Vance Haynes and Paleoindian Geoarchaeology and Geochronology of the Great Plains

Vance T. Holliday

Department of Geography, 550 North Park Street, University of Wisconsin, Madison, Wisconsin 53706

Geoarchaeological and geochronological research has been an intimate component of Paleoindian investigations on the Great Plains for more than 70 years. Current ideas on the geologic, chronologic, and environmental context of the Paleoindian occupation of the region are based on decades of research by many individuals, but no single investigator has been more directly involved and made more substantive contributions to this geoarchaeological research than Vance Haynes. He was the first and still remains one of the few geoscientists to systematically investigate the stratigraphy and geochronology of Paleoindian sites (and late Pleistocene and early Holocene settings in general) throughout the region. In particular, his work at the Hell Gap site, Wyoming, provided the first comprehensive Paleoindian geochronology for the Northern Great Plains, and his initial investigations at the Clovis site, New Mexico, resulted in the first well-dated Paleoindian chronology for the Southern Great Plains. More broadly, his study of the southwestern "alluvial chronology" (1968) is a classic study in regional late Quaternary stratigraphy and environmental reconstructions, a landmark in understanding semiarid alluvial systems, and a stratigraphic and geochronologic model specifically oriented toward geoarchaeology. More than 30 years later, the Paleoindian geoarchaeology and geochronology of the Great Plains that Vance worked out, though much refined (largely through his own efforts), still holds and is the basic framework within which we continue to work.

INTRODUCTION

This article focuses on Vance Haynes' impact on Paleoindian studies in a particular region - the Great Plains of the United States—in terms of his work in geoarchaeology and geochronology. The Great Plains is an appropriate place to highlight some of the specifics of Vance's career in geoarchaeology and geochronology because the region contains one of the highest concentrations of well-known Paleoindian sites in North America and because, more broadly, many of these sites played an important role in establishing our view of Paleoindian subsistence, environments, and artifact styles (e.g., Wormington, 1957; Hofman, 1989, 1996; Frison, 1991; Holliday, 1997). A number of Great Plains sites were also keys to determining the chronology of Paleoindian occupations in the years before, during, and since the development of radiocarbon and other numerical dating methods (Haynes, 1990, 1992; Holliday, 2000a). Because many of these sites are stratified and because many investigators of these sites were earth scientists or had strong geoscience training,

Geoarchaeology: An International Journal, Vol. 15, No. 6, 511–522 (2000)

geoarchaeology has a long tradition in Paleoindian studies on the Great Plains (Holliday, 1997; Mandel, 2000). Not surprisingly, therefore, Vance has been a key figure in Paleoindian research in the region and a large part of his work has been on the Plains.

PALEOINDIAN GEOCHRONOLOGY ON THE GREAT PLAINS, 1927–1960

In the decades following the discoveries at the Folsom site in the late 1920s, one of the fundamental questions in Paleoindian archaeology was the chronological relationship among the many different artifact types that were being identified. The issue was initially addressed using a fundamental geologic method: stratigraphy, both regional stratigraphic correlation or so-called "geologic-climatic dating" and site stratigraphy. Most of this work was on the Great Plains because that is where most of the stratified sites with sequential Paleoindian occupations were turning up (e.g., Haynes, 1990; Holliday, 2000a; Mandel, 2000). Indeed, two of the key sites involved in geologic-climatic dating (Clovis and Lindenmeier) are the best known Paleoindian sites in North America. As it turns out, the principal figures in these stratigraphic approaches to establishing artifact chronologies were leading geologists who would have a profound influence on Vance Haynes' career, working at sites that Vance would become closely associated with.

Geologic-climatic dating involved the long-distance correlation of stratigraphy of the site in question with the closest glacial or pluvial record and then the longer distance correlation between that record and a varve chronology established by Ernst Antevs (Antevs, 1955; Zeuner, 1958:33–36; Haynes, 1990). Antevs, the leading practitioner of geologic-climatic dating, was the first to apply this method in Paleoindian studies in 1935 by correlating strata containing fluted points at the Clovis site in eastern New Mexico (the Clovis and Folsom styles were not yet differentiated) with the lake level history of pluvial Lake Estancia in central New Mexico (Antevs, 1935, 1949). In the final version of his chronology, Antevs proposed that the artifacts were at most 13,000 and at least 10,000 years old (Antevs, 1949).

