artifacts at the Clovis and Finley sites. At the Clovis site, in the first attempt at applying geologic-climatic dating in Paleoindian studies, Antevs (1935, 1949; see also Haynes, 1990:57) correlated the deposits containing fluted points (the "Clovis formation," with both Clovis and Folsom artifacts) and extinct fauna with the lake level history of pluvial Lake Estancia in central New Mexico. In the final version of his chronology, Antevs (1949: 190) proposed "... that the Estancia Pluvial culminated sometime 12,000 to 13,000 years ago. The Clovis formation represents the time from somewhat before to somewhat after this pluvial maximum. The artifacts...therefore appear to be at most 13,000 and at least 10,000 years old." Hack (1943) and Moss (1951) attempted to date the Eden artifacts at the Finley site, which was in eolian sand resting atop a terrace of the Eden Valley. The terrace was traced upstream to the moraines of the nearby Wind River Range. The investigators correlated the terrace below the Finley bone bed and its equivalent moraine system in the Wind Rivers with the terrace-moraine system that Bryan and Ray (1940) considered to be of Folsom age. Thus, the Finley artifacts were believed post-Folsom in age. Moreover, Moss (1951, 1952) argued that the sands with the artifacts predated the Climatic Optimum or "Altithermal" of Antevs (1948) (7500–5000 yr B.P.). The Eden artifacts from Finley were therefore dated to between 10,000 and 7,500 years old, and probably were ca. 9000-7000 yr B.P. (Moss, 1951:80–81).

The years following the Second World War saw a resurgence of Paleoindian studies on the Great Plains, and there were a number of significant developments regarding artifact typology, artifact chronology, and numerical dating. The excavation of new sites and renewed analysis of pre-war finds resulted in the identification of a number of new artifact types, including Plainview, Agate Basin, Angostura, Jimmy Allen, Milnesand, and Midland (Table I, Figure 1). Perhaps more significantly, the chronological relationships of Clovis, Folsom, and the unfluted lanceolate points were clarified by renewed work at the Clovis site. Clues about the relationship of Folsom to Clovis could be found in the earlier work at Clovis (Cotter, 1938), as quoted above, but the relationship otherwise remained unclear. The correlation of the Lindenmeier Folsom occupation with the Dent Clovis finds by Bryan and Ray (1940) influenced others to consider Clovis and Folsom as essentially contemporaneous (e.g., Wormington, 1949:38). The 1949–1951 work at the Clovis site, however, clearly showed that Folsom was younger than Clovis (Sellards, 1952:58).

There were several clues to the relationship of Folsom to the unfluted lanceolates, including the work of Hack (1943) and Moss (1951) for the Finley site Eden artifacts. Paleontological associations suggested that Folsom artifacts were older (Wormington, 1949:60–61). At Lindenmeier, Roberts (1937) noted the presence of "Yuma" (unfluted lanceolate) artifacts coming from the "overburden" that was removed to reach the Folsom deposits (see also Wilmsen and Roberts, 1978:60–62). Roberts (1942:8–10) also believed that "Eden Valley Yuma" occurred above Folsom at the San Jon site and that his type San Jon artifact was contemporaneous with Folsom, but the stratigraphic relationships were far from clear (e.g., Wormington, 1957:122–123; Wheat, 1972:143). At the Clovis site, however, extensive beds of extinct bison were found that contained a variety of unfluted lanceolate points (grouped as the "Portales Complex") (Sellards, 1952:74). These features clearly overlay Folsom bone beds, thus demonstrating their stratigraphic relationships.

The 1950s: Radiocarbon, Fluted Points, and Controversy

At about the same time that Sellards renewed work at the Clovis site (1949–1951) and Moss (1951) was drawing his conclusions about the age of the Finley site, the radiocarbon method became available for numerical dating of archaeological sites. Arguably, the development of this method was one of the most significant steps in Paleoindian studies following the Folsom finds (Wilmsen, 1965:185). This technique evolved in the years just after the Second World War (Taylor 1985, 1987: 147–170; Arnold, 1992). By 1949, its inventor, Willard F. Libby, was prepared to start dating materials of unknown age. In order to secure samples, a group of collaborators in archaeology and geology was selected by the "Committee on Carbon 14" of the American Anthropological Association and the Geological Society of America (Arnold and Libby, 1949:680; Griffin, 1949; F. Johnson, 1951; Taylor, 1987:166). The collaborators were responsible for obtaining samples that addressed specific regional or chronological issues. One of the specific dating issues was "Early Man," and the principal collaborator in charge of generating these samples was Frank H. H. Roberts (Arnold and Libby, 1949:680; Griffin, 1949). The result was the dating of samples from eight sites on the Great Plains (Arnold and Libby, 1951; Roberts, 1951; Libby, 1952a, 1952b, 1955): Horner, Wyoming; Ray Long, South Dakota; Lime Creek, Allen, and Red Smoke, Nebraska; Lindenmeier, Colorado; Folsom, New Mexico; and Lubbock Lake, Texas (Tables I, II, Figure 1).

The charcoal samples from Folsom (C-377) and Lindenmeier (C-451) were not associated with the Paleoindian levels, both coming from post-Paleoindian channel fills. The sample from Lindenmeier apparently was known to postdate the Folsom occupation when it was dated (based on comments by Libby, 1952b:678; see also Wilmsen and Roberts, 1978:39–40), providing an age "approximately half that of the...Folsom material" (Libby, 1952b:678), which turned out to be a surprisingly accurate assessment for Folsom. The sample from the Folsom site, however, was initially believed to come from below the Folsom level (see description for C-377 in Arnold and Libby, 1950:10), but the resulting radiocarbon age of 4283 $\pm$ 250 yr B.P. seemed too young so Harold Cook, excavator of the Folsom site, revisited the locality and determined that the charcoal stratigraphically was post-Folsom (Roberts [1951:20] and, as noted for C-377 by Arnold and Libby [1951:116]). The process of questioning and reevaluating the stratigraphic integrity of radiocarbon ages from Paleoindian sites, to be repeated many times in subsequent decades, was thus established in the first years of the method (Taylor, 1985:316).

Table II. Radiocarbon ages for Paleoindian sites produced by Willard Libby and colleagues, University of Chicago, 1949–1954.[a]

Lab No.	Sample Age[b]	Site[c]	First Reference[d]	Material[e]
C-65	5256 ± 350	Medicine Ck, Ft-50, NE (“soil bands A and B” Allen site)	Arnold & Libby, 1951	Charcoal
C-108a	8274 ± 500	Medicine Ck, Ft-50, NE (“soil B” Allen site)	Arnold & Libby, 1951	Charcoal
C-302[f]	6619 ± 350 7132 ± 350 *av.* 6876 ± 250	Yuma, Sage Ck, WY (Horner site)	Arnold & Libby, 1951	Partially burned bison bone
C-454	7715 ± 740	Angostura Reservoir, SD (Ray Long site)	Arnold & Libby, 1951	Charcoal
C-470	10,493 ± 1500	Medicine Ck, Ft-50, NE (Allen site)	Arnold & Libby, 1951	Charcoal
C-471	9880 ± 670 9167 ± 600 *av.* 9524 ± 450	Lime Ck, Ft-41, NE	Arnold & Libby, 1951	Charcoal
C-558[g]	9883 ± 350	Lubbock, TX (Lubbock Lake)	Libby, 1952a	Burned bison bone
C-604	7073 ± 300	Long Site, SD (Ray Long)	Libby, 1952a	Charcoal
C-795[f]	6151 ± 500 7690 ± 850 *av.* 6920 ± 500	Horner Site, WY	Libby, 1955	Charcoal
C-824	*8570 ± 300* *9153 ± 600* *av.* 8862 ± *230*	Red Smoke Site, NE	Libby, 1955	Charcoal

[a] Samples C-377 (Arnold and Libby, 1951) from the Folsom site and C-451 (Libby, 1955) from the Lindenmeier site are not included because they were not from the Paleoindian levels.
[b] Some samples were subjected to two “runs.” “These runs were completely independent, involving separate portions of the original sample from which the carbon had been extracted independently, unless the dates are linked together with a brace. In this case, the results are those obtained by remeasurement of a given sample, usually in a different counter, and frequently involving re-extraction of the sample with acid” (Libby, 1955:76). The “brace” refers to the typographical symbol { in the date lists presented by Libby (1952a, 1955). Here the dates in italics are those linked by a brace in the original publication.
[c] Site names are as originally published in the date lists; correct site names are in ( ).
[d] All of the dates published by Arnold and Libby (1951) also appeared in Arnold and Libby (1950). The 1950 publication is simply a date list issued by the Institute for Nuclear Studies of the University of Chicago. The 1951 article is the first widely published date list, appearing in the journal *Science.* Samples published by Arnold and Libby (1951) were subsequently published by Libby (1952a, 1955). Samples first published by Libby (1952a, 1952b) were subsequently published by Libby (1955).
[e] Materials dated are as described in date lists.
[f] Also listed in Table IXA.
[g] Also listed in Table IIIA.

In the decade or so following the first applications of radiocarbon dating, more samples from more sites were dated by Libby and by new labs set up in the 1950s. There also were several technological advances such as switching from the solid-carbon to the proportional gas method (Taylor, 1987:168). Relatively few samples, by today's standards, were dated, however. Much also remained to be learned about the vagaries of dating various materials, about variation in radiocarbon production, and the isotopic fractionation of radiocarbon in plants. Indeed, the realization of these vagaries during the first few years that radiocarbon dating was applied in archaeology probably contributed to some suspicion of the method and hesitation in its application (Taylor, 1985:317–320). Through the 1950s, therefore, the geologic-climatic method remained a standard procedure for dating (e.g., Hurt, 1953; Wormington, 1957:15; Miller, 1958); indeed, the classic article on the method (Antevs, 1955) appeared at this time. In retrospect, not until the 1960s did a reasonably accurate, though still incomplete, picture of the Great Plains Paleoindian chronology emerge. The initial resolution of the chronology was largely due to the efforts of C. Vance Haynes, Jr, who, beginning in the late 1950s, attempted to systematically date Paleoindian occupations on the Great Plains (Albritton, 1985; Haynes, 1967, 1968a:597). As indicated below, his work focused on a number of key localities, but of particular note is his initial dating of the long, stratified Paleoindian sequences at Clovis, New Mexico, on the Southern Plains, and Hell Gap, Wyoming, on the Northern Plains.

During the 1950s, there were few attempts at dating occupation zones with fluted points, probably because few fluted point sites were excavated, but the Folsom and Clovis styles were some of the first to be firmly dated. Following the problems with dating the Folsom levels at the Folsom type site and at the Lindenmeier site, the first, and, until 1960, the only generally accepted radiocarbon age for a fluted point occupation on the Great Plains was the one from Lubbock Lake (Figure 1, Tables I, II) dated by Libby (1952a:82): 9883 ± 350 yr B.P. (C-558). The age was accepted as reliable because it "...closely approximates the magnitude estimated for Folsom on geologic evidence" (Roberts, 1951:20–21; see also Griffin, 1952:367–368); that is, it was very close to the estimate of ca. 10,000 years or a little older for the Folsom horizon at the Lindenmeier site and the 13,000–10,000 year estimate for the Clovis site fluted points proposed by Antevs (1941, 1949). The age also was older than other radiocarbon ages which were associated with artifacts considered in 1951 to be younger than Folsom (Roberts, 1951:21).

For some years the Lubbock Lake radiocarbon age was used as a sort of "standard" against which others were compared (e.g., Hurt, 1953:210; Roberts, 1953:276; Wendorf et al., 1955:100; Sellards and Evans, 1960; Krieger, 1964:55). The date was also supported by a subsequently published age of 9700 ± 450 from Lubbock Lake determined on shell from a zone believed to be slightly higher, stratigraphically, than the Folsom date (Broecker and Kulp, 1957). As other dates for Folsom became available, however, the age of the initial Lubbock Lake sample was consistently the youngest of the group (e.g., Haynes, 1964, 1967, 1971). Additional work at Lubbock Lake (Holliday and Johnson, 1986) finally showed that (1) sample C-558 was

Table IIIA. Radiocarbon ages for Folsom assemblages on the Great Plains 1952–1964.

Site	Age (yr B.P.)	Lab No.	Reference	Material[a]
Lubbock Lake, TX	9883 ± 350	C-558[b]	Libby, 1952a Sellards, 1952	Burned bone
	9700 ± 450[c]	L-283G	Broecker & Kulp, 1957 Sellards & Evans, 1960	Shell
Lindenmeier, CO	10,780 ± 135[d]	I-141[e]	Walton et al., 1961 Haynes & Agogino, 1960	Charcoal
Agate Basin, WY (Brewster)	10,375 ± 700	I-472	Haynes, 1964 Trautman & Willis, 1966	Charcoal
Clovis, NM	10,490 ± 900	A-386[e]	Damon et al., 1964 Haynes, 1964	Fossil plants
	9900 ± 320	A-379[e]	Damon et al., 1964	Carbonaceous matter; same sample as A-380?
	10,600 ± 320	A-380[e]	Damon et al., 1964	Humic acid and lignin; same sample as A-379?
	10,250 ± 320	av. A-379 and A-380[e]	Damon et al., 1964 Haynes, 1964	
	10,200 ± 250	A-488[e]	Haynes et al., 1966	Plant remains
	10,490 ± 200	A-492[e]	Haynes et al., 1966	Plant remains

[a] Materials dated are as described in date lists.
[b] Also listed in Table II.
[c] Initially cited as 9300 ± 200 yr B.P. by Kreiger (1956) and subsequently reported as such by Wormington (1957:40) and Sellards and Evans (1960).
[d] First published as 10,780 ± 375 yr B.P. (Haynes and Agogino, 1960; see comment by Haynes, 1992: 357–358); misreported as 10,850 ± 550 (Haynes, 1967:270) and 10,780 ± 175 (Haynes, 1968a:624).
[e] Also listed in Table IIIB.

from a later occupation, not the Folsom horizon, (2) sample L-283G was stratigraphically below C-558 and probably inaccurate, and in any case (3) samples determined by the early solid-carbon method used in Libby's lab were suspect (Taylor, 1987:168). Charcoal collected by Haynes and Agogino (1960) from the Folsom occupation at the Lindenmeier site produced the first reliable radiocarbon age for Folsom artifacts (Table IIIA). This dating was followed relatively soon by publication of dates for the Folsom levels at Agate Basin (the Brewster site) (Haynes, 1964; Trautman and Willis, 1966) and the Clovis site (Haynes, 1964; Damon et al., 1964; Haynes et al., 1966) (Table IIIA).

