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NEW PERSPECTIVES ON THE CLOVIS VS. PRE-CLOVIS CONTROVERSY

David S. Whitley and Ronald I. Dorn

We consider the Clovis vs. pre-Clovis debate from three perspectives: migration models; petroglyph and surface-artifact ages; and scientific method. First, we test the hypothesis that a Clovis migration can account for the temporal and spatial distribution of South American Paleoindian sites "accepted" by Clovis-first advocates. Using a Clovis-first model, site ages are underpredicted by approximately 1,500 years, suggesting that the Clovis hypothesis cannot be reconciled with accepted empirical data. Second, we present North American accelerator mass spectrometry (AMS) ^{14}C minimum-limiting ages from petroglyphs and surface artifacts that demonstrate continued support for a pre-Clovis occupation of the dryland west, as well as a Beringian entry into the hemisphere. Third, the debate has been confounded by a widespread misstatement of the problem. Though Clovis occupation *is a "solved" issue, the competing hypotheses are whether the first* migration *was Clovis or pre-Clovis; the presence of Clovis sites is simply a necessary prediction of both migration theories. The empirical implications of the Clovis-first hypothesis are virtually untested. Scientifically evaluating the first peopling controversy requires scrutinizing the empirical test implications and logical coherency of both competing hypotheses.*

En este artículo consideramos el debate clovis vs. pre-clovis desde tres perspectivas: migración, edad de los artefactos de superficie, y método científico. Primero, a pesar de que la opinión general sostiene que las poblaciones clovis estuvieron presentes en Norte América, nosotros examinamos la hipótesis de que una migración clovis podría explicar la distribución espacial y temporal de los sitios Paleoindios aceptados. El modelo "clovis primero" estima que las edades de los sitios son 1.500 años más tempranas, lo cual sugiere que las poblaciones clovis no pudieron haber ocupado inclusive aquellos sitios Paleoindios sudamericanos que han sido aceptados por los defensores de "clovis primero." Segundo, presentamos una serie de fechas de AMS ^{14}C límite mínimo, extraídas de petroglifos y artefactos superficiales que sugieren una ocupación pre-clovis en las tierras áridas del oeste norteamericano, así como una entrada en este hemisferio a través del Estrecho de Beringe. Tercero, este debate ha sido complicado por una distorsión generalizada del problema. Aunque la ocupación clovis es un tópico "resuelto," las hipótesis contrarias discuten si la primera migración fue clovis o pre-clovis; la presencia de sitios clovis es simplemente una predicción necesaria en ambas teorías de migración. Las implicaciones empíricas de "clovis primero" no han sido examinadas. La evaluación científica de la controversia de la primera población requiere un escrutinio de las implicaciones empíricas y coherencia lógica de estas hipótesis contrarias.

No question has fascinated New World archaeologists more than the origin of Native American populations. Intermittently since 1590, when Fray José de Acosta first suggested a slow, overland migration of small groups of hunters from Asia (Beals 1957), prehistorians have pondered who our predecessors ultimately were, and when they first arrived in the hemisphere. Yet four centuries after de Acosta's speculations, the problem of when migrants first entered the hemisphere remains unresolved, with the profession divided over a post-12,000 B.P., so-called Clovis (or Llano) "culture" first migration, and an indeterminately earlier "pre-Clovis" entry.

The Clovis vs. pre-Clovis debate has accelerated recently, in part due to a series of South American discoveries. These sites, especially Monte Verde, Chile (Dillehay 1989), and Pedra Furada, Brazil (Guidon and Delibirias 1986; Parenti 1993), have been discredited by some (e.g., Lynch 1990; Schmitz 1987:63) and accepted by others (e.g., Bahn 1993; Bahn and Müller-Beck 1991; Gruhn and Bryan 1991). But the growing number of early South American claims (e.g., Guidon and Delibirias 1985), their failure to correlate with expectations of a Clovis-first hypothesis (Dillehay et al. 1992:147, 185–186), and the continuing absence of convincing pre-Clovis sites in North

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America (Meltzer 1989), have led some researchers (Dixon 1993:129; Guidon and Arnaud 1991: 167–168) to question the one hypothesis that both sides of the debate have always accepted: first entry by land in the Bering Strait region. Not only is the Clovis vs. pre-Clovis debate still unresolved, in other words, but previously held common ground is now being challenged.

In this essay we consider three topics pertinent to the debate that have not been adequately explored. The first is the geographical and temporal distribution of South American sites and their implications for first-migration and colonization models. We show that there are South American sites "accepted" by ardent advocates of the Clovis-first hypothesis, whose spatial and temporal distribution cannot be reconciled with an approximate date of 12,000 B.P. for the first migration. We then turn to new North American evidence that, we believe, provides plausible evidence of a pre-Clovis occupation of the dryland west, and continued support for the Bering Strait region as point of first entry. Finally, we consider some of the reasons why the Clovis vs. pre-Clovis debate has been so long-lived.

THE FIRST-MIGRATION PROBLEM

Although there is universal recognition that the Clovis vs. pre-Clovis debate ultimately concerns a cultural-historical problem in human migration, there has been surprisingly limited discussion of the controversy explicitly in terms of migration and colonization processes (Dillehay [1991], Fladmark [1979], Kelly and Todd [1988], and Meltzer [1989] are recent exceptions). We suspect this circumstance has developed in part because migration has become an unpopular topic in Americanist research (cf. Anthony 1990), and perhaps because certain Paleoindian migration models (e.g., Haynes 1966; Martin 1973) appear to have been widely accepted, with the issue then considered moot. Since these Clovis migration models were first proposed, however, a substantial amount of new, and essentially uncontroversial, empirical data have been obtained from South America. Inasmuch as a good hypothesis should have the ability to account for new empirical evidence, these data can be used to test the existing hypotheses' empirical implications in reference to the migration problem, and thereby to clarify the controversy as a whole.

Models of First Migration

One of the earliest explicit considerations of the migration process as its relates to the Late Pleistocene archaeological record in the New World was provided by Haynes (1966). Haynes's migration model assumed a first entry in the Yukon Delta region at about 12,000 B.P., a maximum distance of 2,000 miles (3,218 km) from point of entry to the southernmost Clovis sites in the western United States, a population increase by a factor of 1.2–1.4 per generation (i.e., 20 percent–40 percent/generation, or .7 percent–1.3 percent/year), and an occupational spread rate of four miles (6.4 km)/year. According to Haynes, this model satisfactorily explained the spread of Clovis sites across North America in about 500 years time.

In an effort to explain the rapid extinction of a number of species of megafauna as a result of Clovis overkill, Martin (1973; Mosiman and Martin 1975) developed an alternative, wave-of-advance model of Paleoindian migration. This included a growth rate of 3.4 percent/year, an occupational spread of 16 km (10 miles)/year, and an advancing wave with an average population density of .4 person/km^2. According to Martin's calculations, the colonization of the entire western hemisphere could then have occurred within approximately 1,000 years. Although a number of authors have now questioned the overkill hypothesis (e.g., Grayson 1984, 1989; Meltzer and Mead 1985), Martin's migration and population growth rates, along with the resulting, inferred 1,000-year period for the colonization of the hemisphere, appear to be widely accepted (e.g., Dixon 1993:122; Kelly and Todd 1988:234).