At the Lindenmeier site in Colorado, in what is perhaps the best-known example of geologic-climatic dating, Kirk Bryan and his student Louis Ray attempted to estimate the age of the Folsom occupation (Bryan and Ray, 1940). By correlating the site stratigraphy with the Rocky Mountain glacial sequence, 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. John Hack (1943) and then John Moss (1951), both students of Bryan's, also applied this method to date the unfluted lanceolate artifacts recovered at the Finley site in Wyoming. They determined that these artifacts were post-Folsom in age, and Moss (1951, 1952) further argued that they predated the "Altithermal" of Antevs (1948, 1955). Antevs, Bryan, and the rest clearly were on the right track in their age estimates but otherwise could not resolve the age relationships among the fluted point styles or between them.

While Antevs, Bryan, and Bryan's students were concerned with regional stratigraphic correlations to establish artifact chronologies, the first clear and detailed artifact chronology for the Great Plains and the only one for some years to come appeared with continued research at the Clovis site in the late 1940s (Sellards, 1952). There, E.H. Sellards, Glen Evans, and Grayson Meade, through stratigraphic excavations and careful observation, showed that the Clovis style was older than Folsom and that a variety of unfluted lanceolate forms were younger than Folsom (Sellards, 1952; Sellards and Evans, 1960; Haynes, 1990; Holliday, 1997).

This landmark work at Clovis took place at about the same time that Willard Libby and colleagues were developing the radiocarbon method of dating. Throughout the 1950s, this new method was applied at a number of Paleoindian sites, but little was resolved (Holliday, 2000a). On the Northern Plains, no sites had yet produced a good artifact sequence, and few sites yielded reasonable radiocarbon ages or dateable materials. On the Southern Plains, the dating method was somewhat more widely applied, and in his last article, E. H. Sellards and co-author Glen Evans presented the first dated geochronology spanning the then known Paleoindian sequence (Sellards and Evans, 1960). They also presented one of the first regional models linking the archaeological sequence to changing depositional environments. The details of the chronology—based on field data and radiocarbon ages from Clovis, Lubbock Lake, Plainview, and Midland—turned out to be in error because all of the radiocarbon ages proved unreliable (Holliday, 1997, 2000a), but the scheme was basically correct and of the right order of magnitude.

Besides radiocarbon dating, another major post-war change in archaeology was the growing interest in and application of interdisciplinary "environmental archaeology" (Butzer, 1971:6–11). However, in Paleoindian studies on the Great Plains and elsewhere in the United States, this sort of interdisciplinary work had long been the norm (e.g., Mandel, 2000). One of the first regional interdisciplinary projects in environmental archaeology in North America was the High Plains Paleoecology Project, established by Fred Wendorf (Wendorf, 1961; Wendorf and Hester, 1975; see also Holliday, 1997). This project, which evolved out of Wendorf's interdisciplinary work at the Midland site ran from the late 1950s to the early 1960s, and involved archaeologists, paleontologists, paleobotanists, and geologists.

ENTER VANCE HAYNES

During the 1950s, Vance started combining his long avocational interest in archaeology with his training and career work in geology (though the latter was in engineering geology and metamorphic petrology) (C. V. Haynes, personal communication, 1999). A series of fortuitous military postings in Albuquerque, Austin, and Fairbanks, coupled with his choice of the Colorado School of Mines near Denver for an undergraduate degree, brought him into contact with some of the leading Paleoindian archaeologists of the day, including Frank Hibben, Fred Wendorf, Alex Krieger, E. H. Sellards, Glen Evans, Dave Hopkins, Marie Wormington, Henry and Cynthia Irwin, and George Agogino.

By 1960, he and George Agogino had begun a systematic search for charcoal among the many Paleoindian sites on the Great Plains, resulting in the first reliable date for Folsom based on work at Lindenmeier (Haynes and Agogino, 1960). Their work also resulted in the first reliable age control for the Dent and Agate Basin sites (Haynes, 1964a). This dating project was one of the first regional, systematic applications of the radiocarbon method. Before this time, most radiocarbon dating in archaeology on the Great Plains and throughout North America was based largely on fortuitous discovery of suitable material (Holliday, 2000a). Moreover, and to paraphrase Vance, a lot of the early applications of radiocarbon dating were in conjunction with archaeological discoveries, and too little attention was given to geologic applications of the method or to the stratigraphic provenience of the sample (Haynes, 1968:596).

This work resulted in his landmark 1964 article in *Science* (Haynes, 1964a) that first laid out an accurate Paleoindian chronology based on careful application (mostly by him) of the then still relatively new radiocarbon method. Our understanding of both Clovis and Folsom chronology began with that article.