The first reliable radiocarbon ages for Clovis artifacts were published in 1964 and came from three sites: Dent, Colorado (Haynes, 1964; also Trautman and Willis, 1966), Clovis, New Mexico (Damon et al., 1964; Haynes, 1964) (Table IVA), both on the Great Plains (Figure 1), and Lehner, in the San Pedro Valley of southern Arizona (Damon et al., 1964; Haynes, 1964) (Table IVA). Several sites in the San Pedro Valley yielded spectacular Clovis mammoth kills, and excavations at Lehner (Haury et al., 1959) and Naco (Haury, 1953) in the 1950s included the first attempts

Table IIIB. Acceptable radiocarbon ages for Folsom point assemblages on the Great Plains.[a]

Site	Age (yr B.P.)	Lab No.	Reference	Material[b]
Hanson, WY	10,700 ± 670	RL-374	Frison & Bradley, 1980	Charcoal
	10,080 ± 330	RL-558	Frison & Bradley, 1980	Charcoal
	10,300 ± 150	Beta-22514 ETH-3229	Frison, 1991	Charcoal?
	10,225 ± 125	Beta-31072 ETH-5272	Frison, 1991	Charcoal?
	av. 10,260 ± 90		Haynes et al., 1992a	
	9970 ± 340	Beta-22513	Ingbar, 1992	Charcoal?
Carter-Kerr/ McGee	10,400 ± 600	RL-917	Frison, 1984	Charcoal
Agate Basin, WY[c]	10,780 ± 120	SI-3733	Frison & Stanford, 1982	Charcoal
	10,665 ± 85	SI-3732	Frison & Stanford, 1982	Charcoal
	av. 10,690 ± 70	3733 + 3732	Haynes et al., 1992a	
Hell Gap, WY[d] *Folsom*	10,930 ± 200	A-503	Haynes et al., 1966 Haynes et al., 1992a	Carbonaceous silt, NaOH extract (humic acid)
	10,690 ± 500	A-504	Haynes et al., 1966 Haynes et al., 1992a	Carbonaceous silt, NaOH extract (humic acid)
	10,290 ± 500	A-502	Haynes et al., 1966 Haynes et al., 1992a	Carbonaceous silt, NaOH extract (humic acid)
	av. 10,820 ± 170		Haynes et al., 1992a	
Lindenmeier, CO[e]	10,780 ± 135	I-141[f]	Walton et al., 1961 Haynes & Agogino, 1960	Charcoal Charcoal
	10,560 ± 100	TO-337	Haynes et al., 1992b	Charcoal
	10,500 ± 80	TO-342	Haynes et al., 1992b	Charcoal
	av. 10,660 ± 60		Haynes et al., 1992b	
Folsom, NM[g]	10,780 ± 100	AA-1213	Haynes et al., 1992b	Charcoal
	11,060 ± 100	AA-1708	Haynes et al., 1992b	Charcoal
	10,760 ± 140	AA-1709	Haynes et al., 1992b	Charcoal
	10,890 ± 150	AA-1710	Haynes et al., 1992b	Charcoal
	10,850 ± 190	AA-1711	Haynes et al., 1992b	Charcoal
	10,910 ± 100	AA-1712	Haynes et al., 1992b	Charcoal
	av. 10,890 ± 50		Haynes et al., 1992b	Charcoal
Lipscomb, TX	10,820 ± 150	NZA-1092	Hofman, 1995	Charcoal
Waugh, OK[h]	10,379 ± 85	NZA-3602	Hofman, 1995	Charcoal
	10,404 ± 87	NZA-3603	Hofman, 1995	Charcoal
	av. 10,390 ± 60		Hofman, 1995	
Clovis, NM[i]	10,490 ± 900	A-386[f]	Damon et al., 1964 Haynes, 1964	Fossil plants

(Continued)

Table IIIB. *(Continued)*

Site	Age (yr B.P.)	Lab No.	Reference	Material[b]
Clovis, NM	9900 ± 320	A-379[f]	Damon et al., 1964	Carbonaceous matter; same sample as A-380?
	10,600 ± 320	A-380[f]	Damon et al., 1964	Humic acid and lignin; same sample as A-379?
	av. 10,250 ± 320	A-379 and A-380[f]	Damon et al., 1964 Haynes, 1964	
	10,200 ± 250	A-488[f]	Haynes et al., 1966	Plant remains
	10,490 ± 200	A-492[f]	Haynes et al., 1966	Plant remains
	av. 10,380 ± 140	A-379, 380, 488, 492	Haynes et al., 1992a	
	10,260 ± 230	AA-1370	Haynes, 1995	Charcoal
	10,740 ± 100	AA-1362	Haynes, 1995	Residue (humin)
	10,470 ± 580	A-4701	Haynes, 1995	Humates (humic acid)
	10,250 ± 200	A-1372	Haynes, 1995	Humates (humic acid)
	av. 10,590 ± 80	1370 + 1362 4701 + 1372	calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Lubbock Lake, TX[j]	10,060 ± 170	SMU-251	Haas et al., 1986 Holliday et al., 1983	Diatomite, humic acid
	10,360 ± 80	SI-3200	Haas et al., 1986 Holliday et al., 1983	Marsh soil, humin
	10,160 ± 80	SMU-846	Haas et al., 1986 Holliday et al., 1985	Marsh sediment, humic acid
	10,090 ± 100	SMU-1144	Haas et al., 1986 Holliday et al., 1985	Marsh sediment, humic acid
	10,195 ± 165	SI-4976	Haas et al., 1986 Holliday et al., 1985	Marsh sediment, humin
	av. 10,205 ± 65	251 + 3200 + 846 + 1144 + 4976	calculation by D. Meltzer, 1999 (after Hietala, 1989)	
	10,540 ± 100	SMU-547	Haas etal., 1986 Holliday et al., 1983	Charcoal
	10,880 ± 90	SMU-292	Haas et al., 1986 Holliday et al., 1983	Shell
	10,530 ± 90	SMU-285	Haas et al., 1986 Holliday et al., 1983	Diatomite, humic acid
	10,780 ± 80	SI-3202	Haas et al., 1986 Holliday et al., 1983	Organic-rich mud, humin
	10,300 ± 70	SMU-1110	Haas et al., 1986 Holliday et al., 1985	Marsh sediment, humic acid

Table IIIB. *(Continued)*

Site	Age (yr B.P.)	Lab No.	Reference	Material[b]
Bonfire Shelter, TX[k]	10,230 ± 160	TX-153	Pearson et al., 1965 Dibble & Lorrain, 1968	Charcoal
	10,100 ± 300	TX-658	Dibble, 1970 Valastro & Davis, 1970	Charcoal
	9920 ± 150	TX-657	Dibble, 1970 Valastro & Davis, 1970	Charcoal
	av. 10,080 ± 100		Haynes et al., 1984	
	av. 10,080 ± 130		Dibble, 1970	
	10,280 ± 430	AA-346	Bement, 1986	Charcoal
	av. 10,090 ± 100	153 + 658 + 657 + 346	Haynes, pers. commun., 1998	

[a] Radiocarbon ages from Kincaid Shelter are associated with Folsom occupations in some date lists (Haynes, 1967:Table 1; Hofman, 1996:Table 15) and "look" like reasonable Folsom ages, but are not listed here because of the material dated (shell in a limestone terrain) and aparent lack of association with Folsom artifacts (Stipp et al., 1962; Tamers et al., 1964; see also discussion by Hester et al., 1985, and Collins, 1990).

[b] Materials dated are as described in date lists.

[c] Sample I-472 (10,375 ± 700) from the Brewster site was not included because of "questionable association" (Taylor et al., 1996:517).

[d] Folsom association is based on Haynes et al. (1992a:Table 3.3). Haynes (1992b:Table 24.1) identifies this group of ages as "Folsom-Goshen-Midland." A sample associated with "Midland" points (A-499) was rejected in the original date list (Haynes et al., 1966:16).

[e] For Lindenmeier, sample GX-1282 (11,200 ± 400), reported by Wilmsen and Roberts (1978), is not included because of the possibility of contamination (Haynes et al., 1992a:91). Haynes et al. (1992a:91) note, however, that including the age with the others "would make the average 80 years older."

[f] Also listed in Table IIIA.

[g] Sample SMU-179 (10,260 ± 110) on bone collagen is not included because the charcoal ages are considered to be more likely accurate (Haynes, 1992:358; Haynes et al., 1992a:84, 87).

[h] AMS sample CAMS-16078 (9160 ± 160) on bone is considered unreliable (Hill and Hofman, 1997).

[i] Samples are from or correlated with a Folsom occupation. Samples AA-1361, 1363, 1364, and 1370 (10,640 ± 110, 10,160 ± 120, 10,210 ± 110, and 10,260 ± 230, respectively) are problematic, along with several even younger ages from Folsom-bearing strata (Haynes, 1995:373).

[j] Sample SMU-547 is from stratigraphic equivalent to the Folsom level but collected 2 km upstream from the main escavations; SI-3202 is from the stratigraphic equivalent to the Folsom level but collected approx 150 m from the nearest Folsom-age feature; all other samples collected from archaeological features. SMU-247 (7840 ± 170) and SI-4592 (9040 ± 90) on humin (residue), and SMU-975 (9720 ± 80) on humic acid (humates) are considered falsely young (Haas et al. 1986; Holliday et al., 1983, 1985).

[k] All Bonfire samples are from uppermost of three bone layers comprising Bone Bed 2 of Dibble and Lorrain (1968). Both Plainview and Folsom artifacts are reported from the bone bed.

at dating Clovis artifacts, but the initial results were unacceptable (Wormington, 1957:56; Haury et al., 1959:22, 24–25; Haynes, 1964:1410; Haynes, 1992:359, 362) (Table IVA). Alexander (1963) reported a radiocarbon age of ca. 10,000 yr B.P. associated with a single, purported Clovis point from Levi rockshelter on the southeastern edge of the Edwards Plateau, Texas (Figure 1). The typology of the artifact

Table IVA. Radiocarbon ages for Clovis 1958–1964.

Site	Age	Lab No.	Reference	Material[a]
Lehner, AZ[b]	12,000 ± 450	A-40A	Wise & Shutler, 1958	Solid carbon
	10,900 ± 450	A-40B	Wise & Shutler, 1958	Solid carbon; rerun of A-40A
	av. 11,850	A-40A + A-40B	Haury et al., 1959:24	
	11,170 ± 140	K-554	Tauber, 1960	Charcoal
	11,290 ± 500	M-811	Crane & Griffin, 1959	Charcoal
Levi, TX	10,000 ± 175	O-1106	Alexander, 1963	Shell
Dent, CO	7200 ± 200	I-473	Haynes, 1964 Trautman & Willis, 1966	Bone and tusk; treated with shellac
	11,200 ± 500	I-622[c]	Haynes, 1964 Trautman & Willis, 1966	Bone and tusk; shellac removed
Domebo, OK[d]	11,220 ± 500	SI-172[c]	Leonhardy, 1966 Long & Mielke, 1966	Bone organic carbon
	11,200 ± 600	SI-175[c]	Leonhardy, 1966 Long & Mielke, 1966	Bone humic acid
	11,045 ± 647	SM-695	Leonhardy, 1966 Long & Mielke, 1966	Wood
Clovis, NM	11,170 ± 360	A-481[c]	Damon et al., 1964 Haynes, 1964	Humates and lignin from carbonized plant remains
	11,040 ± 500	A-490[c]	Haynes et al., 1966	Humates and lignin from plant remains
	11,630 ± 400	A-491[c]	Haynes et al., 1966	Humates and lignin from plant remains

[a] Materials dated are as described in date lists.
[b] Unacceptable ages for the Naco and Lehner sites include (A-9, A-10, A-30 8330 ± 450, A-31, A-32 7022 ± 450, A-34 7205 ± 450; Wise and Shutler, 1958; Haury et al., 1959; see also discussion for A-42, Damon and Long, 1962:243) not listed.
[c] Also listed in Table IVB.
[d] Domebo samples TBN-311 (4952 ± 304) on tusk, SM-610 (10,123 ± 180) on "lignitic wood," and OX-56 (9400 ± 300) on "organic earth" were rejected by the investigators (Leonhardy, 1966:24–25).

is unclear (e.g., the site is not mentioned as a Clovis locality by Collins [1995]), and in any case the date was on shell and must be suspect considering that the shelter is in a limestone terrain.

The application of radiocarbon dating at archaeological sites during the "teething years" of the method in the 1950s resulted in several studies that generated confusion and controversy, serving as cautionary tales on radiocarbon sampling and sample association. The example of the "first Folsom date" at Lubbock Lake was noted above. Shortly after Sellards completed his work at Lubbock Lake, human remains were found in association with small unfluted Folsom-like projectile points (later termed Midland), at the Midland site, south of Lubbock (Table I, Figure 1) (Wendorf et al., 1955). Stratigraphic correlations suggested that the bones and Midland points were older than the Folsom occupation of the area. Radiocarbon dating and the newly devised uranium-series method were applied to the problem (Table

Table IVB. Acceptable radiocarbon ages for Clovis point assemblages on the Great Plains.

Site	Age	Lab No.	Reference	Material[a]
Colby, WY[b]	11,200 ± 220	RL-392	Frison & Todd, 1986	Bone collagen
Sheaman, WY (Agate Basin)	10,690 ± 105	Beta-25836 ETH-4006	Frison, 1991	Charcoal?
Lange-Ferguson, SD[c]	11,140 ± 140	AA-905	Haynes, 1992	Charcoal
	10,800 ± 530	I-13104	Hannus, 1989	Bone collagen
Dent, CO[d]	11,200 ± 500	I-622[e]	Haynes, 1964 Trautman & Willis, 1966	Bone and tusk; shellac removed
	10,980 ± 90	AA-2941	Stafford et al., 1991	Bone, AMS
	10,660 ± 170	AA-2942	Stafford et al., 1991	Bone, AMS
	10,800 ± 110	AA-2943	Stafford et al., 1991	Bone, AMS
	10,600 ± 90	AA-2945	Stafford et al., 1991	Bone, AMS
	10,710 ± 90	AA-2946	Stafford et al., 1991	Bone, AMS
	10,670 ± 120	AA-2947	Stafford et al., 1991	Bone, AMS
	av. 10,690 ± 50	2942–2947	Haynes, 1993	
	av. 10,810 ± 40	2941–2947	Haynes, 1992	
Domebo, OK[f]	11,220 ± 500	SI-172[e]	Leonhardy, 1966 Long & Mielke, 1966	Bone organic carbon
	11,200 ± 600	SI-175[e]	Leonhardy, 1966 Long & Mielke, 1966	Bone humic acid
	av. 11,210 ± 390	172 + 175	Haynes, 1992	
	10,980 ± 70	Beta-24212	Hofman, 1988	Wood
	11,480 ± 450	AA-825	Stafford et al., 1987	Bone collagen, AMS
	10,820 ± 270	AA-824	Stafford et al., 1987	Bone collagen AMS
	10,810 ± 420	AA-805	Stafford et al., 1987	Bone XAD gel, AMS
	10,860 ± 450	AA-811	Stafford et al., 1987	Bone collagen, AMS
	10,810 ± 420	AA-805	Stafford et al., 1987	Bone gelatin, AMS
	av. 10,820 ± 230	824 ± 805	Haynes, 1993	
	av. 11,040 ± 250	825 + 811 + 805	Haynes, 1992	
	av. 10,940 ± 180	825 + 811 + 805	Stafford et al., 1991	
Clovis, NM[g]	11,170 ± 360	A-481[e]	Damon et al., 1964 Haynes, 1964	Humates and lignins from carbonized plant remains
	11,040 ± 500	A-490[e]	Haynes et al., 1966	Humates and soluble lignins from plant remains
	11,630 ± 400	A-491[e]	Haynes et al., 1966	Humates and soluble lignins from plant remains
	av. 11,130 ± 290	481 + 490	Haynes et al., 1992b	
	av. 11,300 ± 240	481 + 490 + 491	Taylor et al., 1996	

(Continued)

Table IVB. *(Continued)*

Site	Age	Lab No.	Reference	Material[a]
Aubrey, TX	11,540 ± 110	AA-5271	Ferring, 1995	Charcoal
	11,590 ± 90	AA-5274	Ferring, 1995	Charcoal
	av. 11,570 ± 70		Taylor et al., 1996	

[a] Materials dated are as described in date lists.
[b] The bone collagen from Colby seems to be generally accepted (e.g., Haynes, 1992; Figure 24.1, 1993: Figure 1), but samples SMU-254 (10,864 ± 141) on bone apatite and SMU-278 (8719 ± 392) are not.
[c] Lange-Ferguson sample I-13104 is corrected for fractionation (Hannus, 1989;395); the uncorrected age of 10,730 ± 530 was published by Hannus (1990). Sample I-11710 (10,670 ± 300) came from organic-rich sediments "sealing the bone bed" and establishes "a minimal age for the bone bed" (Hannus, 1989:395)
[d] Dent sample I-473 (7200 ± 200) was rejected by investigators (Trautman and Willis, 1966:172).
[e] Also listed in Table IVA.
[f] Domebo samples TBN-311 (4952 ± 304) on tusk, SM-610 (10,123 ± 180) on "lignitic wood," and OX-56 (9400 ± 300) on "organic earth" were rejected by the investigators (Leonhardy 1966:24–25). Samples SM-695 (11,045 ± 647) and AA-823 (11,490 ± 450) were in "questionable association" (Taylor et al., 1996:Table 1).
[g] The standard deviations of the three samples from Clovis were printed incorrectly by Haynes (1992: Table 24.1, 1993:Table 1)(C. V. Haynes, personal communication, December, 1998). The correct ages appear in date lists by Damon et al. (1964) and Haynes et al. (1966), in the discussion by Haynes et al. (1992b:342) and in Table IV by Haynes (1995). The average of the three ages was printed incorrectly in tables by Haynes (1992, 1993). The correct average is published by Haynes (1995:Table IV; rounded from 11,295 to 11,290) and Taylor et al. (1996:Table 1; rounded from 11,295 to 11,300).