A third, but in this context overlooked, model of first migration was presented by Hassan (1981: 201–203). In addition to using estimates of population growth, colonization rates and population density, Hassan's model was predicated on calculations of potential carrying capacity, and his estimates were based on a thorough review of the demographic literature. Hassan provided a number of potential migration scenarios, using different assumptions, but he favored a growth rate of .1

percent/year and an occupational migration of less than 1 km/year as most likely, given the probable nature of Late Pleistocene hunter–gatherer populations. The result is an estimated period of 8,000–10,000 years for the colonization of *North* America, and thus an initial migration into the New World "between 25,000 to 20,000 years ago, or somewhat earlier" (Hassan 1981:202).

There are, then, three extant migration models for the peopling of the New World. Two of these (Haynes and Martin) were intended to support the Clovis-first hypothesis. The third (Hassan) appears to have been initiated with no presupposition about timing of initial entry.

An Alternative View of First Migration

The divergence in assumed rates among the Martin, Haynes, and Hassan models requires brief discussion. Curiously, although the assumptions of the Martin (1973; Mosiman and Martin 1975) model are by far the most extreme—indeed, they fly in the face of all demographic evidence—it appears to be the most widely accepted of the three. Assumed population growth rates are the best example of the implausiblity of this model. Martin's proposed 3.4 percent/year population increase is over two and a half times as fast as the 1.3 percent/year that Haynes (1966) earlier had argued was plausible, *as an upper limit*, for hunter–gatherers. Moreover, Ammerman et al. (1976:29) set approximately 3.0 percent/year as the upper limit for human population growth under the most ideal circumstances, while Hassan (1981:201) has noted that Martin's model "uses an intrinsic growth rate that is greater than the potential growth rate for hunter–gatherers, even with the child-spacing interval reduced to its natural limits." This last point is important because it has been widely accepted, at least since the work of Alexander Carr-Saunders in 1922, that nomadism and high mobility result in long birth-spacing intervals and low fertility rates (Lee 1979:319).

Low fertility rates, and thus low population-growth rates, are highly adaptive and therefore the norm for mobile hunter–gatherers. They characterize those groups that rely on "a heavy meat diet, high mobility, and a high degree of male absenteeism in the context of a logistical strategy in which males are the primary producers of food" (Binford and Chasko 1976:131), i.e., on large-game hunters, *as well as* populations with a heavy emphasis on female plant gathering (Lee 1972, 1979). Martin's growth rate of 3.4 percent/year, which was based on the rate of increase of eighteenth- and nineteenth-century English/Polynesian inhabitants of Pitcairn Island (Martin 1973:970), can be dismissed as an entirely inappropriate ethnographic analogy. Historical, Euro-Polynesian sedentary farmer/fishers, living on a semitropical island and employing western technological advances, simply cannot be accepted, under the most liberal stretch of the imagination, as an appropriate analog for Paleoindian peoples.

Equally problematic is the ethnographic analogy upon which Martin's migration rate of 16 km/year was based: historical nineteenth-century movements of African southern Nguni-speakers, displaced by the disruptions of the Zulu *difaqane* (Martin 1973:974). To accept this migration rate, we must conceed a similarity between Paleoindian hunter–gatherers and migrating Iron Age pastoralists, moving through a heavily occupied region to escape the historical disintegration of the Zulu state, but still organized in specialized military units, and necessarily leapfrogging over pre-existing Bantu chiefdoms and states in search of a place to settle. As with Martin's assumed population growth rate, we believe this ethnographic analogy too is entirely inappropriate as a model for Paleoindian hunter–gatherers.

Furthermore, it is apparent that each of Martin's ethnographic analogies vitiates the plausibility of the other, and thereby renders the model internally contradictory. As demographic research has demonstrated, high population-growth rates correlate with sedentism (Binford and Chasko 1976), whereas high hunter–gatherer nomadism results in low population growth (Lee 1979:319); both do not occur together, as Martin's model would require. Thus, on numerous counts we cannot accept Martin's reconstruction of the colonization of the hemisphere as plausible, nor can we accept the growth and migration rates that he employed in his model as reasonable estimates for Paleoindian hunter–gatherers.

Although there are some significant differences between the Haynes and Hassan models, Haynes's suggestion of a population increase of .7 percent/year as a lower limit is within the same range as

Hassan's upper (but not preferred) limit of .5 percent. The principal difference between the two, then, is the rate of occupational spread: 6.4 km (4 miles)/year for Haynes, supporting the Clovis-first hypothesis, vs. < 1 km (< .62 miles)/year for Hassan, suggesting an earlier pre-Clovis migration.

The Hassan population growth and migration rates have the advantage of being based on stronger ethnographic analogies, and thus are in closer agreement with other recent estimates of prehistoric migration and colonization speeds. For example, Cavalli-Sforza et al. (1993:642) have derived a rate averaging 1 km/year for the demic spread of Neolithic farmers in the Old World, while Young and Bettinger (1992:91) use a rate of 1.6 km/year for the migration of Numic speaking hunter–gatherers. Perhaps most importantly, Birdsell (1957:67) estimated the colonization of Australia—our closest analog to the peopling of the New World—as spreading at 2.4 km/year. The Haynes rate, then, is 2.6 to 6.4 times faster than other reported prehistoric migration and colonization rates, and therefore must be acknowledged as pushing the limits of plausibility.

We also note that, while Haynes's (1966) rate was originally suggested just for North America, such a fast migration rate fails to accomodate research during the last quarter century that has revolutionized our understanding of late Pleistocene climates and biomes (cf. Bartlein et al. 1991; Webb and Bartlein 1992). Although the biomes of the Americas were changing rapidly and were not analogous to present-day associations such as tundra, grasslands, desert scrub, dwarf conifer woodlands, tropical scrub, and equatorial rainforests, migration into and through each environment may have required changes in subsistence and adaptive strategies (cf. Bryan 1992; Dillehay et al. 1992). A reasonable position is that some time would have been required to adapt to new environments, and that this adaptation would have slowed the southward advance of population.

Although we therefore do not think that Haynes's (1966) migration rate is necessarily likely, it provides a limiting case to test the Clovis-first hypothesis. If the colonization of the western hemisphere was essentially a Clovis-first migration (including the possibility of an Alaskan Nenana complex antecedent to Clovis; cf. Haynes 1987; Hoffecker et al. 1993), then Haynes's Clovis migration model should provide estimates for the earliest occupation of South American sites that approximate (or do not contradict) those from our growing corpus of accepted Paleoindian radiocarbon ages. Alternatively, should the Haynes's model significantly underestimate accepted ^{14}C ages, then this can be taken as support for an earlier pre-Clovis migration.