Being one of the few geologists interested in archaeological questions at the same time that environmental archaeology was taking off, and having been in contact with the Who's Who of Paleoindian studies, he quickly became involved in a variety of projects in the early 1960s such as Hell Gap (Haynes et al., 1965; Irwin-Williams et al., 1973) and Sister's Hill in Wyoming (Agogino and Galloway, 1965; Haynes and Grey, 1965), and was invited by Fred Wendorf to join the High Plains Paleoecology Project (HPPP). This project was also Vance's entrée to work at the Clovis site. All of these events more or less marked the beginning of Vance's professional career in geoarchaeology and Paleoindian studies and resulted in a series of landmark articles in the 1960s, 1970s, and 1980s (e.g., Haynes, 1966, 1970, 1973, 1980, in addition to articles noted below).

Vance's initial work at Hell Gap and Clovis in the early 1960s were milestones in Great Plains geoarchaeology and Paleoindian studies. Both sites contain long and extensive records of Paleoindian habitation, each providing a more or less complete record of the regional Paleoindian sequence. The work at Hell Gap was one of the single biggest advances in understanding the Northern Plains Paleoindian chronology following the development of the radiocarbon dating method itself. Until the Hell Gap work, the stratigraphic relationships of the Paleoindian record in the region largely were inferred based on data elsewhere, especially the Southern Great Plains. The results from Hell Gap combined with his work at Sister's Hill and the U.P. mammoth site (Haynes, 1968) also provided the outlines for the first regional model of late Quaternary geoarchaeology in the Wyoming Basin and Northern Great Plains.

At about the same time, Vance's initial work at Clovis resulted in the first well-dated Paleoindian and post-Paleoindian archaeological sequence for the Southern Great Plains (Haynes, 1967, 1975; Haynes and Agogino, 1966). Because this work was part of the HPPP, it also formed a stratigraphic and geochronologic basis for

refining and revising the regional Paleoindian geoarchaeological stratigraphic sequence proposed by Sellards and Evans (1960).

Hell Gap and Clovis were and are spectacular sites in their own right, but Vance brought something unique to his work in the early 1960s. Beyond simply being the first systematic applications of radiocarbon dating or the first comprehensive assessments of the stratigraphy and geochronology of Hell Gap and Clovis, we also see in this and his other work in the early 1960s what will be a hallmark of "Haynesian geoarchaeology": very careful attention to microstratigraphic detail. Vance's microstratigraphy focuses not just on sedimentology and depositional environments but on archaeological relationships and radiocarbon sampling. Attention to detail in recording and sampling is not unusual in archaeology or in the geosciences, but Vance brought a unique combination of a solid training and experience in field geology, a passion for archaeology, and an understanding of radiocarbon geochemistry.

More generally, Vance's early work at Hell Gap, Clovis, and other sites on the Great Plains was the first and is still one of the few regional geoarchaeological investigations where the same individual studied both the site and regional stratigraphy, assessed the archaeology, and both collected and processed the radiocarbon samples. This has provided him with a perspective at a subcontinental scale that is probably unique in all of North American geoarchaeology.

ALLUVIAL CHRONOLOGY

This work on the Great Plains, combined with similar studies he was engaged with in the Southwest, culminated in Vance's synthesis "Geochronology of Late-Quaternary Alluvium" published in 1968 in one of the many volumes resulting from the 1965 INQUA Congress in Boulder, Colorado (Haynes, 1968). The article was in the tradition of and evolved from the work of Kirk Bryan. Bryan had a long-standing interest in the cycles, causes, and chronology of erosion and deposition in arroyos of the Southwestern United States (e.g., Bryan, 1922, 1925, 1940; see also Miller, 1958, and Haynes, 1990). During Bryan's many years of work in the region, he developed a stratigraphic model for these cycles that became known as the "alluvial chronology" (Bryan, 1941). Of particular interest to Bryan, his students, and others, including Ernst Antevs, was the relationship between climate and these cycles in alluvial systems. This has been a long-standing debate in geomorphology that continues today (e.g., Butzer, 1980; Knox, 1983; Bull, 1991), but Vance Haynes first put the chronology into a regional dated context. He pulled together stratigraphic and geochronologic data from 17 sites and regions (Figure 1). The article is a classic study in regional late Quaternary stratigraphy and environmental reconstructions and is a landmark in understanding semiarid alluvial systems. More to the point of this article, he presented a stratigraphic and geochronologic model specifically oriented toward geoarchaeology. The scheme provided a physical and temporal framework with which sequences from other archaeological sites could be com-