Table IVC. Dated Pre-Folsom (probable/possible Clovis) occupations.

Site	Age	Lab No.	Reference	Material[a]
Lindsay, MT	10,700 ± 290	WSU-652	Davis, 1982	Unburned bone
	10,980 ± 225	I-9220	Davis, 1982	Unburned bone
	av. 10,870 ± 175		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
	11,500 ± 80	Beta-102031	Hill & Davis, 1998	Collagen, AMS
	11,925 ± 350	S-918	Davis, 1982	Unburned bone
Agate Basin, WY	11,840 ± 130	I-10899	Frison & Stanford, 1982	Charcoal
	11,700 ± 95	SI-3731	Frison & Stanford, 1982	Charcoal
	11,450 ± 110	SI-3734	Frison & Stanford, 1982	Charcoal
	av. 11,650 ± 60		Haynes, 1993	
U.P. Mammoth, WY	11,280 ± 350	I-499	McGrew, 1961 Trautman & Willis, 1966	Tusk organics
Lubbock Lake, TX[b]	11,100 ± 100	SMU-548	Holliday et al., 1983 Johnson, 1991	Wood
	11,100 ± 80	SMU-263	Holliday et al., 1983	Wood
	av. 11,100 ± 60		calculation by D. Meltzer, 1999 (after Hietala, 1989)	

[a] Materials dated are as described in date lists.
[b] Dates on shell (I-246 and SMU-295) are problematic because of the hardwater effect and because of unclear association between I-246 and cultural remains (Holliday et al., 1983).

VA) (Rosholt, 1958; Wendorf and Krieger, 1959). The results were ambiguous and included a wide range of radiocarbon ages, the oldest of which were close to the U-series age estimates. In the end, three scenarios were offered for the age of the human remains, based on comparisons of the dates, the stratigraphy, and the archaeology from Midland, Lubbock Lake, Plainview, and Clovis, as well as geologic-climatic dating: (A) ca. 13,400–10,000 yr B.P., considered "most plausible"; (B) ca. 7000 yr B.P., considered "least plausible"; and (C) ca. 20,000 yr B.P., which "should not be entirely discounted" (Wendorf and Krieger, 1959:78). As of 1959, therefore, the Midland remains were believed to predate Folsom occupations and possibly were 20,000 years old. Wendorf (1975:267) eventually realized that the Midland material probably was essentially contemporaneous with Folsom, but the early dates were fixed in the literature and the site generally was accorded an age "substantially pre-Folsom" (Willey, 1966:44) or "more than 10,000, and possibly as much as 20,000 years old" (Jennings, 1989:66). Subsequent research at the site confirmed Wendorf's (1975) reassessment (Holliday and Meltzer, 1996). Holliday and Meltzer (1996) also determined that the original dating probably was compromised by problems of bone dating during the early development of both radiocarbon and U-series dating as well as by stratigraphic miscorrelation.

The first attempt at dating a Clovis occupation on the Great Plains generated similar results though for different reasons. At the Lewisville site, Texas (Table I,

Table VA. Controversial ages for fluted-point sites on the Great Plains: radiocarbon and U-series ages for the Midland site, 1955–1959.

Group[a]	*Method*	Age	Lab No.	Reference	Material[b]
Group A	*C14*	13,400 ± 1200[c]	L-304C	Broecker & Kulp, 1957 Wendorf & Krieger, 1959	Shell in sand below the human remains
Group B	*C14*	8670 ± 600	M-388[d]	Wendorf et al., 1955 Crane, 1956	Fossil bone and mammoth tusk
		7100 ± 1000	M-411	Wendorf et al., 1955 Crane, 1956	Fossil bone
Group C	*C14*	20,400 ± 900	L-347	Olson and Broecker, 1959	Carbon from burned caliche[e]
	U-series	18,000	229122	Rosholt, 1958 Wendorf & Krieger, 1959	Fossil bone
		17,000	249088	Rosholt, 1958 Wendorf & Krieger, 1959	Fragmentary bone
		20,000	253502	Rosholt, 1958 Wendorf & Krieger, 1959	Human bone

[a] Grouped following Wendorf and Krieger (1959:75–78).
[b] Materials dated are as described in date lists.
[c] First reported by Krieger (1957) as 12,500 ± 1200, but later recalculated in the laboratory (Wendorf and Krieger, 1959:75)
[d] Reported as M-389, M-390, and M-391 by Wendorf et al. (1955:9, 99–100)
[e] Calcium carbonate from the caliche itself was dated at 23,500 yr B.P. (Olsen and Broecker, 1959:22); also reported as 23,000 yr B.P. on caliche residue (Wendorf and Krieger, 1959:71).

Table VB. Controversial ages for fluted-points on the Great Plains: radiocarbon ages for the Lewisville site, Texas, 1957–1962.

Age	Lab No.	Reference	Material[a]
>37,000	O-235	Brannon et al., 1957 Crook & Harris, 1957, 1958	Charcoal
>37,000	O-248	Brannon et al., 1957 Crook & Harris, 1957, 1958	Charcoal
>38,000	UCLA-110	Crook & Harris, 1961 Fergusson & Libby, 1962	Charcoal
>40,000	B-487	Oeschger & Riesen, 1965	Charcoal

[a] Materials dated are as described in date lists.

Figure 1), charcoal samples from hearths associated with a Clovis point yielded ages of >37,000 yr B.P. (Table VB). These results generated confusion and controversy from the outset (e.g., Wormington, 1957:58–59) and generally were not accepted (e.g., the dates were not included by Haynes, 1964, in the first synthesis of the fluted point chronology). Subsequent work at Lewisville showed that the material used for burning by the Clovis occupants was Tertiary-age lignite; that is, the material was ^{14}C-dead to begin with (Stanford, 1983).

1950s–1960s: Dating Unfluted Points

The chronometric ages for Clovis and Folsom were relatively well-established by the mid-1960s, but the chronology of the unfluted lanceolate forms was and, to a certain extent, still remains less clear. The initial radiocarbon ages determined by Libby (Table II) for several unfluted lanceolate points provided a confusing array of dates from the outset. For example, Roberts (1951:21), in assessing the dates he helped generate as part of the "Committee on Carbon 14," believed that both the Lime Creek site and the "site on Sage Creek near Cody, Wyoming" (the Horner site) contained "Scottsbluff Yuma." Therefore, if the radiocarbon ages (C-302 from Horner and C-471 from Lime Creek) were correct, Scottsbluff persisted for at least 3000 years, which "seems a bit strange." Slowly, through the 1950s and 1960s, this and similar issues of chronology were clarified, though others appeared.

On the Southern Plains, Sellards and Evans (1960) published one of the first regional Paleoindian chronologies (Figure 2), based on stratigraphic correlation between Clovis and Lubbock Lake, and five radiocarbon ages: two from Lubbock Lake, and one each from the Clovis, Midland, and Plainview sites (Figure 1). Why only the one determination from Midland and one of two from Clovis were selected was not explained. Two post-Folsom "culture complexes" were identified by Sellards and Evans (1960): Plainview, based on their work at the Plainview site (1945) (Table I, Figure 1) and subsequent identification of the Plainview type (Sellards et

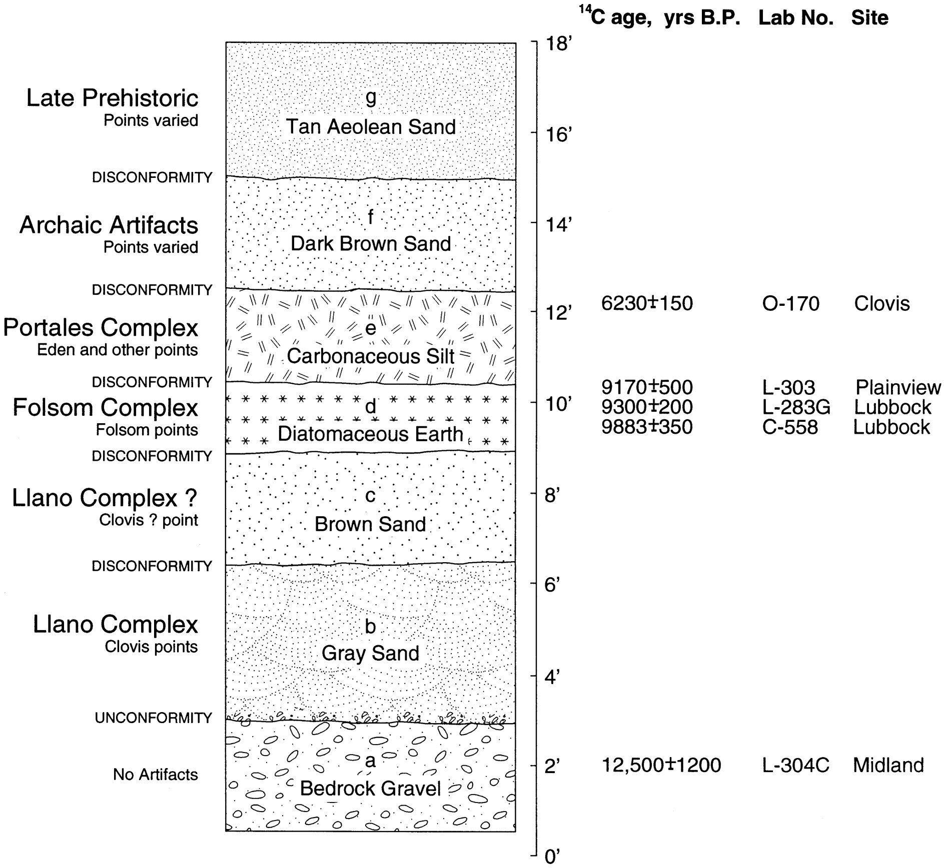

Figure 2. The late-Quaternary geologic and cultural stratigraphy of the Southern High Plains proposed by E. H. Sellards and Glen Evans (modified from Sellards and Evans, 1960:Figure 2), based on geoarchaeological research at the Clovis and Lubbock Lake sites and radiocarbon ages (shown) from the Clovis, Lubbock Lake, Plainview, and Midland sites. The date of 12,500 ± 1200 (L-304C) was for Pleistocene fauna below the human remains at the Midland site as reported by Krieger (1957) and cited by Sellards and Evans. It was recalculated and published as 13,400 ± 1200 by Broecker and Kulp (1957). The date of 9300 ± 200 (L-283G) was for the Folsom level at the Lubbock Lake site as reported by Krieger (1957) and cited by Sellards and Evans. It was recalculated and published as 9700 ± 450 by Broecker and Kulp (1957). The date of 9170 ± 500 (L-303) was for the Plainview bone bed at the Plainview site as reported Krieger (1957) and cited by Sellards and Evans. It was recalculated and published as 9800 ± 500 by Broecker and Kulp (1957).

al., 1947); and Portales, based on their work at the Clovis site and recovery of a wide variety of seemingly contemporaneous post-Folsom artifact types (Sellards, 1952:72–74). Their initial age estimates for Clovis and Folsom turned out to be reasonable, as noted previously and below, but the post-Folsom ages were more problematic. The relationship of Plainview to Folsom was long unclear because no other archaeological zones were found at the Plainview site, and Plainview artifacts were not found in place at Clovis or in the early work at Lubbock Lake. Sellards and Evans (1960:644) report a date of ca. 9170 for the artifacts at Plainview (Figure 2), but this shell date was recalibrated to ca. 9800 yr B.P. (Table VIA, Figure 2). Bone from the site was dated to ca. 7100 yr B.P. (Table VIA). Subsequent attempts at dating the Plainview bone bed, including recent application of AMS technology (discussed below) yielded a frustratingly wide range of ages. The first reliable ages for Plainview were determined on charcoal from a bone bed at Bonfire Shelter, Texas (Figure 1) (Tables I, VIA, VIB) (Dibble, 1970; Dibble and Lorrain, 1968) and show that Plainview artifacts are slightly younger than Folsom or perhaps overlap late Folsom time. This interpretation was confirmed by the stratigraphic relationship of Plainview to Folsom at Bonfire Shelter (Dibble and Lorrain, 1968) and as subsequently determined at Lubbock Lake (Johnson and Holliday, 1980).

On the Edwards Plateau, excavations at Levi rockshelter (Table I, Figure 1) (Alexander, 1963), and at the Devil's Mouth site (Table I, Figure 1) (L. Johnson, 1964) yielded purported Plainview materials. The "Plainview" artifacts from the Levi site probably are not Plainview. Moreover, the radiocarbon ages all were determined on shell and must be considered suspect because of the potential for contamination from ancient carbon derived from the limestone in which the shelter formed. The artifacts from Devil's Mouth originally were termed "Plainview Golondrina" (L. Johnson, 1964). Additional field work at the site yielded a radiocarbon age of ca. 8800 yr B.P. (Table VIIA) (Sorrow, 1968), suggesting that these materials were younger than Plainview. Subsequent technological analyses clearly show that this type is not the same as Plainview and is now termed simply Golondrina (T. Hester, 1977; Kelly, 1982; Knudson, 1983:165).

The typology and chronology of the Portales Complex artifacts have been almost as problematic as Plainview. The type collection is the source of considerable typological confusion. For example, Sellards (1952:74) describes the type Portales collection to include artifacts similar to Eden, Scottsbluff, Plainview, and San Jon types, while J. Hester (1972:37, 136–137) describes Milnesand, Eden, Scottsbluff, Angostura, and Plainview types. Agogino and Rovner (1969), J. Hester (1972), and Hofman (1989), among others, suspected that the Portales Complex is a mix of assemblages. These suspicions were confirmed: the bone bed probably was a mixture of at least two bone beds (Johnson and Holliday, 1997). The "Portales Complex" therefore is no longer valid.

Wheat (1972) systematically reassessed the Portales Complex type collection (the only such reanalysis to date) as part of his study of unfluted lanceolate projectile points from the Olsen-Chubbuck site, a bison kill in southeastern Colorado

Table VIA. Radiocarbon ages for the Plainview occupation of the Great Plains: 1950–1965.

Site	Age	Lab No.	Reference	Material[a]
Plainview	9800 ± 500[b]	L-303	Broecker & Kulp, 1957	Snail shell
	7100 ± 160	O-171	Brannon et al., 1957	"Organic portion of bones"
Bonfire Shelter	10,230 ± 160	TX-153[c]	Pearson et al., 1965 Dibble & Lorrain, 1968	Charcoal

[a] Materials dated are as described in date lists.
[b] Originally published as 9170 ± 500 by Krieger (1957) and cited as such by Wormington (1957:108).
[c] Also listed in Table VIB.