Our empirical test proceeds by: (i) calculating approximate distances from North America to "accepted" South American sites (see Lynch 1990), along with a few other South American localities[1]; (ii) estimating earliest possible occupations at these sites based on distance and Haynes's Clovis-model migration rate of 6.4 km/year; and (iii) comparing the predicted and empirical ages of the sites. Because there is still some ambiguity concerning the age of the Alaskan Nenana complex and its relation to Clovis, whereas all parties agree that Clovis peoples occupied the southwestern United States (Meltzer 1989), we have measured distances from the southern limit of the southwestern United States (taken to be at El Paso) to the South American sites. It is also important to note that the age of Clovis sites has been revised recently: "There is now ample evidence that reliably well-dated Clovis sites fall into a very narrow period from 11,200 to 10,900 yr B.P." (Haynes 1991a: 446; cf. Haynes 1987; Hoffecker et al. 1993). Accordingly, we have employed 11,200 B.P. as the date of earliest possible migration southwards from this point.[2]

The distance we compute from El Paso to the northern limit of South America (at the Columbia/Panama border) is 5,945 km, assuming foreknowledge of the most direct route. At an occupational migration rate of 6.4 km/year, humans could have entered northernmost South America 929 years after reaching El Paso, or no earlier than 10,271 B.P. Colonization of other portions of South America would necessarily have been somewhat later.

Table 1 presents our tabulations for eight South American Paleoindian sites/occupational phases that are "accepted"—presumably as "unequivocal"—by at least one vocal Clovis advocate (Lynch 1990), and nine additional sites/phases accepted by some but not all archaeologists (Figure 1). All of these sites/phases post-date 12,000 B.P. with the exception of Monte Verde, Phase II; that is, we have intentionally not included a number of highly controversial sites and phases. If a site has both "accepted" and controversial occupational phases, we utilize those phases and radiocarbon ages that have been accepted by Clovis proponents, or the more conservative age estimates. At Pedra

Table 1. Comparison of Clovis Migration-Model Predictions with Existing Evidence from South American Sites.

Site	Distance (kilometers)	Predicted ^{14}C Age	Actual ^{14}C Age	Variance ^{14}C Age	Predicted Calibrated Age	Actual (B.P.) Calibrated Age	Variance Calibrated Age
Sites "accepted" by Lynch (1990)							
El Abra, Columbia	6,470	10,189	11,200 ± 90	−1,011	12,099	13,110 ± 110	−1,011
Guitarrero, Peru	8,480	9,875	10,535 ± 290	−660	11,785	12,460 ± 420	−675
Quereo, Chile	11,720	9,369	11,410	−2,041	11,279	13,321	−2,042
Pedra Furada, Brazil	11,994	9,326	10,400 ± 180	−1,074	11,236	12,520 ± 220	−1,284
Tagua-Tagua, Chile	12,020	9,322	11,380 ± 320	−2,058	11,232	13,290 ± 360	−2,058
Cerro La China II, Argentina	13,480	9,094	10,691 ± 180	−1,597	11,004	12,620 ± 200	−1,616
Cerro La China I, Argentina	13,480	9,094	10,790 ± 120	−1,696	11,004	12,720 ± 130	−1,716
Los Toldos, Argentina	13,990	9,014	10,675	−1,661	10,924	12,607	−1,683
Other Sites/Ages/Phases[a]							
Tibitó, Columbia	6,470	10,189	11,740 ± 110	−1,551	12,099	13,690 ± 160	−1,591
Cubilan, Ecuador	7,320	10,056	10,500 ± 130	−444	11,966	12,420 ± 190	−454
Pachamachay, Peru	8,990	9,795	11,800 ± 930	−2,005	11,705	13,760 ± 1,250	−2,055
Lapa do Boquete, Brazil	12,440	9,256	11,000 ± 1,000	−1,744	11,166	12,920 ± 1,800	−1,754
G. Abrigo de Santana, Brazil	12,440	9,256	11,960 ± 250	−2,704	11,166	13,940 ± 340	−2,774
Alice Böer, Bed III, Brazil	12,880	9,188	10,950 ± 1,000	−1,763	11,098	12,870 ± 1,800	−1,773
Monte Verde II, Chile	12,900	9,184	12,300	−3,116	11,094	14,372	−3,278
Fell's Cave, Argentina	14,320	8,963	10,080 ± 160	−1,118	10,873	11,600 ± 600	−728
Tres Arroyos, Argentina	14,420	8,947	10,280 ± 160	−1,333	10,857	12,120 ± 410	−1,263

[a] Age for Monte Verde II from Dincauze (1991); for Pachamachay see Rick (1980, 1987); remaining sites/phases/ages from Dillehay et al. (1992).

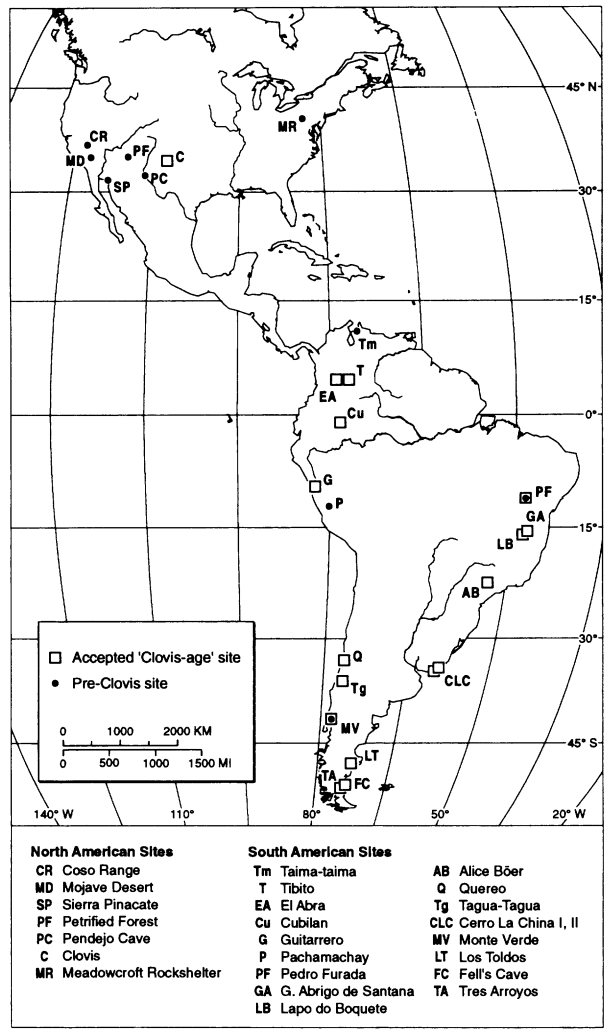

Figure 1. Locations of North and South American sites discussed in the text, as well as certain other sites central to the Clovis vs. pre-Clovis debate.