Deposition	Hopi Country, Arizona	Big Bend Region, Texas	Mexican Springs Wash, New Mexico	Eastern Wyoming	Kassler area, Colorado	Nebraska	La Sal Mountains, Utah	Domebo site, Oklahoma
E	Naha formation	Kokernot formation	Upper Nakaibito formation		Post-Piney Creek alluvium		Gold Basin formation	Q3
							Paleosol	
D	Tsegi formation	Calamity formation	Lower Nakaibito formation	Kaycee formation	Piney Creek alluvium		Gold Basin formation	Q2
Soil	(erosion and dunes)	(erosion and dunes)	(erosion and paleosol)	Paleosol	Paleosol	Soil Y	Paleosol	Upper Domebo formation
C					Pre-Piney Creek alluvium			
B					Broadway alluvium	Bignell Loess and T2 terrace	Beaver Basin formation	Lower Domebo formation
Soil			Paleosol	Paleosol	Paleosol	Soil X	Paleosol	bedrock
A	Jeddito formation	Neville formation	Gamerco formation	Ucross formation	Younger Loess	Loess	Beaver Basin formation	

Deposition	Tule Springs, Nevada	Lehner	Naco	Blackwater No. 1, (Clovis) New Mexico	Lindenmeier site, Colorado	Sister's Hill site	Union Pacific Mammoth site	Brewster site	Hell Gap site
		Arizona				Wyoming			
E	G	H	H	H			E		H
D	F	G_3 / G_2	G	G	G	G	D	G	G_2
Soil	Soil 5	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
C		G_1	F	F	F	F			G_1
B	E_2	F_4 / F_{1-3}	E / D	E / C-D	E / D	E / B-D	D / C	E / B-D	F / E
Soil	Soil 4	Soil	Soil	Erosion	Soil	Soil	Soil		Soil
A	E_1	E	C	B	C	A	A	A	B-D

Figure 1. Correlation chart of alluvial chronologies from the Great Plains, Rocky Mountains, and Basin and Range region of the western United States as proposed by Vance Haynes (modified from Haynes, 1968: Figure 4). Triangles indicate deposits that were radiocarbon dated. The top row represents the work of others; the bottom row is the result of work by Haynes and colleagues. Over 100 radiocarbon ages were available to facilitate correlations, averaging a little more than one date per unit per site. Although some chronologies were revised (e.g., Haynes, 1995), and some correlations may no longer hold, the scheme was the first to document broadly synchronous, regional shifts in depositional environments, though possibly varying in direction and magnitude of change.

pared or correlated. The alluvial chronology also included the concepts of facies variation and soil stratigraphy and attempted to explain, in terms of geomorphology, vegetation, and climate, what the depositional processes were, and how they changed through time and space.

In the 30 years since the chronology was published, many more dated and detailed stratigraphic sequences have become available, and we have learned a lot more about the sensitivity and complexities of alluvial systems and their relationship to biotic and climatic systems (Butzer, 1980; Knox, 1983; Bull, 1991). But generally speaking, the scheme still holds up (e.g., Knox, 1983). What has become apparent since his alluvial chronology was published is that specific types of depositional environments and the sequence of depositional processes may vary over a large area (or even a small one), but significant breaks in a stratigraphic sequence, such as a major erosional unconformity or a depositional hiatus tend to be regionally synchronous. Vance was the first to propose this based on a relatively comprehensive set of dated stratigraphic records.

THE 1970s AND BEYOND

By the late 1960s, Vance was well established as one of the country's leading (and few) geoarchaeologists and Paleoindian researchers. He began his own long-term interdisciplinary archaeological project in the San Pedro Valley of Arizona (e.g., Haynes, 1981, 1982) and was frequently lured away from the Great Plains and Southwest to such places as Egypt, the Sudan, and the northern Ozarks (e.g., Haynes, 1985). The 1970s, however, saw something of a resurgence of Paleoindian studies on the Great Plains and a growing interest in geoarchaeology throughout North America, so Vance remained grounded in his archaeological roots in the Paleoindian "heartland."