Table VIB. Reliable radiocarbon ages for Plainview assemblages.[a]

Site	Age	Lab No.	Reference	Material[b]
Bonfire Shelter, TX[c]	10,230 ± 160	TX-153[d]	Pearson et al., 1965 Dibble & Lorrain, 1968	Charcoal
	10,100 ± 300	TX-658	Dibble, 1970 Valastro & Davis, 1970a	Charcoal
	9920 ± 150	TX-657	Dibble, 1970 Valastro & Davis, 1970a	Charcoal
	av. 10,080 ± 100		Haynes et al., 1984	
	av. 10,080 ± 130		Dibble, 1970	
	10,280 ± 430	AA-346	Bement, 1986	Charcoal
	av. 10,090 ± 100	153 + 658 + 657 + 346	Haynes, pers. comm., 1998	
Lubbock Lake, TX	9990 ± 100[e]	SMU-728	Holliday & Johnson, 1981 Holliday et al., 1983	Organic-rich mud, humic acid
	9960 ± 80	SMU-275[f]	Johnson & Holliday, 1980	Diatomaceous earth, humic acid
	10,015 ± 80	SI-3203[f]	Holliday et al., 1983	Organic-rich mud, humin
	av. 9990 ± 50		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Lake Theo, TX[g]	9950 ± 110	SMU-866	Johnson et al., 1982	Soil, humic acid

[a] TX-333 from Red Smoke, NE is cited as a Plainview date (Knudson, 1983:190–191), but, according to a description of the sampling (Valastro et al., 1967;451), the material was recovered from above the "Plainview" zone.
[b] Materials dated are as described in date lists.
[c] All Bonfire samples are from uppermost of three bone layers comprising Bone Bed 2 of Dibble and Lorrain (1968). Both Plainview and Folsom artifacts are reported from the bone bed.
[d] Also listed in Table VIA.
[e] SMU-728 was initially reported as 9985 ± 100 by Holliday and Johnson (1981), but rounded to 9990 ± 100 by Holliday et al. (1983).
[f] SMU-275 and SI-3203 were correlated stratigraphically with Plainview features.
[g] Lake Theo samples TX-2880 (8010 ± 100) and TX-2879 (9360 ± 170) are not included because they were determined on bone.

Table VIC. Radiocarbon ages of uncertain reliability or association with Plainview.

Site	Age	Lab No.	Reference	Material[a]
Plainview, TX	9860 ± 180	TX-3908	Speer, 1990	Bone apatite[b]
	10,200 ± 400	TX-3907	Speer, 1990	Bone apatite[b]
	8860 ± 110	SMU-2341[c]	Holliday, 1995, 1997	Organic-rich mud, humic acid
	8380 ± 100	NSRL-3466 CAMS-38694	Holliday et al., 1999	Tooth gelatin, AMS
	8790 ± 60	NSRL-1881 CAMS-16166	Holliday et al., 1999	Bone gelatin, AMS
	8790 ± 80	NSRL-3469 CAMS-38695	Holliday et al., 1999	Tooth gelatin, AMS
	9110 ± 90	NSRL-3464 CAMS-38693	Holliday et al., 1999	Tooth gelatin, AMS
	10,170 ± 100	NSRL-2060 CAMS-35909	Holliday et al., 1999	Bone gelatin, AMS
	10,660 ± 70	NSRL-2061 CAMS-35910	Holliday et al., 1999	Bone gelatin, AMS
	11,440 ± 80	NSRL-2059 CAMS-35908	Holliday et al., 1999	Bone gelatin, AMS
Ryan, TX	9220 ± 220	SMU-2448	Hartwell, 1995	Organic-rich mud
Horace Rivers, TX[d]	9000 ± 70	Beta-55909	Mallouf & Mandel, 1997	Charcoal
	9040 ± 70	Beta-55908	Mallouf & Mandel, 1997	Charcoal
	9060 ± 90	Beta-55907	Mallouf & Mandel, 1997	Charcoal
	9290 ± 80	AA-9367	Mallouf & Mandel, 1997	Charcoal

[a] Materials dated are as described in date lists.
[b] Dating of bone apatite is notoriously problematic (Haynes, 1968b; Hassan et al., 1977; Taylor, 1992).
[c] SMU-2341 sampled from zone at or overlying bone bed based on stratigraphic correlation.
[d] Typological and stylistic affiliations of the Horace Rivers collection are uncertain because they have not been described or illustrated.

(Table I, Figure 1). He proposed the term “Firstview” in lieu of Eden and Scottsbluff for the Portales Complex materials, and “Firstview Complex” in lieu of “Portales Complex” based on systematic morphometric and technological analysis. Subsequent research indicated that the San Jon type (represented by the single type specimen as well as artifacts in the Portales collection) simply is the result of reworking Firstview points (Wheat, 1976). Wheat (1972) also reported a single radiocarbon age for the Firstview type assemblage (Table VIIIA). The sample produced abundant, well-preserved collagen and should have produced a reliable age (Haynes et al., 1971:14; C. V. Haynes, personal communication, 1997), but the assay has been problematic since it was first published because it seemed older than expected (Haynes et al., 1971:14; Hofman, 1989:43). The sample also had a large standard deviation, rendering precise chronological interpretations difficult.

Samples from the bone bed at the Clovis site yielding the type Portales artifacts were submitted for dating by Sellards in the early years of the method. The bone produced two ages (O-169 and O-170; Table VIIIA), but as noted above, only one

Table VIIA. Radiocarbon ages for "Texas Angostura," "Golondrina," and parallel-oblique ("Frederick") projectile point assemblages on the Southern Great Plains.

Site	Age	Lab No.	Reference	Material[a]
Devil's Mouth, TX *Golondrina, Angostura*[b]	8780 ± 310	TX-526	Sorrow, 1968 Valastro et al., 1968	Charcoal
Baker Cave, TX *Angostura*	6510 ± 80	Beta-14733	Hester, 1988	Charcoal
Golondrina	8910 ± 140	TX-128	Pearson et al., 1965 Word & Douglas, 1970	Charcoal
	9030 ± 230	TX-129	Pearson et al., 1965 Word & Douglas, 1970	Charcoal
	9020 ± 150	TX-2466	Hester, 1982	Charcoal
	9180 ± 220	RL-828	Hester, 1982	Charcoal
Horn Shelter, TX *St Mary's Hall*[c]	9458 ± 300	SM-761	Watt, 1978	Shell
	9275 ± 360	SM-689	Watt, 1978	Shell
	8400 ± 110	TX-1996	Valastro et al., 1979 Watt, 1978	Shell
Wilson-Leonard, TX *Golondrina and St Mary's Hall*	8940 ± 100	TX-4784b	Collins et al., 1993	Charcoal
	8860 ± 150	TX-4784c	Collins et al., 1993	Charcoal
	8820 ± 120	TX-4784a	Collins et al. 1993	Charcoal
	av. 8885 ± 70		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Hausman Road, TX *Angostura*	7920 ± 50	Beta-82227	Tennis, 1996	Charcoal, AMS
Richard Beene, TX[d] *Angostura*	8640 ± 60	Beta-80687 CAMS-18801	Thoms et al., 1996	Charcoal
	8805 ± 75	Beta-47527 ETH-8540	Thoms, 1992	Charcoal, AMS
	av. 8705 ± 45		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Loeve, TX[e] *Angostura*	8500 ± 130	TX-2675	Bond, 1978 Valastro et al., 1978	Charcoal
	9650 ± 910	TX-3405	Prewitt, 1982	Charcoal
	av. 8520 ± 130		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Nall, OK *Allen/Frederick*	7740 ± 80	Beta-121880	LaBelle, 1999	

[a] Materials dated are as described in date lists.
[b] The sample was associated with artifacts now termed "Wilson" points (B. Bousman, pers. commun., 1999), was found below a "Plainview" (probably Golondrina) point (Sorrow, 1968:43, 47, and Table 1), and was correlated stratigraphically with Golondrina and probably Angostura artifacts (Sorrow, 1968:45).
[c] Horn Shelter artifacts originally identified as "Plainview" by Watt (1978). Reclassification follows Collins (1995).
[d] The "late Paleoindian zones" at the Richard Beene site yielded a series of radiocarbon ages ranging from ca. 10,130 to ca. 8640 yr B.P. (Thoms and Mandel, 1992; Thoms, 1993; Thoms et al., 1996), but all except the two listed here were determined on bulk soil carbon from a buried soil. The two listed ages are considered to be the most reliable indicators of the age of the Angostura assemblages because they are on charcoal and because of the close association of the charcoal with Angostura artifacts and features (Thoms, 1993:23; A. Thoms, pers. commun., 1998).
[e] The Angostura zone yielded five radiocarbon ages ranging from ca. 9650 to ca. 6810 yr B.P. (Prewitt, 1982:237), though none of the radiocarbon samples were in direct association with Angostura points. The two oldest ages are listed here and considered the best indicators of the age of the Angostura occupation because they are from the same feature (Prewitt, 1982:236–238; E. Prewitt, pers. commun., 1998) and because contamination by older carbon is less likely.

Table VIIB. Paired shell and charcoal samples, Horn Shelter.

Site	Age	Lab No.	Reference	Material[a]
Horn Shelter, TX	9500 ± 200	TX-1830	Valastro et al., 1979 Watt, 1978	Charcoal; same layer as TX-1998
	10,030 ± 130	TX-1998	Valastro et al., 1979 Watt, 1978	Snail shell; same layer as TX-1830
	9980 ± 370	TX-1722	Valastro et al., 1979 Watt, 1978	Charcoal; same layer as TX-1997
	10,310 ± 150	TX-1997	Valastro et al., 1979 Watt, 1978	Snail shell; same layer as TX-1722

[a] Materials dated are as described in date lists.

(O-170) was reported by Sellards and Evans (1960) (Figure 2). Subsequently, two more ages were reported (A-489 and A-512; Table VIIIA) that J. Hester (1972:174–176) linked to the unit that yielded the Portales material. The wide range of ages led Hester (1972:174) to suspect that the two younger ages on bone were unreliable. This is certainly the case, because of problems inherent in dating bones (Taylor, 1987). However, the samples producing the two older ages (determined by Haynes et al., 1966) were collected some distance from the Portales bone bed (J. Hester, 1972:176) and may be from a stratigraphically lower unit (Unit E) (Haynes, 1995: 375). The first reasonable age estimate for Firstview may be a date of ca. 8830 yr B.P. (Y-2488; Table VIII) determined in the late 1960s for a "Cody" occupation (Haynes, 1995:375) and never published by the investigator or the laboratory. Otherwise, the first reliable Firstview ages probably came from the Lubbock Lake site (Johnson and Holliday, 1981) (Table VIIIB).

Table VIIIA. Problematic radiocarbon ages for the "Portales Complex" at the Clovis site and Firstview assemblages elsewhere on the Southern Plains.

Site	Age	Lab No.	Reference	Material[a]
Olsen-Chubbock[b]	10,150 ± 500	A-744	Haynes et al., 1971 Wheat, 1972	Bone collagen
Clovis, NM *Portales*	6300 ± 150	O-169	Brannon et al., 1957 Krieger, 1957	Uncharred bone
	6230 ± 150	O-170	Brannon et al., 1957 Krieger, 1957 Sellards & Evans, 1960	Charred bone
	9890 ± 290[c]	A-489	Haynes et al., 1966	Humates and soluble lignins from plant remains
	8560 ± 350[d]	A-512	Haynes et al., 1966, 1967	Burned bone

[a] Materials dated are as described in date lists.
[b] The first radiocarbon age from Olsen-Chubbuck is listed as problematic because of the large standard deviation.
[c] A-489 misreported as coming from Unit C by Hester (1972:176).
[d] First reported as 8470 ± 350 by Haynes et al. (1966:13), but corrected for fractionation by Haynes et al. (1967:12).

Table VIIB. Reliable ages for Firstview assemblages.

Site	Age	Lab No.	Reference	Material[a]
Olsen-Chubbuck, CO	10,150 ± 500	A-744	Haynes et al., 1971 Wheat, 1972	Bone collagen
	9290 ± 60	NSRL-2801 CAMS-31812	Holliday et al., 1999	Bone gelatin, AMS
	9340 ± 60	NSRL-2797 CAMS-31813	Holliday et al., 1999	Bone gelatin, AMS
	9350 ± 70	NSRL-2797 CAMS-32682	Holliday et al., 1999	Bone gelatin, AMS
	9370 ± 60	NSRL-2799 CAMS-32683	Holliday et al., 1999	Bone gelatin, AMS
	9420 ± 60	NSRL-2798 CAMS-24968	Holliday et al., 1999	Bone gelatin, AMS
	9460 ± 50	NSRL-2801 CAMS-32684	Holliday et al., 1999	Bone gelatin, AMS
	9480 ± 60	NSRL-2799 CAMS-31814	Holliday et al., 1999	Bone gelatin, AMS
	av. 9395 ± 20		Holliday et al., 1999	
San Jon, NM	8275 ± 65	A-7438.1	Hill et al., 1995 Holliday, 1997	Humates (humic acid), AMS
Clovis, NM *"Portales"*	8830 ± 160[b]	Y-2488	Haynes, 1995	Sediment organic residue
	8830 ± 160	Y-2488	Haynes, 1995	Sediment organic residue (humin)
Clovis, NM *Firstview*	8690 ± 70	SMU-1671	Johnson & Holliday, 1997	Humates
Clovis, NM	8970 ± 60	SMU-1672	Johnson & Holliday, 1997	Humates
	av. 8690 ± 50	1671 + 1672	Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Lubbock Lake, TX	8210 ± 240	SMU-830	Holliday et al., 1983 Johnson & Holliday, 1981	Humates (humic acid)
	7980 ± 180	SMU-827	Holliday et al., 1983 Johnson & Holliday, 1981	Humates (humic acid)
	8655 ± 90	SI-4177	Holliday et al., 1983 Johnson & Holliday, 1981	Residue (humin)

[a] Materials dated are as described in date lists.
[b] Originally determined by the Yale University radiocarbon lab in the late 1960s but never published (Haynes, 1995:Table IV and p. 375).

The only other radiocarbon determinations for a site producing artifacts seemingly related to the Portales Complex were from the San Jon site (Haynes et al., 1967). The San Jon samples were not from the area of the archaeological excavations, however, and could not be directly linked to the artifact zone, and in any case were considered unreliable (Haynes et al., 1967; J. Hester, 1975:19–20).

Other common unfluted lanceolate projectile points, some of which were included in the "Portales Complex," include types with constricted stems such as

Agate Basin and Milnesand. Milnesand was the first to be defined, based on a large collection of artifacts found with bone at the Milnesand site in eastern New Mexico (Table I, Figure 1) (Sellards, 1955; Warnica and Williamson, 1968). This is the only substantial collection of Milnesand points reported in the literature, and it was never directly dated. Agate Basin artifacts were recovered from the Clovis site, but this categorization is based on general morphological characteristics and not on a systematic comparison with the type Agate Basin collection from Wyoming. Haynes and Agogino (1966:819) suggest that these "Agate Basin" types share a "late contemporaneity" with Folsom, but otherwise the artifacts were not directly dated.

Besides the investigation of specific typological issues and single-component sites, the other significant development in the Southern Plains Paleoindian chronology in the 1950s and the 1960s was continued research at the Clovis site (Table I). Most of this work was unfortunately salvage archaeology resulting from continued and extensive gravel quarrying at the site (J. Hester, 1972). Considerable data were lost and much confusion persists concerning the existing data (J. Hester, 1972), but enough information was recovered to show that the site had occupation levels representing many of the Southern Plains Paleoindian complexes (Haynes and Agogino, 1966; J. Hester, 1972). Moreover, systematic geochronological studies by C. V. Haynes (1967; 1975; Haynes and Agogino, 1966) provided the first sequence of reliable radiocarbon ages to span the Paleoindian record of the region (Figure 3).