Furada, for example, we employ the age of 10,400 ± 180 B.P. for the base of the Serra Talhada Phase (Guidon and Arnaud 1991), which has been accepted as cultural by one of the site's most vocal critics (Lynch 1990:21). At Los Toldas, we use the average of two radiocarbon ages that is "the expected result for a Toldense industry" (Lynch 1990:22). At Guitarrero, we utilize Lynch's revised and youngest age of 10,535 ± 290 B.P. (Lynch 1990:24), instead of earlier estimates (Lynch 1980). At Alice Böer, we cite the revised age for Bed III of 10,950 ± 1000 B.P. (Dillehay et al. 1992:166), rather than putative earlier ages for Bed IV. At Quereo Level 1, with an earliest age of 11,600 ± 190 B.P., we use instead the accepted younger one-sigma error age of 11,410 B.P. (Lynch 1990:26). And at Monte Verde Phase II, we employ Dincauze's (1991:118) conservative estimate of 12,300 B.P., rather than Dillehay's (1989) preferred 13,000 B.P.

Table 1 reveals a clear pattern in these data: "Accepted" Paleoindian radiocarbon ages from South America are *consistently and systematically older* than the Clovis-model predictions. Using Haynes's Clovis migration rate, the model underpredicts the empirical ages of the eight "accepted" Paleoindian

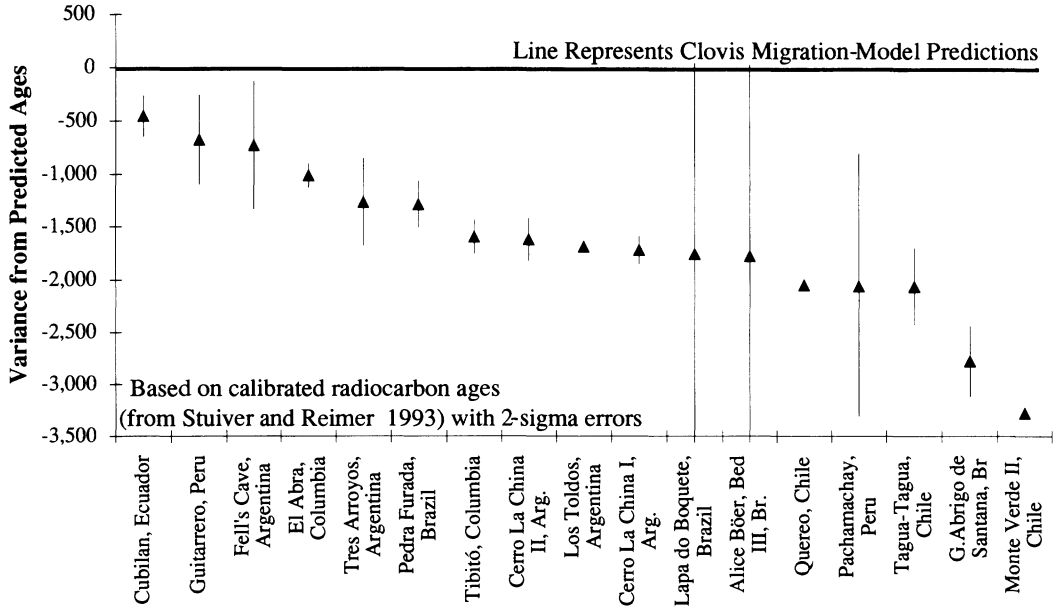

Figure 2. Predictions of Haynes's (1966) Clovis migration model compared to empirical ^{14}C ages from South American sites.

sites by a range of 660 to 2,058 years (mean = 1,475 years). Note that these are, in all cases, figures that are greater—in some cases, alarmingly greater—than the *two-sigma* uncertainties of the radiocarbon measurements (Figure 2). At the lower two-sigma errors of the site ages, the model's underprediction still averages 956 years. That is, at the *95 percent confidence interval*, the Clovis migration model underpredicts the accepted empirical ages of South American sites by approximately *one millenium*.

Similar results are obtained for the additional nine sites we have included in the table. Five of these are Paleoindian in age. Underestimations for these five range from 444 to 1,762 years, with a mean of 1,280 years; the underestimation of the lower one-sigma errors of these sites averages 790 years. The remaining four are immediately pre-Clovis, in the sense of just predating 11,200 B.P., and they, not surprisingly, are also underestimated (range, 1,551 to 3,116 years; mean = 2,344 years). When we combine all of the 17, on average the sites are 1,622 years older than the Clovis migration model predicts. Again, for no site does the amount of underprediction fall within the one-sigma error range of its radiocarbon age, and the underpredictions exceed the two-sigma error ranges for all but two of the sites with calculated deviations.

The Clovis migration model, then, can neither be reconciled with accepted, noncontroversial Paleoindian radiocarbon ages for South American sites, nor with additional sites and ages that are at least possible evidence of Late Pleistocene occupation. Instead, and considering our most conservative calculations, *the model underpredicts the accepted "unequivocal" evidence for Paleoindian occupation of South America by an average of almost a millenium and a half.*

This fact is emphasized when we express these figures in slightly different terms; first, by calculating backwards from the radiocarbon ages on these sites to derive required colonization rates for a Clovis migration. Quereo Level 1 is the earliest of Lynch's (1990:26) acceptable sites, with an accepted radiocarbon age, at its younger one-sigma error, of 11,410 B.P. Since the age of Clovis sites in the southwestern United States has been revised downward to 11,200 B.P. (Haynes 1987, 1991a; Hoffecker et al. 1993), even this younger one-sigma age alone is impossible to reconcile with the North American evidence. However, if we employ the even more conservative "confirmatory date of 11,100 ± 100 B.P." from Level 2 at Quereo (Lynch 1990:26), occupation of this site would still

require a migration in excess of 117 km/year (72 miles/year)! Such a forced-march invasion and colonization of the hemisphere at this speed would have required a migration over seven times faster than Martin's (1973) implausible rate of 16 km/year, derived from historical movements of African Iron Age pastoralists, fleeing the Zulu *difaqane*.

Although Quereo may be the extreme case, even the best-case scenario for these sites is implausible. The radiocarbon age from Cubilan comes closest to meeting the predictions of the Clovis model, albeit the model's underprediction still exceeds the two-sigma radiocarbon error for the age of the site. But for Cubilan to have been colonized by its radiocarbon age, a migration rate of 10.5 km/year is required. This is over one-and-a-half times faster than the rate that Haynes (1966) suggested as plausible for a Clovis migration, while it is 4.4 times Birdsell's (1957) rate for the colonization of Australia, 6.5 times faster than Young and Bettinger (1992) report for the Numic migration, 10.5 times the rate of the Neolithic spread (Cavalli-Sforza et al. 1993), and over 10.5 times the rate that Hassan (1981) preferred for Late Pleistocene migrations.