The decades of the 1970s, 1980s, and 1990s saw similar sorts of research questions being addressed in familiar patterns. For example, he continued using microstratigraphy and careful application of radiocarbon dating (the AMS method in particular) to clarify artifact chronologies. Radiocarbon dating of the Mill Iron bone bed and analysis of the associated Goshen artifacts has raised a number of questions regarding the age and typological relationships between the Goshen style of the Northern Great Plains and the Plainview style of the Southern Great Plains (Frison et al., 1996). His microstratigraphic work at the Clovis site (Haynes, 1995) has shown how short the Clovis–Folsom transition was, something he first proposed in 1964. Additional work at Clovis (Haynes, 1995; Haynes et al., 1999), Folsom (Anderson and Haynes, 1979; Haynes et al., 1992), and Lindenmeier (Haynes et al., 1992), combined with his data from the San Pedro Valley and from other research on the Great Plains (including work by his own students and coworkers; e.g., Stafford et al., 1991) tightened the age range for Clovis to between 11,200 and 10,900 radiocarbon yr B.P., and for Folsom to between 10,900 and 10,300 radiocarbon yr B.P. (Haynes, 1992, 1993). Significantly, these age ranges, based on dozens of dates, are not substantially different from the original age ranges of 11,500 to 11,000 for

Clovis and 11,000 to 10,000 for Folsom, published in the 1964 *Science* article based on a handful of samples from a few sites (Haynes, 1964a). The dating of Clovis and Folsom also brings up the thorny issue of radiocarbon calibration (Taylor et al., 1996). Another noteworthy aspect of Vance's work is that a quarter century ago Vance predicted the possibility of an atmospheric accordion effect on our Paleoindian time scale (Haynes, 1971).

Vance also merged his microstratigraphic observations with his broader view of trends in depositional and erosional cycles to infer climate changes. His work at Clovis (Haynes, 1975, 1995; Haynes et al., 1999), Miami (Holliday et al., 1994), Lindenmeier (Haynes and Agogino, 1960; Haynes et al., 1992), Hell Gap, and Lange-Ferguson, combined with his San Pedro Valley project and data from other regions led him to propose the Clovis Drought Hypothesis which he has championed for the past decade (Haynes, 1991, 1993; Haynes et al., 1999).

Another key methodological aspect of Vance's work in recent decades has been to return to sites either he or others worked on to see new sections or apply new techniques or to reassess old sections perhaps decades after he first saw them. Much of his research over the decades has included sites where he launched his career: Clovis (e.g., Haynes, 1975, 1995; Haynes and Agogino, 1966), Lindenmeier (Haynes and Agogino, 1960; Haynes et al., 1992), and Hell Gap (Irwin-Williams et al., 1973), and new work at other important sites from the early days of Paleoindian research such as Dent (Haynes, 1974; Haynes et al., 1998), Folsom (Anderson and Haynes, 1979; Haynes et al., 1992), and Miami (Holliday et al., 1994).

THE BIG PICTURE AND THE PERSONAL TOUCH

This discussion will close by noting Vance's impact on the broader field of geoarchaeology. He has not written much on the method and theory of geoarchaeology. I know of one article and that was published back in 1964 (Haynes, 1964b), resulting from his association with the HPPP. Since then, he must have realized that rather than philosophizing on geoarchaeology, it is easier and more inspirational (and certainly more fun) to just go out and do it. When he started out in the late 1950s and on through the 1960s, there were very few individuals engaged in what we now call geoarchaeology (a term that wasn't even invented back then). But with the growth of interdisciplinary archaeology in the 1960s and 1970s, Vance's interests, abilities, and visibility in both the earth sciences and archaeology, his substantial publication record, and the fascinating issues he has addressed concerning the peopling of the New World inspired generations of students. These students include both his advisees, first at Southern Methodist University and then at the University of Arizona, and also many others, including this writer (e.g., Holliday, 1999), who never had the opportunity to take a formal class with Vance but have learned from his articles and, more enjoyably, have learned directly from him in the field.

Besides the intellectual stimulation of his research, Vance has inspired us by being remarkably generous in sharing his time, talents, and ideas. There are few stratified Paleoindian sites on the Great Plains he has not visited, few kinds of

radiocarbon samples he has not worked with, and few aspects of Plains Paleoindian chronology and typology he has not addressed. I have always been particularly amazed by his ability to get along with so many different personalities. In my own experience, we don't see eye-to-eye on the dating of Plainview, for example (Holliday et al., 1999), or the Clovis Drought hypothesis (Holliday, 2000b), but have cordially agreed to disagree.