On the Northern Plains, as on the Southern Plains, the chronology of the unfluted projectile point styles emerged fitfully through the 1950s and 1960s. The first major step was essentially coincident with the development of radiocarbon dating. Following excavations at the Horner site in Wyoming (Table I, Figure 1), Jepson (1953) recognized that Scottsbluff and Eden points co-occur, along with the distinctive "Cody knife" and proposed that this artifact assemblage be termed the "Cody Complex." Wormington (1957:128, 136–137, 266–267) provided the first systematic discussion and description of the Cody Complex. Horner yielded the first radiocarbon samples for this complex (Table IXA; C-302 and C-795) and one (C-302) was part of the initial set of Paleoindian ages determined by Libby (Arnold and Libby, 1951) (Table II). The two averages calculated for each of the two runs yielded surprisingly similar results considering that one sample was burned bone, which is notoriously problematic, and the other was charcoal, and that the solid carbon method was applied to all samples. Subsequent dating of samples from the site provided somewhat older and more acceptable results (Table IXB), the first acceptable dating of the Cody Complex (Frison, 1978:34). SI-74, however, yielded a very large standard deviation. At about the same time that the second series of samples from Horner were assayed, dates became available from Cody Complex (Eden and Scottsbluff) levels at the Hell Gap site, also in Wyoming (Table I, Figure 1) and the Lamb Spring site, Colorado (Table I, Figure 1) (Table IXB). Frison (1987:105) states that there are no Cody Complex dates from the initial work at Hell Gap. However, I-245 is described as dating "...time at which Scotts Bluff [sic] and other peoples occupied the site..." (Trautman, 1964:279), and A-753A and A-753C_3 are from the "Eden occupation" (Haynes et al., 1971:4–5).

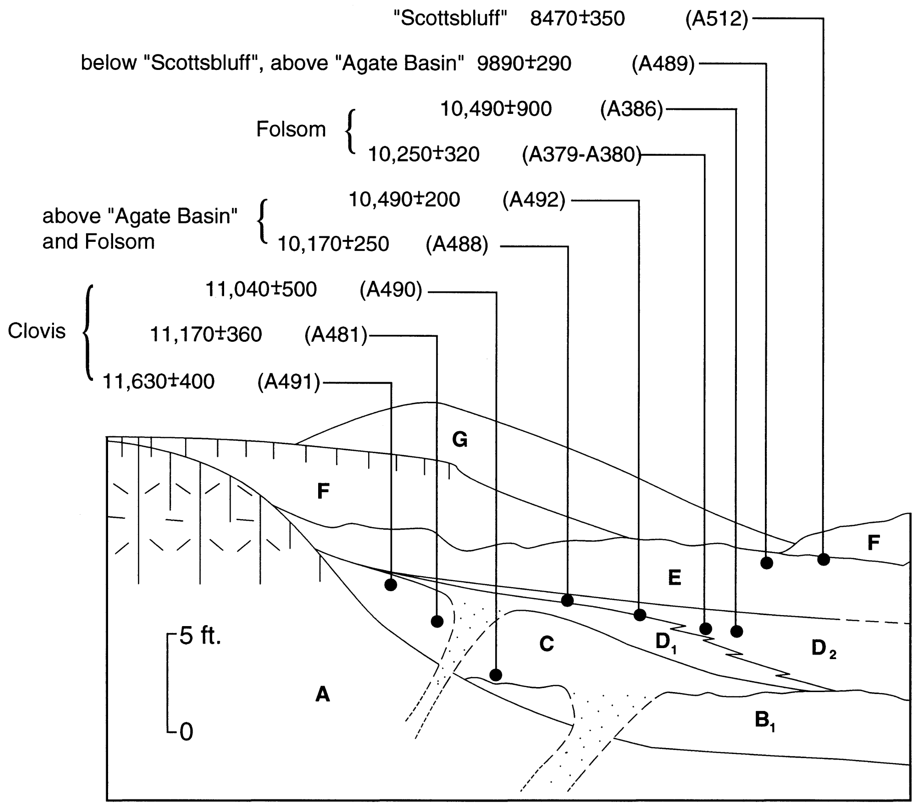

Figure 3. The geologic stratigraphy and radiocarbon chronology of the Clovis site established by C. V. Haynes (1967:Figure 4), showing the locations of radiocarbon samples relative to lithostratigraphic units (lettered), buried soils (vertical hachures), and spring-feeder conduits (stippled). The stratigraphic relationships of the archaeological assemblages are as follows: Unit C = Clovis; Unit D1 = Folsom and Agate Basin; Unit D2 = Folsom; Unit E = Portales. The radiocarbon ages and associated artifact types follow Haynes (1967:Table 1). This sequence was the first reliably dated archaeological record spanning the Paleoindian period on the southern Great Plains.

In 1955 and 1956 in southern Alberta, systematic archaeological studies of extensive surface collections resulted in the identification of “Alberta points” (Wormington, 1957:134; Wormington and Forbis, 1965:1–2, 185–187). Alberta points are comparable to robust Scottsbluff points. They were also commonly found in association with Cody Complex artifacts, but in deflated contexts. Excavations at the Fletcher site (Table I) indicated that Alberta and Scottsbluff artifacts were at least in part contemporaneous (Forbis, 1968).

At about the same time as the work at Horner, archaeologists excavated the Ray Long site in Angostura Reservoir of South Dakota (Table I, Figure 1). The site became the type locality for the Angostura point, one of the most enigmatic and

Table IXA. Radiocarbon ages for the Cody Complex (Eden-Scottsbluff) on the Northern Plains, 1950–1965.

Site	Age	Lab No.	Reference	Material[a]
Horner, WY	6619 ± 350	C-302[b]	Arnold & Libby, 1951	Partially burned bone
	7132 ± 250			
	av. 6876 ± 250			
	6151 ± 500	C-795[b]	Libby, 1955	Charcoal
	7690 ± 850			
	av. 6920 ± 250			
	7880 ± 1300	SI-74[c]	Long, 1965	Charcoal
	8750 ± 120	UCLA-697A[c]	Berger et al., 1965	Bone collagen
	8840 ± 140	UCLA-697B[cd]	Berger et al., 1965	Charred carbon from partially burned bone
Hell Gap, WY	8600 ± 600	I-245[c]	Trautman, 1964	Charcoal
Lamb Spring, CO	7870 ± 240	SI-45[c]	Long, 1965	Unburned bone

[a] Materials dated are as described in date lists.
[b] Also listed in Table II.
[c] Also listed in Table IXB.
[d] UCLA-697B is part of same sample as C-302 according to Frison (1987:Table 4.1)

controversial of Paleoindian styles on the Great Plains. The issues include the typological affiliations of the Angostura form (is it related to Agate Basin or Frederick?) and indeed whether it is a valid type at all (see Hannus, 1986; Thoms, 1993; Hofman, 1996:67–68). Three charcoal samples from the site were dated in the 1950s, including two samples (C-454 and C-604) run by Libby (Table II), but interpretations of the two younger ages are difficult owing to uncertainties of the artifact associations and early dating methods. An older age of ca. 9380 yr B.P. (Table X) "is certainly in the right order of magnitude" (Hofman, 1996:67) for a post-Folsom, obliquely flaked variant. Additional dates are now reported for the site based on reinvestigation by Hannus (1986), but none of the samples were associated with diagnostic artifacts.

In 1959 and 1961, excavations were renewed at and near the Agate Basin site, Wyoming (Table I, Figure 1). The 1959 work at the Brewster site, now considered a component of the Agate Basin site (Frison and Stanford, 1982), showed that the Agate Basin level was stratigraphically above the Folsom occupation, providing the first firm clue to the age of Agate Basin. Radiocarbon samples collected stratigraphically from the Brewster site by C. V. Haynes (Table XIA) further indicated a post-Folsom age for the Agate Basin assemblage, but the large standard deviations precluded a more precise age estimate for the artifacts other than that they are probably $>$ 9000 yr B.P.

The Allen site in Nebraska, excavated in 1947 and 1949 (Table I, Figure 1) contained two Paleoindian occupation levels that yielded charcoal and soil samples first dated by Libby (Table II). Two of these three samples yielded what are prob-

Table IXB. Reliable Alberta and Cody (Eden-Scottsbluff) radiocarbon ages.

Site	Age	Lab No.	Reference	Material[a]
Fletcher, Alberta[b] *Cody*	9380 ± 110	TO-1097	Vickers & Beaudoin, 1989	Seeds, AMS
Benz, ND *Alberta-Cody*	9540 ± 50	UCR-3466	Root, 1998	Charcoal, AMS
Horner, WY *Cody*	7880 ± 1300	SI-74[c]	Long, 1965	Charcoal
	9390 ± 75	SI-4851	Frison, 1987	Charcoal
	av. 9385 ± 75		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
	8750 ± 120	UCLA-697A[c]	Berger et al., 1965	Bone collagen
	8840 ± 140	UCLA-697B[c]	Berger et al., 1965	Charred carbon from partially burned bone
Horner, WY *Alberta-Cody*	9875 ± 85	SI-4851A	Frison, 1987	Charcoal
	10,060 ± 220	I-10900	Frison, 1987	Charcoal
	av. 9900 ± 80		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
	9390 ± 75	SI-4851	Frison, 1987	Charcoal
Finley, WY *Cody*	8950 ± 220	RL-574	Frison, 1978:23, 182–188; 1991:184–185	Material dated not published
	9026 ± 118	SMU-250	Frison, 1978:23, 182–188; 1991:184–185	Material dated not published
	av. 9010 ± 105		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Hell Gap, WY *Cody*	8600 ± 600	I-245[c]	Trautman, 1964	Charcoal
	8890 ± 110	A-753A	Haynes, 1968b Haynes et al., 1971	Bone collagen
	9050 ± 160	A-753C_3	Haynes, 1968b Haynes et al., 1971	Bone apatite
	av. 8935 ± 90		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Frasca, CO *Cody*	8910 ± 90	SI-4848	Fulgham & Stanford, 1982	Uncharred bone
Lindenmeier, CO *Alberta-Cody*	9690 ± 60	TO-341	Haynes et al., 1992a	Charcoal
	9880 ± 70	TO-339	Haynes et al., 1992a	Charcoal
	9770 ± 45		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	

(Continued)

Table IXB. *(Continued)*

Site	Age	Lab No.	Reference	Material[a]
Lamb Spring, CO	7870 ± 240	SI-45[c]	Long, 1965	Unburned bone
Cody				
	8870 ± 350	M-1463	Stanford et al., 1981	Bone collagen
Jurgens, CO[d]	9070 ± 90	SI-3726	Wheat, 1979	Charcoal
Hudson-Meng, NE[e]	9820 ± 160	SMU-224	Agenbroad, 1978	Charcoal
Alberta				
Hell Gap, WY	8590 ± 350	A-707	Haynes et al., 1967	Charcoal
Alberta				
	10,240 ± 300[f]	A-500	Haynes et al., 1966	Carbonaceous silt

[a] Materials dated are as described in date lists.
[b] The Fletcher date is considered a “lower limiting date” for the Cody Complex at the site, but based on stratigraphic considerations, the occupation occurred “not long after” the sample material was deposited (Vickers and Beaudoin, 1989:264).
[c] Also listed in Table IXA.
[d] The Jurgens date is given as 9070 ± 90 B.C. (Wheat, 1979:151), which must be a typographical error based on subsequent discussion of the dating. Wheat (1979:152) identified the projectile points from Jurgens as “Kersey points” and considered them part of the Firstview Complex on the southern Great Plains. The Jurgens date is included here because the site is located on the northern Great Plains as broadly defined.
[e] Hudson-Meng dates SMU-52 and SMU-224 were determined on bone apatite and bone collagen, respectively; SMU-224 is considered the most reliable age for the site (Agenbroad, 1978;116; Haynes and Haas, 1974:374). Recent reinvestigation of the site indicates that the Alberta artifacts may not be associated with the bone bed (L. Todd, pers. commun., 1992).
[f] Sample A-500 was correlated to both Alberta and Hell Gap occupations (Haynes et al., 1966:15).

ably the first Paleoindian radiocarbon ages, at least based on their low laboratory numbers (C-65 and C-108a). The typological affiliations of the Paleoindian artifacts from the Allen site were long unknown, but Bamforth (1991) indicates that the lower of the two levels included some Agate Basin artifacts. But the lower level also was associated with a buried soil surface and, therefore, may have been exposed for some time. In any case, the radiocarbon ages did not clarify the chronology of the site, given the inconsistencies among the ages and their large standard deviations.

Following the development of the radiocarbon method, the single biggest advance in understanding the Northern Plains Paleoindian chronology was the discovery and excavation of the Hell Gap site, Wyoming (Table I, Figure 1). This site is well stratified both geologically and archaeologically, with an essentially complete Paleoindian sequence from a pre-Folsom level to the Paleoindian-Archaic transition. The work at the site in the 1960s was never fully published, but the radiocarbon ages (Figure 4) (Damon et al., 1964; Haynes, 1967; Haynes et al., 1967) and preliminary archaeological data (Irwin-Williams et al., 1973) are available. In terms of geochronology, the Hell Gap site can be viewed as the Northern Plains equivalent to the Clovis site by providing the first sequence of reliable radiocarbon

Table X. Radiocarbon ages for various "parallel-oblique" projectile point assemblages on the Northern Great Plains.

Site	Age	Lab No.	Reference	Material[a]
Ray Long, NE[b] *Angostura*	9380 ± 500	M-370	Crane, 1956 Wheeler, 1995	Charcoal, solid carbon method
James Allen, WY *Jimmy Allen*	7900 ± 400	M-304	Mulloy, 1959 Crane & Griffin, 1958	Burned bone
Little Canyon CK Cave, WY *parallel-oblique*	8790 ± 210	RL-640	Frison, 1978	Material dated not published
Hell Gap, WY[c] *Frederick*	8600 ± 380[d]	A-501	Haynes et al., 1966 Irwin-Williams et al., 1973	Mixed charcoal and earth
Norton, KS *Jimmy Allen/ Frederick*	9080 ± 60	CAMS-16032	Hofman, 1996 Hofman et al., 1995	Bone collagen, AMS
Sutter, KS *Frederick*	7990 ± 245	SM-1420	Katz, 1971, 1973	Charcoal
	7818 ± 245	SM-1421	Katz, 1971, 1973	Charcoal
	7668 ± 237	SM-1423	Katz, 1971, 1973	Charcoal
	av. 7820 ± 140		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	

[a] Materials dated are as described in date lists.
[b] The original "Libby dates" from the Ray Long site (Table II) are not included because (1) the association with the artifacts is unclear, (2) they are on bone, and (3) because they were determined using the solid carbon method. Radiocarbon ages determined on charcoal collected in 1985 (Hannus, 1986) are not included because of uncertain artifact associations.
[c] A date of 7880 ± 430 is reported for the Lusk complex (Frison, 1991:Table 2.2), but the relationship of the artifacts to the date are unclear (Frison, 1991:66–67) so the date is not listed here.
[d] Reported as 8690 ± 380 by Frison (1978:Table 2.5; 1991:Table 2.4).

ages to span the Paleoindian record of the region (Figure 4). Recent restudy indicates, however, that the site stratigraphy is more complex and less clear than originally indicated (Sellet, 1999). Diagnostic artifacts, for example, are not in "proper" chronological order.

The Hell Gap record confirmed the sequence Folsom-Agate Basin-Cody, clarified the stratigraphic relationships of several other assemblages, and also provided evidence for previously unrecognized types. Below the Folsom level was an occupation characterized by unfluted lanceolate projectile points named "Goshen" by the investigators (Irwin-Williams et al., 1973). The point morphology is similar to Plainview, and Irwin (1971) abandoned the name Goshen and applied the name Plainview to these finds after examining casts of the type Plainview collection provided by C. V. Haynes (Haynes, personal communication 1999; see also Frison, 1996:205, 207). Plainview in its type area on the Southern Plains, however, is clearly

Table XIA. Radiocarbon ages for various "constricted-stem" projectile point assemblages on the Great Plains: Agate Basin.