Second, taking Haynes's (1966) figure of 6.4 km/year as a plausible rate of occupational spread, then the *accepted* South American Paleoindian sites necessitate a first migration into the southwestern United States *before* 13,258 B.P., or 2,058 years before Clovis. When we add the ages of the additional sites we have considered here, this figure is pushed back even further: colonization of Monte Verde II at 12,300 B.P. would necessitate immigration into the southwestern United States before 14,316 B.P. First migration into the North American side of Beringia would necessarily have been earlier. If Haynes's (1966) proposed migration rate is lowered to more realistically account for concerns and difficulties associated with colonization of and adaption to new biomes, the probable date of first entry into the eastern side of Beringia recedes even further back in time.

There are four possible explanations for our South American migration results:

(1) The least likely is that *all* of these South American radiocarbon ages, sites, artifacts and stratigraphic associations are wrong, noncultural, stratigraphically mixed, etc. This is unlikely in light of the fact that eight of these sites have been scrutinized in detail and accepted by Lynch (1990), a vocal pre-Clovis critic. Although some of the ages that Lynch has accepted may still be controversial, at least eight sites/phases from the total of 17 (i.e., Guitarrero, Cerro La China I, Cerro La China II, Fell's Cave, Tres Arroyos, Cubilan and the Serra Talhada phase at Pedra Furada) are not controversial, one way or another, to our knowledge.

(2) A second possible explanation is that Haynes's (1966) migration-rate figures are too slow and our distances are wrong. But, as we have indicated above, even Martin's (1973) manifestly implausible rate of 16 km/year cannot account for the majority of the sites and ages already accepted by Clovis-first advocates. In addition to Quereo, these include El Abra, Tagua-Tagua, Cerro La China I, Cerro La China II, and Los Toldos. Further, as noted above, faster colonization speeds require population growth rates grossly beyond anything remotely possible for hunter–gatherers, especially given that there continues to be genetic support for a small initial founder population (Schurr et al. 1990). And, although we expect that other researchers may calculate slightly different distances than those that we have derived, we do not believe that any plausible revisions of our distances will substantially modify our results.

(3) Perhaps the underlying assumption of a Bering Strait region entry and migration southward through the hemisphere is incorrect. This challenges our most widely accepted assumption concerning the peopling of the hemisphere. Although a Beringian entry and southward migration continue to be supported by genetic (e.g., Wallace et al. 1985) and dental (Turner 1986) studies, at least some South American archaeologists are now questioning the imposition of what they view as North American models for the peopling of the New World on the hemisphere as a whole (e.g., Dillehay et al. 1992; Guidon and Arnaud 1991; see also Dixon 1993).

(4) It may be that the Clovis-first hypothesis is simply incorrect.

THE NORTH AMERICAN CASE

A large part of the tension in the Clovis vs. pre-Clovis debate turns on the continued absence of widely accepted pre-Clovis sites and radiocarbon ages in North America. In this regard, Butzer

Table 2. Pre-Clovis Surface-Exposure Ages for Rock Varnish Formed on Top of Surface Artifacts and Petroglyphs.

Site	Sample	Lab Number
Petroglyphs on Stable Talus Boulders		
Conejo Mine site, Coso Range, California	CM-8 (petroglyph)	NZA-2364
Petrified Forest National Park, Northern Arizona	PEFO-7 (petroglyph)	
	sample 1	NZA-2115
	sample 2	NZA-2191
Artifacts from Stable Desert Pavements		
Baker site, north shore of Silver Lake, California	Dames and Moore 5j (primary flake)	NZA-1919 NZA-1918
Manix Lake Quarry, Mojave Desert, California	#85-8 (biface chopper)	
	flake scar 1	ETH-6577; Beta-37038
	flake scar 2	AA-6547
Manix Lake Quarry, Mojave Desert, California	#85-12 (blade-like flake)	ETH-4478; Beta-32774
Manix Lake Quarry, Mojave Desert, California	SBr-2100, Locus 70 Artifact No. 1, Lot 96	NZA-2637

Note: Radiocarbon method is detailed in Dorn et al. (1992), and cation-ratio method in Dorn et al. (1990). All cation-ratio ages are calibrated by radiocarbon ages. Errors are ±1 sigma. Calibrated ages are from Stuiver and Reimer (1993) using Method A, where the calibrated age is in parentheses, and 1-sigma errors are outside the parentheses. The position of the dated organics is indicated in the radiocarbon-age column, by either weathering rind (wr) or interface (i).

(1988, 1991) has provided a geomorphologist's perspective on the problems associated with finding undisturbed, stratified archaeological sites dating to the Late Pleistocene in the New World. Site-formation processes appear to have varied greatly, particularly between the pre-Clovis and Clovis periods and especially in North America, and thus the archaeological problem is compounded by largely unconsidered geomorphological circumstances.

The Late Pleistocene was a period of great change in climate and in landscape and biotic communities (Webb and Bartlein 1992). Tremendous shifts occurred in the location of erosion and deposition, as well as in the intensity of transportation events. The geomorphic response to climatic and eustatic sea-level changes resulted in rapid incision in many places, while drastic responses in hillslope and river systems took place (Baker 1983; Bull 1991; Knox 1983). The result is that there would have been few places at the close of the Pleistocene in North America where nondestructive sedimentary processes, conducive to the preservation of archaeological deposits, could have operated. Butzer correctly points out that it should be very difficult to find New World late Pleistocene archaeological remains in undisturbed stratigraphic settings. And since the end of the Pleistocene is now set at 11,000 B.P. (Haynes 1984, 1991a, 1991b), we do not consider it coincidental that a geomorphological transition to more favorable site-preservation conditions occurred at essentially the point at which Clovis sites appear in the archaeological record[3].

Moreover, and contrary to the analogical arguments of Jelinek (1992), there is no basis for the contention that the geomorphological processes in the New World would have resulted in similar patterns of site preservation as in Australia, or that North America would have been equivalent to South America. The absence of a continental ice sheet and distance of alpine glaciation from preserved sites, the dominance of eolian landforms, along with the extremely different paleoclimatology and vegetation history in Australia, in contrast to the greater relief in North America combined with numerous other factors, all suggest that there should be *little if any* comparability in late Pleistocene site-preservation processes for the two continents. Most significantly from geomorphological and site-preservation perspectives, landscape-modifying processes appear to operate at much slower rates in Australia than in North America (e.g., see Gale [1992], and entire issue of

Table 2. Extended.

Radiocarbon Age	Calibrated Age	Cation-Ratio Age	Site Context
14,070 ± 130 (wr)	15,100 (14,930) 14,747 B.C.	14,200 ± 1,700	Whitley and Dorn 1988
18,180 ± 190 (wr)	beyond calibration	19,000 ± 1,500	Dorn 1992
16,600 ± 120 (i)	17,825 (17,600) 17,400 B.C.	20,000 ± 1,800	
12,820 ± 100 (wr)	13,405 (13,200) 12,970 B.C.	cannot be compared to curve	Dorn 1991
12,020 ± 140 (wr)	12,280 (12,070) 11,867 B.C.	due to abundant silica skins	
14,840 ± 115 (i)	15,947 (15,800) 15,645 B.C.	18,900 ± 2,000	Bamforth and Dorn (1988)
13,655 ± 105 (i)	14,576 (14,420) 14,250 B.C.	18,900 ± 2,000	
26,070 ± 360 (i)	beyond calibration	25,000 ± 2,000	Bamforth and Dorn (1988)
26,590 ± 230 (wr)	beyond calibration	22,000 ± 5,000 (artifact #1) 24,000 ± 1,500 (refitted sequence)	Bamforth et al. (1986: Plate 8-2)

Earth Surface Processes and Landforms 17[4]). Young and McDougall (1993:35) emphasize this point: "[Our Australian] findings, together with those of earlier research in the uplands of New South Wales, imply a rate and pattern of Cenozoic denudation very much at odds with widely accepted models derived from areas, like the [American] Appalachians."