Vance followed in a rich and highly respected tradition established by his very unofficial but very influential mentors: Kirk Bryan, Ernst Antevs, Marie Wormington, E. H. Sellards, Glen Evans, and Claude Albritton, among geologists, and a host of archaeologists. They set a standard of wide-ranging interests, wide geographical experience, careful observation, and insightful interpretation. Vance was able to combine those aspects of his intellectual forbears with his geological training and archaeological interests, as well as the fortuitous developments in radiocarbon dating technology and a burgeoning population of Great Plains archaeologists in need of dating and geological insight. To paraphrase Vance's assessment of Kirk Bryan (Haynes, 1990:66), he crossed over disciplinary boundaries in the pursuit of knowledge and encouraged his students (that is, all of us) to do likewise.

My sincere thanks and gratitude to Vance Haynes for his many years of support and collegiality. Vance also provided some of the information that went into this article. Thanks also to Andrea Freeman, Bruce Huckell, and David Meltzer for coorganizing the symposium for Vance. Andrea and Rolfe Mandel provided useful comments on the final draft. Dave Meltzer provided considerable input and feedback on several versions of the article.

REFERENCES

Agogino, G.A., & Galloway, E. (1965). The Sister's Hill site: A Hell Gap site in north-central Wyoming. Plains Anthropologist, 10, 190–195.

Anderson, A.B., & Haynes, C.V., Jr. (1979). How old is Capulin Mountain?: Correlation between Capulin Mountain volcanic flows and the Folsom type site, northeastern New Mexico. In R.M. Linn (Ed.), Proceedings of the First Conference on Scientific Research in the National Parks (Volume II, pp. 893–899), National Park Service Transactions and Proceedings Series No. 5. Washington, DC: National Park Service.

Antevs, E. (1935). The occurrence of flints and extinct animals in pluvial deposits near Clovis, New Mexico, Part III: Age of the Clovis lake beds. Proceedings of the Philadelphia Academy of Natural Sciences, 87, 304–311.

Antevs, E. (1941). Age of the Cochise culture stages. Medallion Articles, 29, 31–56.

Antevs, E. (1948). The Great Basin with emphasis on glacial and post-glacial time, Part 3: Climatic changes and pre-white man. University of Utah Bulletin, 38, 168–191.

Antevs, E. (1949). Geology of the Clovis sites. In H.M. Wormington, Ancient Man in North America (pp. 185–192). Denver: Denver Museum of Natural History.

Antevs, E. (1955). Geologic-climatic dating in the West. American Antiquity, 20, 317–335.

Bryan, K. (1922). Erosion and sedimentation of the Papago country, Arizona, with a sketch of the geology. U.S. Geological Survey Bulletin, 730, 19–90.

Bryan, K. (1925). Date of channel trenching (arroyo cutting) in the arid Southwest. Science, 62, 338–344.

Bryan, K. (1940). Erosion in the valleys of the Southwest. New Mexico Quarterly, 10, 227–232.

Bryan, K. (1941). Geologic antiquity of Man in America. Science, 93, 505–514.

Bryan, K., & Ray, L. (1940). Geologic antiquity of the Lindenmeier site in Colorado, Smithsonian Miscellaneous Collections 99. Washington, DC: Smithsonian Institution.

Bull, W.B. (1991). Geomorphic responses to climatic change. New York: Oxford University Press.

Butzer, K.W. (1971). Environment and archaeology: An ecological approach to prehistory (2nd ed.). Chicago: Aldine.

Butzer, K.W. (1980). Holocene alluvial sequences: Problems of dating and correlation. In R.A. Cullingford, D.A. Davidson, & J. Lewin (Eds.), Timescales in geomorphology (pp. 131–142). London: John Wiley.

Frison, G.C. (1991). Prehistoric hunters of the High Plains (2nd ed.). San Diego: Academic Press.

Frison, G., Haynes, C.V., & Larson, M.L. (1996). Discussion and conclusions. In G.C. Frison (Ed.), The Mill Iron site (pp. 205–216). Albuquerque: University of New Mexico Press.

Hack, J.T. (1943). Antiquity of the Finley site. American Antiquity, 8, 235–241.

Haynes, C.V., Jr. (1964a). Fluted projectile points: Their age and dispersion. Science, 145, 1408–1413.

Haynes, C.V., Jr. (1964b). The geologist's role in Pleistocene paleoecology and archaeology. In J.J. Hester & J. Schoenwetter (Eds.), The reconstruction of past environments (pp. 61–66). Taos, New Mexico: Fort Burgwin Research Center.

Haynes, C.V., Jr. (1966). Elephant hunting in North America. Scientific American, 214, 104–112.