Site	Age	Lab No.	Reference	Material[a]
Agate Basin, WY	10,430 ± 570	RL-557	Frison & Stanford, 1982	Charcoal
Agate Basin (Brewster), WY	9350 ± 450[b]	O-1252	Frison & Stanford, 1982	Charcoal
	9990 ± 225	M-1131	Agogino & Frankforter, 1960 Crane & Griffin, 1959 Frison & Stanford, 1982	Charcoal
	av. 9860 ± 200	1252 ± 1131	Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Hell Gap, WY	10,850 ± 550	I-167	Trautman, 1964	Charcoal from buried soil
Frazier, CO[c]	9550 ± 130	SMU-32	Haynes & Haas, 1974 Wormington, 1984	Soil humates
	9650 ± 130	SMU-31	Haynes & Haas, 1974 Wormington, 1984	Soil humates
	av. 9600 ± 90		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Allen, NE	10,260 ± 360	TX-6596	Bamforth, 1991	Charcoal
	10,600 ± 620	TX-6594	Bamforth, 1991	Charcoal
	av. 10,345 ± 310		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	

[a] Materials dated are as described in date lists.
[b] O-1252 was never published by the lab (Humble) but is noted by Crane and Griffin (1959:244) in the discussion of M-1131. Frison (1991:57) rejected the age as "probably too young," but it is included here because the large standard deviation makes it statistically indistinguishable from M-1131.
[c] The radiocarbon ages for Frazier probably are minimum ages for the occupation level (Haynes and Haas, 1974:373).

Table XIB. Radiocarbon ages for various "constricted-stem" projectile point assemblages on the Great Plains: Hell Gap.

Site	Age	Lab No.	Reference	Material[a]
Hell Gap, WY[b]	10,240 ± 300	A-500	Haynes et al., 1966	Carbonaceous silt
Agate Basin, WY	10,445 ± 110	SI-4430	Frison & Stanford, 1982	Charcoal
Sister's Hill, WY	9600 ± 230	A-372	Agogino & Galloway, 1965 Damon et al., 1964 Haynes & Grey, 1965	Carbonaceous organic matter, humic acid
	9650 ± 250	I-221	Agogino & Galloway, 1965 Haynes & Grey, 1965 Trautman, 1964	Charcoal
	av. 9620 ± 170		Calculation by D. Meltzer, 1999 (after Hietala, 1989)	
Casper, WY	9830 ± 350	RL-125	Frison, 1974	Charcoal
	10,060 ± 170	RL-208	Frison, 1974	Bone
Jones-Miller, CO	10,020 ± 320	SI-1989	Bonnichsen et al., 1987	Charcoal

[a] Materials dated are as described in date lists.
[b] Sample A-500 was correlated to both Hell Gap and Alberta occupations (Haynes et al., 1966:15).

Table XIC. Radiocarbon ages for various "constricted-stem" projectile point assemblages on the Great Plains: Lubbock.

Site	Age	Lab No.	Reference	Material[a]
Lubbock Lake, TX	9950 ± 120	SMU-1261	Knudson et al., 1998	Organic-rich mud, humic acid

[a] Materials dated are as described in date lists.

younger (i.e., post-Folsom). The "Goshen Complex" was problematic and remained unstudied for several decades. The Agate Basin level at Hell Gap "was the best represented of all Paleoindian complexes at the site" (Frison, 1991:57) and was contemporaneous with late Folsom time (10,500–10,000 yr B.P.), based on both stratigraphy and radiocarbon ages (Irwin-Williams et al., 1973). The data from Hell

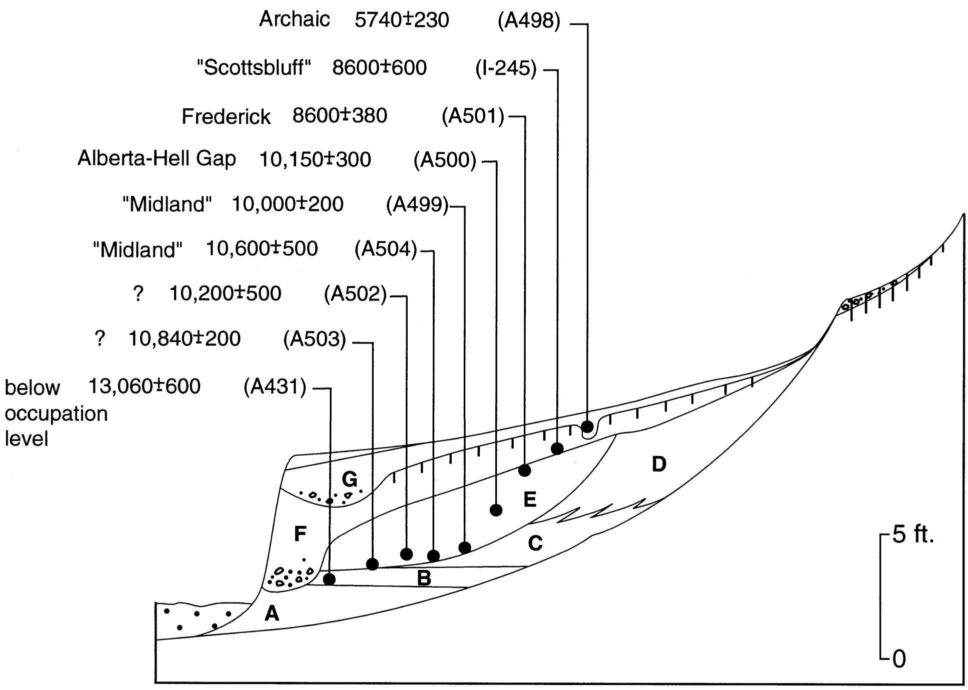

Figure 4. The geologic stratigraphy and radiocarbon chronology of the Hell Gap site established by C. V. Haynes (1967:Figure 5), showing the locations of radiocarbon samples relative to lithostratigraphic units (lettered) and buried soils (vertical hachures). The stratigraphic relationships of the archaeological assemblages are as follows: Unit D = probable Clovis; lower Unit E = Midland (bottom), Agate Basin (middle), and Alberta-Hell Gap (top); upper Unit E = Cody; lower Unit F = Frederick. The radiocarbon ages and associated artifact types follow Haynes (1967:Table 1). This sequence was the first reliably dated archaeological record spanning the Paleoindian period on the northern Great Plains.

Gap and Agate Basin, therefore, indicated that the Agate Basin style was both late-Folsom and post-Folsom in age.

Above the Agate Basin level at Hell Gap was the Hell Gap occupation, first identified on the basis of surface collections in the area prior to excavations at the site (Agogino, 1961). Like Agate Basin, Hell Gap was another of the unfluted post-Folsom variants with a strongly constricted stem. Apparently no radiocarbon ages were determined on the Hell Gap level at the type site, but Irwin-Williams et al. (1973) estimated its age as 10,000–9500 yr B.P. This estimate was confirmed by radiocarbon ages of ca. 9600 yr B.P. at the Sister's Hill site in Wyoming (Haynes and Grey, 1965), also excavated in the mid-1960s (Agogino and Galloway, 1965) (Tables I, XIB, Figure 1).

Below the Cody level at Hell Gap was an Alberta occupation and above the Cody level was an occupation with parallel-oblique-flaked points termed Frederick. Frederick and the previously-named Jimmy Allen type (Mulloy, 1959) were part of the old "oblique Yuma" type and were rarely found *in situ*, much less in stratified contexts. They also represent the final distinct artifact type in the Northern Plains Paleoindian sequence.

THE PALEOINDIAN CHRONOLOGY 50 YEARS AFTER LIBBY

The broad outline of the Paleoindian chronology for the Great Plains that emerged in the 1960s basically has not changed. It was refined and in some regions added to, but with the exception of a few local records, it has not undergone a significant revision. Perhaps the most significant change is the realization that there probably was significant temporal overlap of some point types, and that the old unilinear sequence does not account for all the known typological variation (Frison, 1993; Hofman, 1996:76). The following discussion summarizes the current status of the (uncalibrated) radiocarbon chronology of the Paleoindian record. It is based on the lists of acceptable radiocarbon ages compiled for this article (Tables IIIB, IVB, IVC, VIB, VIIA, VIIIB, X, XI; Figures 5, 6) and on chronologies published by Frison (1991), Hofman (1989, 1996), Bonnichsen et al. (1987), and Haynes (1967, 1992, 1993; Haynes et al., 1992a).

Through the 1960s and 1970s, the dating for Clovis on the Great Plains, based on just a few sites (Clovis, Dent, Domebo, and Colby) suggested an age range of 11,500–11,000 yr B.P. (Haynes, 1970, 1971, 1980). In the 1980s and 1990s a few new Clovis sites on the Great Plains were found and investigated, providing additional dating: the Sheaman component of the Agate Basin site; Lange-Ferguson, South Dakota; and Aubrey, Texas (Figure 1; Tables I, IVB). Some new dates were forthcoming from previously excavated sites such as Dent and Domebo (Table IVB). In addition, a number of sites were excavated that yielded Clovis-age occupations but no diagnostic artifacts (Table IVC). Continued systematic attempts to refine the Clovis chronology by C. V. Haynes tightened and slightly shifted the age range to 11,200–10,900 yr B.P. (Haynes, 1992, 1993). However, radiocarbon ages from the

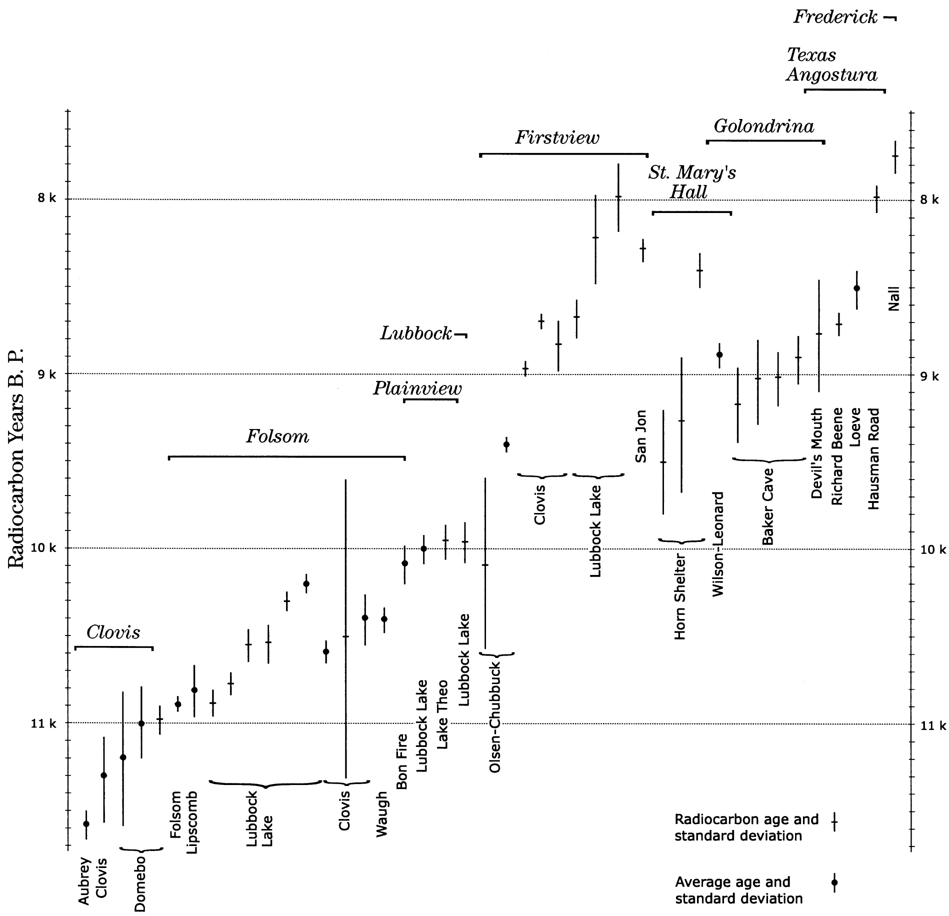

Figure 5. Plot of radiocarbon ages (averages if available, unaveraged individual ages otherwise) for the Southern Great Plains (from Tables IIIB, IVB, VIB, VII, VIIIB, XIC), grouped by artifact type (italic, above) and archaeological site (below).

Aubrey site (Figure 1; Tables I, IVB) suggest that Clovis in that region is as old as 11,500 yr B.P. (Ferring, 1995). Plotting of radiocarbon ages by region further suggests some regional variation in the age of Clovis occupations: 11,600–11,000 yr B.P. on the Southern Great Plains (Figure 5) and 11,200–10,900 (or 10,800?) yr B.P. on the Northern Great Plains (Figure 6).

Dating of Folsom assemblages, like Clovis assemblages, has resulted in a tightening of the chronology because a number of Folsom sites are now dated (Table IIIB), again due in part to the efforts of C. V. Haynes. Folsom is the best dated

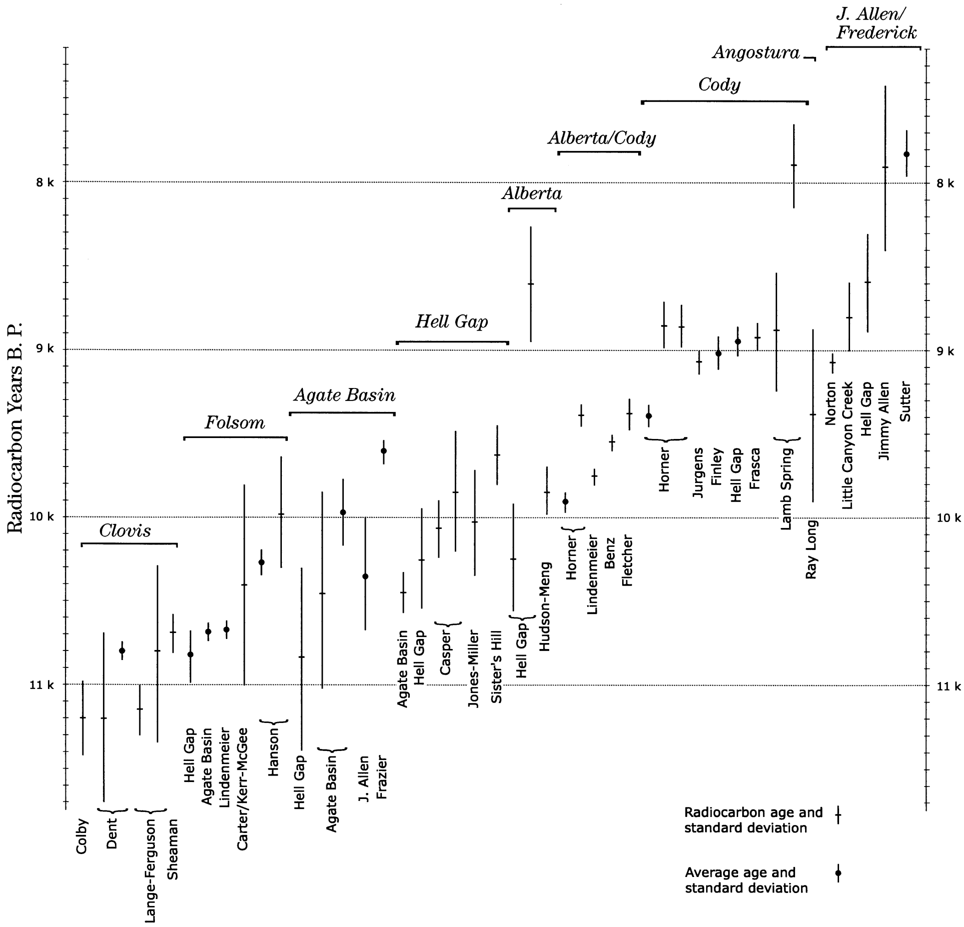

Figure 6. Plot of radiocarbon ages (averages if available, unaveraged individual ages otherwise) for the Northern Great Plains (from Tables IIIB, IVB, IXB, X, XIA,B), grouped by artifact type (italic, above) and archaeological site (below). Dating for Goshen artifacts is not included.