In contrast to contexts requiring gradual and nondestructive stratified deposition, and following Butzer's (1988, 1991) suggestions, there are a variety of stable geomorphic slope positions that have remained largely unaffected by late Pleistocene environmental changes, where we might expect early human occupation and exploitation to be preserved. Included are large talus boulders, basalt cuestas, and desert pavements (e.g., Hayden 1976) on ancient alluvial-fan surfaces and lake terraces that are greater than 11,200 years old. There is an ongoing revolution in dating surface contexts such as these (Beck 1993; Dorn 1993a, 1993b; Dorn and Phillips 1991). Our research, using surface-exposure rock-varnish-dating techniques to provide minimum-limiting-age estimates on petroglyphs on the talus boulders and on surface artifacts on the desert pavements, provides plausible and continued support for the pre-Clovis occupation of western North America.

Varnish Dating

We have developed and employ three independent techniques to assign minimum-limiting ages to the rock varnish that forms over petroglyphs and surface-artifact flake scars. These yield numerical ages, using AMS ^{14}C dating (Dorn 1993a, 1993b; Dorn et al. 1992); calibrated ages, with cation-ratio (CR) varnish dating (Dorn et al. 1990); and correlated age control through the examination of microstratigraphic layering in varnish (Dorn 1986, 1990, 1992, 1993a, 1993b). We note that the controversy associated with varnish dating (reviewed in Dorn [1993a]) concerns CR dating; we use CR dating here only as supporting evidence for our AMS ^{14}C varnish ages. We discuss methodological concerns first, before turning to the results presented in Table 2.

Varnish radiocarbon dating is analogous to dating organic remains in a stratigraphic layer resting on archaeological material. It provides a limiting age for the underlying older, culturally produced surface, in this case either a flake scar on a stone tool, or the engraved-out area of a petroglyph.

The organic material found underneath the rock varnish consists of remnants of lichen, charcoal, fungal mats, cyanobacteria, endolithic algae, pollen and plant remains, as well as unidentified organic matter (Dorn and DeNiro 1985; Dorn et al. 1992; Nagy et al. 1991; Nobbs and Dorn 1993; Watchman 1992a). Varnish radiocarbon dating, therefore, requires the extraction of a sample of this organic matter (usually under low-power magnification), harsh pretreatment of the extracted organics, and then AMS radiocarbon dating.

The organic remains sealed by rock varnish may be present within three microstratigraphic contexts. First, organic matter is sometimes entombed within the varnish section itself. We avoid sampling this material because such intravarnish organics are found in unlayered stratigraphic contexts. Unlayered varnishes yield unreliable radiocarbon ages (Nobbs and Dorn 1993). Second, organic matter is frequently trapped between the cultural surface and the varnish, per se, thus sitting in an interface position. Third, organics are also found in the weathering rind of a rock surface. When the original rind is removed (e.g., by flaking or pecking a petroglyph), a new weathering rind starts to form. At this time, endolithic algae, epilithic lichens, and other rock surface organisms grow and leave organic remains within the pore spaces in the rind. Later, varnish starts to form over this new weathering rind, sealing the organics. The organic matter dated here derives from the two subvarnish microstratigraphic contexts specified for each sample in Table 2: interface positions and weathering rinds.

Over the last several years, we have conducted a series of tests to assess the validity and reliability of AMS ^{14}C varnish dating (see Dorn et al. 1986, 1987, 1989, 1992; Nobbs and Dorn 1993). These include replications using multiple samples, applications to different kinds of sampling sites/archaeological remains, different techniques for chemically processing samples, and different organic extraction techniques, as well as cross-checks against surfaces of independently established, known ages. The tests have shown that AMS ^{14}C varnish ages are slightly younger than the radiocarbon-dated control surfaces, emphasizing that they should be interpreted as *minimum-limiting* numerical ages.

These tests also allow us to identify and review all known potential sources of error in AMS ^{14}C varnish dating. The first, and most important, is assessing the likelihood of noncontemporaneous carbon contaminating an archaeological sample.

(i) Can Varnish Radiocarbon Ages Predate Human Manufacture of a Petroglyph or Artifact? We have constrained the ages of over 280 geomorphological and archaeological samples using AMS ^{14}C analyses of varnish and subvarnish organic matter. All but one of these have yielded ^{14}C ages younger (or consistent with) available independent age data. The only problematic sample is a measurement on a petroglyph that yielded a petroleum hydrocarbon signal during analysis, indicating contamination, probably during some earlier recording of the motif. Dorn et al. (1989) and Nobbs and Dorn (1993) also suggest that it is *theoretically* possible that natural, older organic matter could be incorporated into a sample; e.g., older carbon from nearby soils or older carbon from a preexisting weathering rind. Yet, in *all* other tests, including comparisons of varnish radiocarbon ages with control radiocarbon ages, the varnish radiocarbon age has been younger than the control (Dorn et al. 1989). Since we have not found evidence of a petroleum hydrocarbon signal in any of the samples in Table 2, there is no plausible reason to interpret our AMS ^{14}C ages as anything other than minimum ages for the manufacture of the petroglyphs and artifacts.

(ii) Can Varnish Radiocarbon Ages Postdate Human Manufacture of a Petroglyph or Artifact? To this, we answer yes. The most likely source of any contamination is younger material that could get incorporated into a varnish coating after the varnish started to form. Watchman (1992a) demonstrated this hazard by radiocarbon dating plant fragments collected from *within* the varnish microstratigraphic profile, rather than subvarnish organic remains at the interface or from the weathering rind below the varnish. As expected, this produced younger radiocarbon ages than subvarnish samples (Nobbs and Dorn 1993). In sample collection and processing, it is also easy to contaminate a sample with younger organics; but again, the result is younger rather than older age estimates. Examples include: sampling unlayered varnishes (Watchman 1992a, 1992b); improper chemical pretreatment (Dorn et al. 1989); the inclusion of textile filaments with a varnish sample

sent to a dating laboratory; and collecting organisms growing on the surface of the varnish (Nagy et al. 1991).

(iii) What Is the Type of Organic Matter Being Dated? The samples dated in this study include endolithic algae that was removed from the weathering rinds below varnished flake scars, and unidentified organic matter in an interface position, on the Mojave Desert artifacts, and unidentified organics from petroglyphs. Future tests must resolve what type of subvarnish material yields the most reliable radiocarbon ages.