Haynes, C.V., Jr. (1967). Carbon-14 dates and Early Man in the New World. In P.S. Martin & H.E. Wright, Jr. (Eds.), Pleistocene extinctions: The search for a cause (pp. 267–286). New Haven: Yale University Press.

Haynes, C.V., Jr. (1968). Geochronology of late-Quaternary alluvium. In R.B. Morrison & H.E. Wright, Jr. (Eds.), Means of correlation of Quaternary successions (pp. 591–631). Salt Lake City: University of Utah Press.

Haynes, C.V., Jr. (1970). Geochronology of man-mammoth sites and their bearing on the origin of the Llano Complex. In W. Dort & J.K. Jones (Eds.), Pleistocene and Recent environments of the central Great Plains (pp. 77–92). Lawrence: University of Kansas Press.

Haynes, C.V., Jr. (1971). Time, environment, and Early Man. Arctic Anthropology, 8, 3–14.

Haynes, C.V., Jr. (1973). The Calico site: Artifacts or geofacts? Science, 181, 305–310.

Haynes, C.V., Jr. (1974). Archaeological geology of some selected Paleo-Indian sites. In C.C. Black (Ed.), History and prehistory of the Lubbock Lake site. The Museum Journal (West Texas Museum Association), 15, 133–139.

Haynes, C.V., Jr. (1975). Pleistocene and Recent stratigraphy. In F. Wendorf & J.J. Hester (Eds.), Late Pleistocene environments of the Southern High Plains (pp. 57–96). Taos, New Mexico: Fort Burgwin Research Center.

Haynes, C.V., Jr. (1980). The Clovis culture. Canadian Journal of Anthropology, 1, 115–121.

Haynes, C.V., Jr. (1981). Geochronology and paleoenvironments of the Murray Springs Clovis site, Arizona. National Geographic Society Research Reports, 13, 243–251.

Haynes, C.V., Jr. (1982). Archeological investigations at the Lehner site, Arizona, 1974–1975. National Geographic Society Research Reports, 14, 325–334.

Haynes, C.V. Jr., (1985). Mastodon-bearing springs and late Quaternary geochronology of the Lower Pomme de Terre Valley, Missouri, Special Paper 204. Boulder, Colorado: Geological Society of America.

Haynes, C.V., Jr. (1990). The Antevs–Bryan years and the legacy for Paleoindian geochronology. In L.F. Laporte (Ed.), Establishment of a geologic framework for paleoanthropology (pp. 55–68), Special Paper 242. Boulder, Colorado: Geological Society of America.

Haynes, C.V., Jr. (1991). Geoarchaeological and paleohydrological evidence for a Clovis-age drought in North America and its bearing on extinction. Quaternary Research, 35, 438–450.

Haynes, C.V., Jr. (1992). Contributions of radiocarbon dating to the geochronology of the peopling of the New World. In R.E. Taylor, A. Long, & R.S. Kra (Eds.), Radiocarbon after four decades: An interdisciplinary perspective (pp. 355–374). New York: Springer-Verlag.

Haynes, C.V., Jr. (1993). Clovis–Folsom geochronology and climatic change. In O. Soffer & N.D. Praslov (Eds.), From Kostenki to Clovis: Upper Paleolithic–Paleo-Indian adaptations (pp. 219–236). New York: Plenum Press.

Haynes, C.V., Jr. (1995). Geochronology of paleoenvironmental change, Clovis type site, Blackwater Draw, New Mexico. Geoarchaeology, 10, 317–388.

Haynes, C.V., Jr., & Agogino, G.A. (1960). Geological significance of a new radiocarbon date from the Lindenmeier site, Proceedings 9. Denver: The Denver Museum of Natural History.

Haynes, C.V., Jr. & Agogino, G.A. (1966). Prehistoric springs and geochronology of the Clovis site, New Mexico. American Antiquity, 31, 812–821.

Haynes, C.V., Jr., & Grey, D.C. (1965). The Sister's Hill site and its bearing on the Wyoming postglacial alluvial chronology. Plains Anthropologist, 10, 196–211.

Haynes, C.V., Jr., Irwin, H.T., Irwin-Williams, C., & Agogino, G.A. (1965). Hell Gap archaeological site, Wyoming. INQUA, Guidebook for Field Conference E, Northern and Middle Rocky Mountains (pp. 17–20). Boulder, CO: INQUA.