Paleoindian artifact assemblage on the Great Plains. Initially, Folsom appeared to fit well in the 11,000–10,000 yr B.P. range (Haynes, 1971, 1980). Haynes' work on dating the Folsom type site and the Lindenmeier site, as well as data from other sites, old and new (Hanson and Carter-Kerr/McGee, Wyoming; Waugh, Oklahoma; Lipscomb and Lubbock Lake, Texas; and Clovis, New Mexico) (Figure 1, Table I) on the Great Plains refined the dating of Folsom, placing it in the 10,900–10,300 yr B.P. range (Haynes, 1992, 1993; Haynes et al., 1992a) (Table IIIB). Plotting of Folsom radiocarbon ages (Figures 5, 6) suggests an upper age limit of 10,200 yr B.P. on the Northern Plains and 10,100 yr B.P. on the Southern Plains.

Attempts at dating the various unfluted assemblages has provided mixed results. The chronology of some of them appears clear, but others remain somewhat if not altogether ambiguous. One significant advance in recent years is recovery of additional data on the Goshen artifact tradition. The Goshen type remained enigmatic for several decades after its first identification at Hell Gap. Stratigraphically, it was below Folsom at the Hell Gap site, but otherwise was undated. Recent reinvestigation has raised questions about the clarity of this relationship at Hell Gap (Sellet, 1999). Investigations at the Mill Iron site, Montana, produced a number of radiocarbon ages from a Goshen kill and camp site (Frison, 1996). The ages are somewhat problematic, falling into two groups: one set averaging ca. 11,360 yr B.P. and the other averaging ca. 10,840 yr B.P. (Haynes, 1992:364). The older ages may be affected by contamination from Cretaceous lignite (Haynes, 1992:364), so the site is either Clovis age or early Folsom (Frison, 1991:45; 1996:8). In any case, Goshen is indicative of more technological and typological variability at ca. 11,000 yr B.P. on the Northern Plains than was indicated by the classical Clovis-Folsom artifact chronology (Frison, 1993). What is less clear are the broader stylistic affinities of Goshen. The form is strikingly similar to Plainview points of the southern Great Plains. Haynes (1991; and in Frison, 1996:206) and Bradley and Frison (1996:66), for example, see no significant difference between the types, and Frison and Haynes (in Frison, 1996:206) suggest the designation "Goshen-Plainview" for this morphology on the Northern Plains. As indicated above and below, however, Plainview on the Southern Plains is late- and post-Folsom in age. The basic Goshen-Plainview type, therefore, seems to vary in age, depending on the regional setting.

Related to Folsom is the Midland assemblage. Since excavations at the type Midland site in the 1950s and the resulting confusion over the initial dating of the site (Wendorf et al., 1955; Wendorf and Krieger, 1959), there has been considerable debate over the technological, typological, and chronological relationship of Midland to Folsom (e.g., Agogino, 1969; Judge, 1970; Amick, 1995). The idea that Midland substantially predated Folsom was not long-lived, although Krieger (1964: Table 3) associated the site with Clovis occupations but without elaboration. Presumably, he viewed Midland as a predecessor to Folsom. The proposition that Midland points simply are Folsom points too thin to be fluted is generally no longer considered valid (Hofman et al., 1990), though some debate continues (e.g., Haynes, 1991; Frison, 1996:207). Midland appears to be most common on the southern end of the Southern High Plains (though more widespread if Midland is simply unfluted Folsom, as noted by Haynes [1991] and in Frison [1996:207]) and the lack of fluting on Midland points may be a matter of resource conservation (Hofman, 1989:38, 1992:212; Amick, 1995). Midland also may represent the transition from fluted forms to the classic unfluted lanceolate points, specifically Plainview (Hofman et al., 1990). There are some technological similarities between the two types (Knudson, 1983; Haynes, 1991) and apparently some overlap in age between Folsom and Plainview (and therefore between Midland and Plainview), discussed below. Midland appears to be essentially contemporaneous with Folsom, and there is some evidence that it also slightly predates and slightly postdates Folsom (Holliday, 1997). The similarities between Midland and Folsom, Midland and Goshen, and Midland and Plainview raises another possibility: Perhaps Goshen, Midland, and Plainview represent technological and morphological traditions that paralleled, were directly related to, and continued beyond Clovis-Folsom (see also discussions by Haynes [1991] and Frison [1996:68, 207]).

The Plainview type has proven to be problematic in terms of typological distinctiveness and age. One problem is the considerable morphological variation in the type collection. Moreover, because it was one of the first large collections of Paleoindian projectile points to be published and well described, it became a catch-all typology as other investigators attempted to compare their collections with one of the few available well-published unfluted assemblages. Plainview on the Southern High Plains, the type region, is at least in part post-Folsom in age based on the stratigraphic relationship of Plainview above Folsom at Lubbock Lake (Johnson and Holliday, 1980; E. Johnson, 1987), Anderson Basin #2 (J. Hester, 1975; Holliday, 1997), and the Lake Theo site (Harrison and Killen, 1978) (Figure 1). Plainview also overlaps in time with Folsom based on stratigraphic relationships at Bonfire Shelter (Dibble and Loraine, 1968). Radiometrically, Plainview appeared to date to ca. 10,000 yr B.P. based on radiocarbon ages from Lubbock Lake, Lake Theo, and Bonfire Shelter (Johnson and Holliday, 1980; Johnson et al., 1982) (Figure 5). More recent research at Ryan's site (Hartwell, 1995) and the Horace Rivers site (Mallouf and Mandel, 1997) (Figure 1, Tables I, VIC) raises the possibility that Plainview continued as late as ca. 9000 yr B.P. (Holliday, 1997; Holliday et al., 1999), but the reliability of the younger ages from the Ryan's site is uncertain, and the typological associations of the Horace Rivers assemblage is not yet firmly established. An attempt was made to date bone associated with the type Plainview collection using the AMS radiocarbon method of Stafford et al. (1987, 1991), but the results are a frustratingly wide array of ages (Holliday et al., 1999) (Table VIC). As of this writing, Plainview appears to date 10,000 ± 200 yr B.P. (Figure 5) but may have continued as late as 9000 yr B.P.

Generally contemporaneous with Plainview are a variety of unfluted lanceolate artifacts, some with constricted or contracting stems, including the well-known Agate Basin and Hell Gap types common on the Northern Great Plains, and the Milnesand and newly defined Lubbock types on the Southern Great Plains (Table XI). Stratigraphically, Agate Basin occurs above Folsom and below Hell Gap at the Hell Gap (Irwin-Williams et al., 1973), Agate Basin (Frison and Stanford, 1982), and Carter/Kerr-McGee (Frison, 1984) sites (Figure 1). Agate Basin is not particularly well dated (Table XIA), but it appears to overlap with both Folsom and Hell Gap, dating 10,500–10,000 yr B.P. (Irwin-Williams et al., 1973; Frison and Stanford, 1982: 178–180; Frison, 1991:57; Hofman, 1996:65–66) (Table VI). The Hell Gap type dates to 10,000 ± 500 yr B.P. (Table XIB, Figure 6) (Frison, 1991:59–62; Hofman, 1996: 66–68). On the Southern Plains, artifacts described as Agate Basin and sharing a "late contemporaneity" with Folsom are reported from the Clovis site (Haynes and Agogino, 1966), but these artifacts have not been systematically compared with the type Agate Basin collection from Wyoming.

The Milnesand and Lubbock assemblages are each known from one site. The collections from the Milnesand site (Sellards, 1955; Warnica and Williamson, 1968) are the only sizeable assemblages of this type reported. It is undated but includes a variety of morphologies including a few Plainview points (Buchanan et al., 1996). A few hundred meters away is the Williamson site, which yielded a large collection of Plainview points along with a few Milnesand artifacts (Buchanan et al., 1996), but is likewise undated. Based on these assemblages, a reasonable assumption can be made that Milnesand and Plainview are at least in part contemporaneous. The Lubbock assemblage is a small collection of constricted-stem artifacts from the Lubbock Lake site (Knudson et al., 1998). It is contemporaneous with the Lubbock Lake Plainview assemblage both stratigraphically and radiometrically, dating to ca. 9950 yr B.P. (Table XIC). The Milnesand and Lubbock points appear to be Southern Plains time equivalents of the Agate Basin type.

Cody Complex artifact assemblages of the Northern Great Plains, along with Plainview, include some of the best known unfluted Paleoindian types in North America, Eden, and Scottsbluff. In the decades since the complex was defined, archaeologists have recognized a wide range of artifact types as part of Cody including Alberta and Alberta-Cody points (Wormington, 1957; Bradley and Frison, 1987; Hofman, 1996:68–69). The few radiocarbon ages for Alberta and Alberta-Cody (Table IXB, Table VI) fall into the range of ca. 10,200–9400 yr B.P. (one sample from Hell Gap, A-707, Table IXB, has a mean age of 8590 yr B.P., but also a large standard deviation, and is not included in the age estimate) and suggest that those types may have been precursors to and overlapped with Eden and Scottsbluff. Irwin-Williams et al. (1973) even suggest that Alberta evolved from Hell Gap. Otherwise, radiocarbon ages from several sites show that classic Cody (i.e., Eden-Scottsbluff) dates to a relatively narrow interval between 9400 and 8800 yr B.P. (Table IXB, Figure 6; the younger age from Lamb Spring is not included in this estimate) (Frison, 1991:66; Hofman, 1996:69). Plotting of radiocarbon ages shows that Alberta overlaps with Hell Gap and that Alberta, Alberta-Cody, and Cody artifacts represent a long (at least 1400 radiocarbon years) stylistic continuum (Figure 6).

The Firstview assemblage, typologically the Southern Plains equivalent of the Cody Complex, also has an age range similar to Cody. Initially, the type Firstview assemblage (from the Olsen-Chubbuck site) was thought to be a time equivalent to Plainview based on the single radiocarbon age with the large standard deviation from Olsen-Chubbuck (Table VIII, Figure 5) (Wheat, 1972). Dating of Firstview materials from other localities suggested that this was not the case (Holliday 1997; Holiday et al., 1999). AMS radiocarbon ages are now available on bone from Olsen-Chubbuck (Holliday et al., 1999) (Table VIIIB) and confirm this interpretation. This dating also shows that the initial radiocarbon age from Olsen-Chubbuck was in fact reliable within the range of its standard deviation. Firstview has an age range of 9400–8200 yr B.P. (and perhaps as young as 8000 yr B.P.) and therefore is in part a time equivalent of the Cody Complex.

Angostura has been enigmatic since the first excavations at the Ray Long site in the late 1940s. The early charcoal date of ca. 9380 yr B.P. may be reliable, but it has large sigma (Table XI). Reinvestigation of the site has yet to clarify the chronological issues (Hannus, 1986), but Hofman (1996:67–68) suggests that, stylistically and technologically, Angostura may be intermediate between Agate Basin and Frederick.

The Frederick/Jimmy Allen artifact complex of the Northern Plains is one of the youngest recognized Paleoindian artifact assemblage known on the Plains. Frison (1991:74) notes that the parallel-oblique styles such as "Angostura, Frederick, James Allen, Lusk, and others may be local or regional variants of the terminal Paleoindian manifestation for the Northwestern Plains." Hofman (1996:73) notes that "[t]o this list in the Central Plains we need to add Meserve and Dalton [two types more common on the east-central Plains]." These are technological/typological groupings, however, and not temporal. Frederick probably should be subsumed under Jimmy Allen (Frison et al., 1996:16). In any case, Frederick and Jimmy Allen are poorly dated, with a few ages providing only a broad estimate. Frederick at the Hell Gap site was estimated to be 8400–8000 yr B.P. (Irwin-Williams et al., 1973; Frison, 1991:66). A single bone date of ca. 7900 yr B.P. but with a large sigma is reported for the type Jimmy Allen site (Table XI) (Mulloy, 1959). Artifacts similar to Allen were found at the Norton site, Kansas (Figure 1), and dated to ca. 9000 yr B.P. (Table XI). Plotting of radiocarbon ages for Angostura, Jimmy Allen, Frederick, and other parallel-oblique types suggests an age continuum of 9400–7800 yr B.P. (Figure 6).

Dalton generally dates to ca. 10,000 $\pm$ 500 yr B.P. (Goodyear, 1982, 1991; Ray et al., 1998). It is an eastern Plains time-equivalent of Plainview and Agate Basin. Meserve probably is not a valid type but rather reworked Plainview or Dalton (Hofman, 1996:74–75).

Post-Firstview Paleoindian assemblages are poorly documented on the Southern Great Plains. Moreover, evidence for terminal Paleoindian and early Archaic occupations is very scarce in the region (Holliday, 1997). In the Oklahoma Panhandle, a few clues to the latest Paleoindian artifact chronologies are beginning to emerge from reinvestigation of the Nall site (Figure 1). Collecting at Nall during the "Dust Bowl" days of the 1930s resulted in a very large collection of Paleoindian artifacts dominated by unfluted, lanceolate parallel-sided points called "Plainview" (Baker et al., 1957). Reinvestigation of the site and the collections indicates that the artifacts have parallel-oblique flaking more similar to the Frederick/Allen styles (LaBelle, 1999). A radiocarbon age of ca. 7740 yr B.P. (Table VII) further supports this interpretation.

Farther south on the Edwards Plateau and east on the Osage Plains, several artifact styles appear to post-date Firstview, but age relationships are just emerging. The most commonly identified types have been referred to as Plainview, Golondrina, and Angostura. Golondrina is ubiquitous on the southern edge of the Edwards Plateau on into southern Texas (T. Hester, 1977; Hester et al., 1995; Thurmond, 1990:Figure 10) and is well dated at several sites to 9200–8900 yr B.P. (Table VII, Figure 5). Most artifacts termed "Plainview" on the southern Edwards Plateau seem to be technologically and morphologically distinctive from Plainview on the High Plains and are now termed "St. Mary's Hall" points (Collins, 1995:382; T. Hester, 1995:435). Dating remains unclear. Such artifacts were found at Levi rockshelter (Alexander, 1963), but, as noted above, the radiocarbon sequence from the site is problematic. Horn Shelter yielded an assemblage now considered to be "St. Mary's Hall" artifacts (Redder, 1985; Collins, 1995), but again most of the radiocarbon ages are on shell (Watt, 1978) and are therefore suspect. Paired samples of charcoal and shell from one of the Paleoindian levels at Horn Shelter (Table VIIB) indicate that the shell ages are falsely old by several hundred years, so the St. Mary's Hall assemblage probably dates from the period ca. 9500–8500 yr B.P. This age range is supported by dating at the Wilson-Leonard site (Table VIIA) (Collins et al., 1993; Masson and Collins, 1995).

The Angostura type, in Texas as elsewhere, is a very poorly defined category of contracting-base, lanceolate points with oblique, parallel flaking, but is very common in southern Texas (Thurmond, 1990:Figure 10; Thoms, 1993; Turner and Hester, 1993). The Texas variety of Angostura seems to be distinct from the type Angostura at the Ray Long site on the northern High Plains and is now usually referred to as "Texas Angostura" (Turner and Hester, 1993). This artifact type was first well documented on the Edwards Plateau at Levi shelter (Alexander, 1963), associated with three questionable radiocarbon ages (see above) ranging from ca. 9300 to 6800 yr B.P. Texas Angostura assemblages are dated by only a few radiocarbon ages from three sites, Richard Beene, Loeve, and Baker Cave (Tables I, VII; Figures 1, 5). The one date from Baker Cave is substantially younger than the other Angostura ages (Table VII), though the group of ages from Loeve included one $<$ 7000 yr B.P., but that date is not considered reliable (Table VII) (Prewitt, 1982:236–238; E. Prewitt, personal communication, 1998). The date from Baker Cave is listed, but should be viewed with caution and is not plotted in Figure 5. The radiocarbon ages from Wilson-Leonard (Table VII) apparently come from below or at the base of the Texas Angostura level. A date of ca. 8800 yr B.P. from the Devil's Mouth site (Tables I, VII, Figure 1) was correlated with both Angostura and Golondrina (Sorrow, 1968). The stratigraphic association of the sample is not clear, but the assay fits nicely between Angostura and Golondrina ages (Figure 5). These limited data indicate that Texas Angostura dates in the 8800–8000 yr B.P. range.