(iv) Can Results be Replicated? The high cost of AMS measurements and the difficulty in finding enough organic matter prohibited us from making replicate ^{14}C measurements on more than three specimens (Table 2). Our replicate ages do not overlap within two-sigma errors, although analytical overlap has occurred in some prior tests (Dorn et al. 1989, 1992; Nobbs and Dorn 1993). The lack of overlap, however, is consistent with the interpretation that the dates provide reliable *minimum* ages for the specimens, because we are dating organics resting on worked surfaces that have been buried by varnish that has started to form at different times.

(v) What Are the Problems with the Sampling Technique? Mechanical removal of varnish and associated organic matter is a tedious procedure (Dorn et al. 1992; Watchman 1992a), much like picking roots from a charcoal sample. Yet, the sampling method has evolved greatly over the last several years (Dorn et al. 1986, 1992). The next advance will hopefully be the laser extraction of organic matter, if problems associated with chemical preparation of cross sections can be overcome (cf. Nobbs and Dorn 1993).

We present here minimum-limiting ages for rock varnishes formed over cultural surfaces (i.e., flake scars and engraved petroglyphs) that have been dated using more than one chronometric technique (Table 2). They include surface artifacts obtained from stable desert pavements in the Manix Lake region, California, and petroglyphs from the Coso Range, California, and Petrified Forest National Park, Arizona (Figure 1). The petroglyph ages are particularly important because there is no plausible argument by which they can be dismissed as noncultural. We consider the results in detail.

Chronometric Rock-Art Ages

Two petroglyphs have yielded independent pre-Clovis chronometric assays using both AMS ^{14}C and CR varnish-dating techniques.[4] The AMS ^{14}C ages on these petroglyphs exceed, at their lower two-sigma errors, the upper Clovis date of 11,200 years B.P. The late Pleistocene age of these petroglyphs, moreover, is confirmed by analyses of their varnish microstratigraphy (see below).

Two independent AMS ^{14}C ages have been obtained on one of these, petroglyph PEFO-7 (illustrated in Dorn et al. [1993:Figure 1B]), a geometric pattern from the Petrified Forest National Park, Arizona. The first assay, from the weathering rind underneath the varnish, has a radiocarbon age of 18,180 ± 190 B.P. (NZA-2115). The second assay, from the interface position between the varnish and the rock (Figure 3), yielded a radiocarbon age of 16,600 ± 120 B.P. (NZA-2191). Although these two ages do not overlap within their two-sigma errors, we emphasize again that these are both *minimum-limiting* ages. Thus, the older of these two ages, 18,180 B.P., is in agreement with the interpretation of the age of the engraving as *greater than* 16,600 ± 120 B.P., and is consistent with its microstratigraphic placement below the younger dated sample. Two independent CR ages for this petroglyph (19,000 ± 1500 and 20,000 ± 1800 B.P.) overlap the older radiocarbon age within the one-sigma ^{14}C error ranges. Thus, we have obtained four independent chronometric assays on this petroglyph, all of which indicate that it is significantly older than the upper Clovis age of 11,200 B.P.

The second AMS ^{14}C assayed petroglyph, CM-8 (illustrated in Whitley and Dorn [1988:Figure 3C]), an unidentified zoomorphic engraving from the Coso Range, California, has an assigned age of 14,070 ± 130 B.P. (NZA-2364). This petroglyph has also been independently CR dated at 14,200 ± 1700 B.P. In this case, the AMS ^{14}C and CR ages overlap at their one-sigma errors.

Combined with our previous CR ages on petroglyphs from the Coso Range, which have yielded

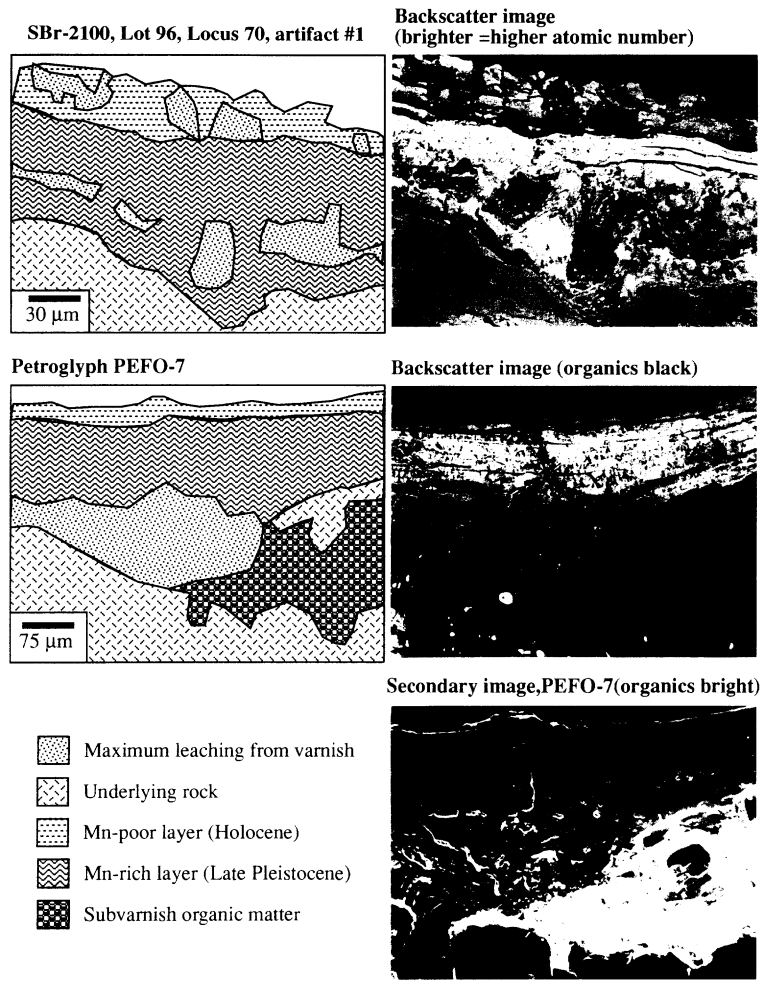

Figure 3. Late Pleistocene microstratigraphy of rock varnish found on petroglyphs and artifacts examined in this study. The purpose of this figure is to illustrate the layering seen in varnishes formed on the petroglyphs and artifacts in Table 2. The *top row*, of varnish on Artifact #1, Locus 70, Lot 96, from SBr-2100 (see Bamforth and Dorn 1988; Bamforth et al. 1986:Plate 8-2), presents a backscatter electron micrograph (where brightness is proportional to average atomic number) and map showing the Mn-poor Holocene layer on the Mn-rich late Pleistocene layer. The *middle row*, of varnish on Petrified Forest National Park petroglyph PEFO-7, presents a similar sequence. The *bottom row* presents a matching view of PEFO-7 only imaged by secondary electrons where topography is shown and where organic matter often charges brightly. We refer the reader to the color thin sections shown in Dorn (1992) to illustrate microstratigraphy even more dramatically.

four additional pre-Clovis age assignments ranging from 12,900 to 18,200 B.P. (Whitley and Dorn 1988), these data provide support for late Pleistocene rock-art production in North America. They constitute part of a growing body of late Pleistocene to middle Holocene art dated by stratigraphic superpositioning *and* chronometric techniques (e.g., Francis 1993; Randolph and Dahlstrohm 1977; Ricks and Cannon 1985; Thomas and Thomas 1972; Whitley and Dorn 1987, 1993), and are matched by similar dates suggested for rock art from Pedra Furada (Guidon and Delibrias 1986).