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

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

Haynes, C.V., Jr., Stanford, D.J., Jodry, M., Dickenson, J., Montgomery, J.L., Shelley, P.H., Rovner, I., & Agogino, G.A. (1999). A Clovis well at the type site 11,500 B.C.: The oldest prehistoric well in America. Geoarchaeology, 14, 455–470.

Hofman, J.L. (1989). Prehistoric culture history—hunters and gatherers in the Southern Great Plains. In J.L. Hofman et al. (Eds.), From Clovis to Comanchero: Archeological overview of the southern Great Plains (pp. 25–60), Research Series 35. Fayetteville: Arkansas Archeological Survey.

Hofman, J.L. (1996). Early hunter-gatherers of the central Great Plains: Paleoindian and Mesoindian (Archaic) cultures. In J.L. Hofman (Ed.), Archeology and paleoecology of the central Great Plains (pp. 41–100), Research Series 48. Fayetteville: Arkansas Archeological Survey.

Holliday, V.T. (1997). Paleoindian geoarchaeology of the Southern High Plains. Austin: University of Texas Press.

Holliday, V.T. (1999). Response, Kirk Bryan Award citation. GSA Today, 9, 31–32.

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

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

Holliday, V.T., Haynes, C.V., Jr., Hofman, J.L., & Meltzer, D.J. (1994). Geoarchaeology and geochronology of the Miami (Clovis) site, Southern High Plains of Texas. Quaternary Research, 41, 234–244.

Holliday, V.T., Johnson, E., & Stafford, T.W., Jr. (1999). AMS radiocarbon dating of the type Plainview and Firstview (Paleoindian) type assemblages. American Antiquity, 64, 444–454.

Irwin-Williams, C., Irwin, H.T., Agogino, G.A., & Haynes, C.V. (1973). Hell Gap: Paleo-Indian occupation on the High Plains. Plains Anthropologist, 18, 40–53.

Knox, J.C. (1983). Responses of river systems to Holocene climate, In H.E. Wright, Jr., (Ed.), Late-Quaternary environments of the U.S. (Volume 2, pp. 26–41). Minneapolis: University of Minnesota Press.

Mandel, R.D. (Ed.) (2000). Geoarchaeological research in the Great Plains. Norman: University of Oklahoma Press. In press.

Miller, J.P. (1958). Problems of the Pleistocene in Cordilleran North America as related to reconstruction of environmental changes that affected Early Man. In T.L. Smiley (Ed.), Climate and Man in the Southwest (pp. 19–49), Contribution 6. Tucson: University of Arizona Program in Geochronology.

Moss, J.H. (1951). Glaciation in the Wind River Mountains and its relation to Early Man in the Eden Valley, Wyoming. In J.H. Moss (Ed.), Early Man in the Eden Valley (pp. 9–92), Museum Monographs. Philadelphia: The University Museum, University of Pennsylvania.

Moss, J.H. (1952). The antiquity of the Finley (Yuma) site: Example of the geologic method of dating. In S. Tax (Ed.), Indian tribes of aboriginal America (pp. 164–171). New York: Cooper Square Publishers.

Sellards, E.H. (1952). Early man in America. Austin: University of Texas Press.
Sellards, E.H., & Evans, G.L. (1960). The Paleo-Indian cultural succession in the Central High Plains of Texas and New Mexico. In A.F.C. Wallace (Ed.), Men and cultures (pp. 639–649). Philadelphia: University of Pennsylvania Press.
Stafford, T.W., Jr., Hare, P.E., Currie, L., Jull, A.J.T., & Donahue, D. (1991). Accelerator radiocarbon dating at the molecular level. Journal of Archaeological Science, 18, 35–72.
Taylor, R.E., Haynes, C.V., Jr., & Stuiver, M. (1996). Clovis and Folsom age estimates: Stratigraphic contexts and radiocarbon calibration. Antiquity, 70, 515–525.
Wendorf, F. (Ed.) (1961). Paleoecology of the Llano Estacado, Publication of the Fort Burgwin Research Center 1. Santa Fe: The Museum of New Mexico Press.
Wendorf, F., & Hester, J.J. (Eds.) (1975). Late Pleistocene environments of the Southern High Plains, Publication 9. Taos, New Mexico: Fort Burgwin Research Center.
Wormington, H.M. (1957). Ancient Man in North America (4th ed.), Popular Series 4. Denver: Denver Museum of Natural History.
Zeuner, F.E. (1958). Dating the past: An introduction to geochronology (4th ed.). London: Methuen.

Received January 15, 2000
Accepted for publication February 20, 2000