Plotting of radiocarbon ages for St. Mary's Hall, Golondrina, and Texas Angostura suggests an age continuum of 9200–8000 yr B.P. (Figure 5). These artifact traditions are a rough time equivalent to the Angostura-Frederick parallel-oblique assemblages of the Northern Great Plains.

Artifact types such as Golondrina and Texas Angostura appear to be characteristic of the late Paleoindian occupation of Central Texas and probably the Osage Plains, but are comparatively rare on the High Plains. Moreover, in Central Texas projectile points with more “Archaic” characteristics (e.g., “early Barbed,” “early stemmed,” and Baker) appear to overlap in time with Golondrina (Collins, 1976; T. Hester, 1982, 1988; Prewitt, 1981, 1983). Golondrina and Angostura may be Paleoindian artifacts only in a technological and morphological sense. Emerging data suggest these and probably other unfluted lanceolate types are associated with an Archaic subsistence (Collins, 1976; Prewitt, 1981; T. Hester, 1982), though cooccurring in time with the classic late Paleoindian artifact styles and subsistence of the High Plains.

Beyond establishing chronologies for individual artifact types, radiocarbon dating has contributed to a better understanding of the complexities of the Paleoindian record of the Great Plains. As Hofman (1996:55) notes, “we have generally assumed that the chronological and technological variation in Plains Paleoindian projectile points was a single unilinear development,” that is, Clovis-Folsom-Cody or Clovis-Folsom-Plainview. These were reasonable assumptions for the 1940s, 1950s, and 1960s, based on the stratigraphic evidence from multicomponent sites such as Clovis, Lubbock Lake, Agate Basin, and Hell Gap. Indeed, some temporal overlap in post-Folsom styles has been recognized for some time. However, as outlined in the foregoing discussions, the widespread and liberal application of the radiocarbon method at a large number of sites in the past few decades clearly demonstrates that during much of the Paleoindian stage, several artifact styles were present at essentially the same time in some regions of the Great Plains: Goshen cooccurs with either Clovis or Folsom or both on the Northern Plains; Midland is contemporaneous with Folsom; Agate Basin, Plainview, Milnesand, and Lubbock types are all present at ca. 10,000 yr B.P.; and Agate Basin and Plainview overlap with late Folsom. Morphologic (and therefore taxonomic) variability among projectile points becomes even more pronounced after 10,000 yr B.P. throughout the Plains. Frison (1993) and Hofman (1996:76–78) discuss the archaeological implications of this emerging non-unilinear view of Paleoindian artifact assemblages. Moreover, archaeologists are becoming increasingly aware of significant variability among individual artifact “types” across and beyond the Great Plains, including the classic Clovis and Folsom forms (e.g., Howard, 1990; Hofman, 1996:46–47, 55–60).

PROBLEMS AND PROSPECTS

The Paleoindian archaeological record for the Great Plains arguably is the best known and best dated of any regional latest Pleistocene/early Holocene assemblage in the Western Hemisphere. The Great Plains Paleoindian record has served as a typological and temporal model of Paleoindian occupation elsewhere in North America, perhaps to the detriment of the other regions, owing to stylistic variations across time and space. As the previous discussions illustrated, questions and problems regarding the Paleoindian chronology abound, although the broad outlines seem clear. Several technological developments in dating offer the promise of resolving these problems, but some seemingly intractable issues remain.

One of the most fundamental issues for refining the Paleoindian chronology is the discovery of stratified sites with multiple, well-preserved Paleoindian occupation levels. Most of the well-known and dated sites were discovered and first investigated in the 1930s–1960s. Many of the more recent studies of stratified, multicomponent Paleoindian sites have focused on returning to the known sites: Clovis (Stanford et al., 1990; Haynes, 1995), Lubbock Lake (E. Johnson, 1987), Agate Basin (Frison and Stanford, 1982), and Hell Gap (currently under reinvestigation). In the past several decades, only one site of this type has been discovered, investigated, and reported: Carter-Kerr/McGee (Frison, 1984).

Stratified multicomponent archaeological sites often gain considerable attention, but discovery of single-component sites have been and probably will continue to be more common than the multicomponent sites. Indeed, the attention given to the Paleoindian sites with multiple, stratified occupation zones probably reinforced the notion of a linear development sequence of artifact styles. Single-component sites sometimes seem difficult to fit into existing cultural chronological schemes (the Plainview type site may be an extreme example of this problem), but the lack of older or younger artifact styles may also free us from thinking about a simple sequential typological evolution (e.g., excavations at the Mill Iron site and the resulting ideas on the Goshen assemblage). Refinements in the radiocarbon method also make single component sites somewhat easier to date (e.g., resolution of the age of the Olsen-Chubbuck site using AMS dating of amino acids from bone). As noted below, however, calibration of radiocarbon ages limits the degree of precision and accuracy necessary to refine the details of artifact geochronology.

Regardless of the kinds of sites necessary for refinement of a radiocarbon chronology, the broader question is: How to find *in situ* Paleoindian sites? Many of the discoveries in the 1930s– 1960s were related to the wind erosion of the 1930s and 1950s and to the large post-World War II river basin projects. The advent of more wide-spread CRM or "contract" archaeology beginning in the 1970s should have resulted in discovery of many more suitable Paleoindian sites (35 out of 54 or two-thirds of the sites listed in Table I were first investigated between 1926 and 1966). Equally curiously, very few Paleoindian sites have been found as a result of surveys designed specifically for that purpose (e.g., Frison, 1984). In spite of all we seem to know about settlement patterns, paleogeomorphology, and site formation processes (e.g., Ferring, 1994), we obviously do not yet know enough to successfully predict site locations!

Reinvestigation of known and previously studied sites has helped resolve many chronological and typological issues. And as Tiffany (1993:2–3) notes, many of the "well-known" or "classic" sites on the Great Plains are not that well known or well reported. The importance of reinvestigation has been amply demonstrated at such sites as Clovis, Lubbock Lake, Midland, Agate Basin, and Horner, among others. Equally important, however, is the reinvestigation of collections from earlier work. Dating of bone from Olsen-Chubbuck, for example, solved a decades-old problem regarding the age of that significant site.

Beyond simply finding more sites or producing more dates in order to understand the chronology, archaeologists must address more fundamental issues of typology.

In particular, there should be a more systematic basis for typological classification and for determining what variation within a type is important and what is not. This includes not only morphological and technological variation, but geographic and temporal variation. For example, these issues are at the heart of debate over the validity of the Firstview Complex versus the Cody Complex or the Goshen versus Plainview types. Because chronology is only one of several goals of typology, however, there will probably be no simple or single solution to this issue.

At a practical level, a recurring problem for all archaeological periods on the Great Plains is the relative lack of dateable materials because of the relative paucity of wood and charcoal. This is particularly notable on the drier western and southwestern High Plains (Martin and Johnson, 1995; Holliday, 1997). For example, of the 62 radiocarbon ages on Paleoindian strata and features at the Lubbock Lake site, only three are on wood or charcoal (Holliday et al., 1983, 1985). The dating at many sites, especially on the Southern Plains, has had to rely on sampling of organic-rich sediments and soils. The resulting dates are generally adequate in semiarid, nonleaching environments, but can be problematic. Again using Lubbock Lake as an example, of the 46 radiocarbon ages determined on Paleoindian sediment or soil, 17 are questionable (Holliday et al., 1983, 1985).

The advent of AMS radiocarbon dating in the last two decades has somewhat eased the problem of finding suitable materials. The AMS method allows dating of very small charcoal fragments which, for example, has helped refine the chronology of Folsom occupations at the Lindenmeier and type Folsom sites (Haynes et al.,1992a). The AMS method has also been applied to the dating of bone, whereby specific amino acids are extracted and then dated, thus circumventing some of the many problems encountered in radiocarbon dating of bone (Stafford et al., 1987, 1991). This method was successfully applied to the dating of the Dent and Domebo Clovis sites (Stafford et al., 1987, 1991) and the Firstview type collection from Olsen-Chubbuck (Holliday et al., 1999). AMS is not a panacea, however. Attempts at precision radiocarbon dating at the Clovis site, though helping to refine some aspects of the geochronology, also resulted in a number of age reversals (Haynes, 1995). The AMS dating of bone also can result in as yet unexplainable, very large (several thousand years) ranges in ages from a single bone bed (e.g., Holliday et al., 1999).

A broader problem of concern to all investigators studying late Pleistocene or early Holocene chronologies, conditions, or processes is the issue of radiocarbon calibration. For several decades following the recognition (in the late 1960s) of secular variations in the radiocarbon time scale, calibrations extended back to ca. 8000 radiocarbon yr B.P. and included only the very late Paleoindian period (e.g., Olsson, 1970; Suess, 1980). A number of investigators speculated about the possible effect of calibration on the Paleoindian chronology (e.g., Haynes, 1971; Taylor, 1987, 1991; Batt and Pollard, 1996). C. V. Haynes was once again at the forefront by being the first to raise the issue. This situation changed dramatically in the past decade with (1) extension of the dendrochronological calibration to ca. 11,000 radiocarbon yr B.P. (Becker, 1993; Stuiver and Reimer, 1993) and (2) pairing of uranium/thorium and radiocarbon ages from samples of marine corals to extend the calibration further back into the late Pleistocene (Bard et al., 1993a, 1993b; Edwards et al., 1993). Radiocarbon calibrations are now available for the entire Paleoindian period.

The precision and accuracy of the radiocarbon calibrations that span the Paleoindian period are not yet as well established as the initial tree-ring calibrations and probably will require correction (e.g., Stuiver and Pearson, 1992; Becker, 1993; Stuiver, 1993), but the trends and their impact on interpreting the Paleoindian chronology are clear (e.g., Taylor et al., 1996; Fiedel, 1999; for some broader implications see also Bartlein et al., 1995). There are several radiocarbon "plateaus" in the calibration curve (Figure 7) that interfere with the precision of the calibrations; that is, some radiocarbon ages do not have unique conversions to calendar years. This is particularly apparent for 10,100–9900 and 9600–9400 radiocarbon yr B.P. For example, a radiocarbon age of 10,015 years has 14 calibration points spread over about 400 calendar years, or, as Becker and Kromer (1993) show, two samples dated 10,000 ^{14}C yr B.P. and 9500 ^{14}C yr B.P., respectively, with an age error of $\pm$ 50 years, may be between 150 and 1000 calendar years apart. Radiocarbon dating by itself, therefore, can never determine how much or how little temporal overlap there was between some Paleoindian artifact styles (Folsom and Plainview, for example). At this time, there is little that Paleoindian researchers can do about this problem except to be aware of it and to realize that some issues of the chronology are and probably will remain beyond the capabilities of radiocarbon resolution and ultimately must be worked out stratigraphically in the field.

The issue of calibration returns the focus to stratified archaeological sites with multiple, sequential Paleoindian occupation zones. These sites will play key roles in addressing some of the chronological problems posed by calibration. For example, the radiocarbon plateau at ca. 10,000 yr B.P. poses a significant problem for dating the Plainview type, but the stratigraphic sequence at Lubbock Lake clearly shows that Plainview is at least in part younger than Folsom. Stratified archaeological sites will also be keys in making subregional comparisons of artifact chronologies. For example, if additional work at Hell Gap shows the Goshen type below the Folsom occupation, this will be important in drawing conclusions about the relationship of Goshen to the similar but post-Folsom Plainview type.

Regardless of technological advances in dating or for that matter in archaeological field techniques, the fundamental principles of careful observation, recording, and sampling still remain. In the earliest days of the radiocarbon method, Cressman (1951:311) reminded archaeologists that sound stratigraphy, observation, and correlation are even more necessary as more precision in dating is attained. Put another way, the reliability of dating results is never better than the reliability of our field work.

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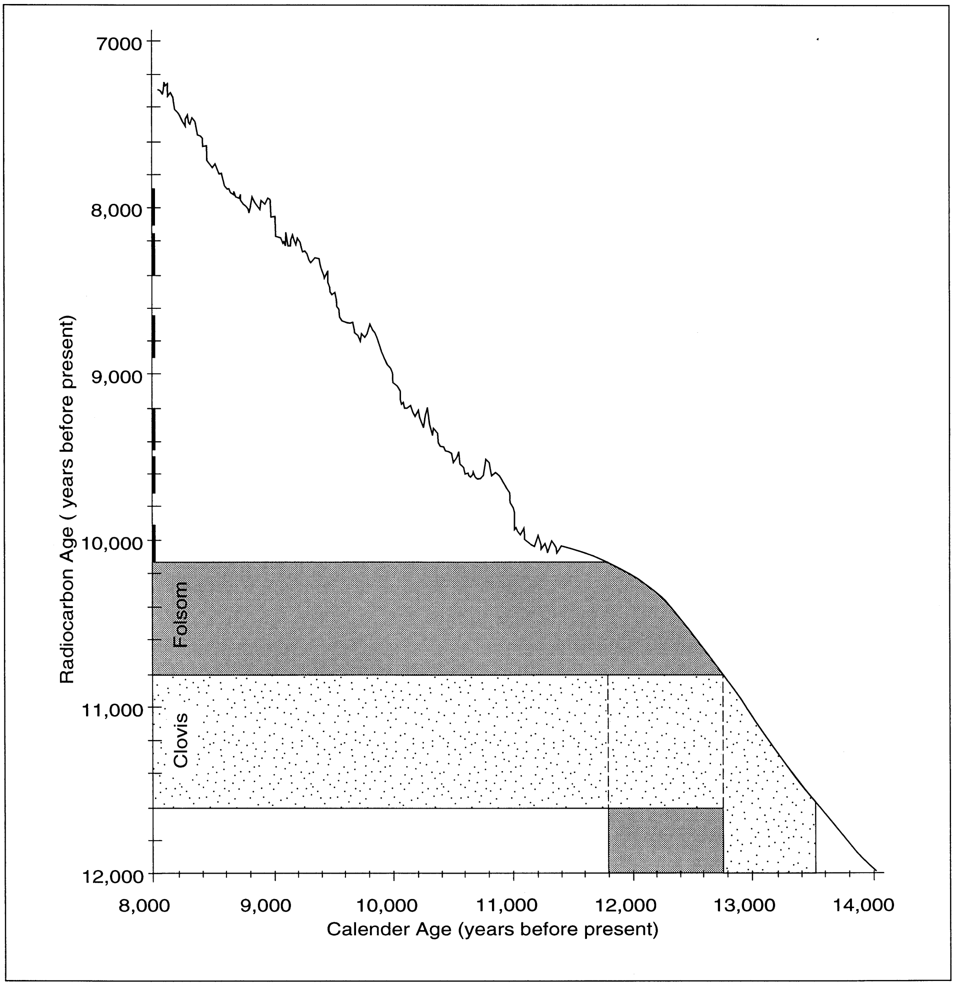

Figure 7. Radiocarbon calibration curve for the Paleoindian period (modified from Lowell and Teller, 1994:Figure 1; see also Taylor et al., 1996:Figure 4) illustrating the "plateau effect" on the Paleoindian chronology. The intervals for Clovis and Folsom are highlighted with shading. Post-Folsom periods of problematic interpretation on the radiocarbon scale are indicated by the bars.

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