Surface-Artifact Varnish Ages

We have also obtained AMS ^{14}C pre-Clovis ages on four Manix Lake Lithic Industry artifacts (Bamforth and Dorn 1988; Semenza 1984) collected from stable desert pavements in eastern Cal-

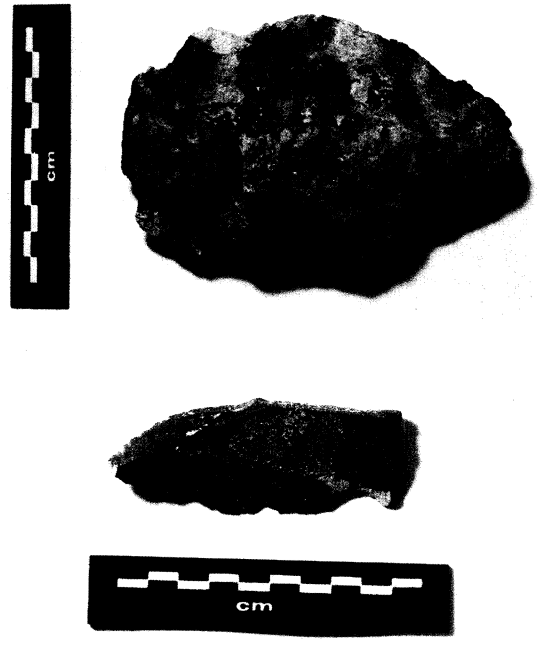

Figure 4. Surface artifacts with independent AMS ^{14}C and CR ages: (*top*) Artifact Manix #85-8, a chert biface chopper. AMS ^{14}C ages on this biface are 14,840 ± 115 and 13,655 ± 105 B.P. The CR age is 18,900 ± 2000 B.P.; (*bottom*) Artifact Manix #85-12, a chert blade-like flake with an AMS ^{14}C age of 26,070 ± 360 B.P. and a CR age of 25,000 ± 2000 B.P.

ifornia. These four surface artifacts have a total of six AMS ^{14}C subvarnish ages (Table 2). These range from 12,020 ± 140 to 26,590 ± 230 B.P. All of these radiocarbon ages exceed the upper age of Clovis at their lower two-sigma errors.

Two of them also have two independent ^{14}C assays each. Specimen Baker #5j, a chert primary flake, has radiocarbon ages of 12,820 ± 100 and 12,020 ± 140 B.P. Manix #85-8, a large chert biface chopper (perhaps a biface core), has ^{14}C ages of 14,840 ± 115 and 13,655 ± 105 B.P. (Figure 4). An independent CR age on this last specimen is considerably older: 18,900 ± 2000 B.P. Artifact #1, Lot 96, Locus 70, CA-SBR-2100, is another chert primary flake, derived from a refit flake–core sequence (see Bamforth and Dorn 1988; Bamforth et al. 1986:Plate 8-2). The radiocarbon age of this flake is 26,590 ± 230 B.P. The independent CR age, recalculated using the new approach in Dorn et al. (1990), is 22,000 ± 5000 B.P., while the mean CR age of the refit sequence is 24,000 ± 1500 B.P. The final lithic specimen, Manix #85-12, a large chert blade-like flake with evidence of two previous flake removals on its dorsal surface (Figure 4) , has a radiocarbon age of 26,070 ± 360 B.P. and a CR age of 25,000 ± 2000 B.P. Although these last two ages overlap within their one-sigma ranges, the divergence between the independent assays on the other specimens emphasizes, once again, that these are minimum-limiting ages.

Note that, in addition to these AMS ^{14}C ages, we have obtained 26 pre-Clovis CR ages on 23 additional Manix Lake Lithic Industry specimens, including 11 independent CR ages on four refit flake–core sequences (Bamforth and Dorn 1988; Dorn et al. 1986). The internal variability within the refit sequences is only 4.6 percent, indicating a significant level of accuracy for CR surface-artifact dating. The 26 ages on these specimens range from 12,000 to 32,000 B.P.

Varnish Layering

Independent checks are provided for our samples by the layering observed in the microstratigraphy of their rock varnishes. As is well established (e.g., Spaulding 1990; Webb and Bartlein 1992), a major environmental change occurred in the southwestern United States between the Pleistocene and Holocene: from more moist to drier conditions. The timing of this climatic change appears to have differed from place to place, starting as early as 13,000 B.P. in some places and as late as 10,000 B.P. in others.

Well-layered subaerial varnishes, developed on surfaces known to be late Pleistocene in age by independent age controls, contain a microstratigraphic sequence that reflects this climatic change. In the late Pleistocene the dominant varnish micromorphology was botryoidal with a varnish chemistry greatly enriched in manganese. Varnish development changed in the Holocene to a lamellate micromorphology that was less enriched in manganese (Dorn 1986, 1990, 1992).

Examination of the varnish microstratigraphy of all samples in Table 2 reveals this distinctive change (Figure 3; color micrographs showing varnish layering on pre-Clovis petroglyphs are presented in Dorn [1992:6]). Varnishes on our archaeological specimens formed during a late Pleistocene, more moisture-effective, climate. This is consistent with numerical and calibrated ages in Table 2. Given the relative thickness of the lower layers of these varnishes, it is *unlikely* that the late Pleistocene layers formed during the last 1,000 years of the Pleistocene/Holocene interface (between 11,200 B.P. and dessication at approximately 10,000 B.P.); i.e., the varnishes appear to be pre-Clovis in age.

Viewed from the perspective of finding preserved stratigraphic pre-Clovis sites, the transition from a net degradational to net depositional regime at the Pleistocene/Holocene boundary in North America should have had a significant influence on site-formation and preservation processes (Butzer 1988, 1991). More favorable conditions for site preservation developed at essentially the time at which Clovis sites appear in the archaeological record: 11,200 B.P. Because of this difficulty, we have looked instead for archaeological evidence on stable desert pavements on alluvial fans and terraces, and on talus boulders. From these Late Pleistocene geomorphological contexts, we have obtained a series of pre-Clovis numerical, calibrated, and correlated ages on surface lithic artifacts and petroglyphs. Although the cultural attributes of lithic flakes may always be debatable, artifact Manix #85-8, a biface chopper, is undoubtedly cultural. There is no question, as well, that the petroglyphs were made by humans. Moreover, we have cross-checked and/or replicated our pre-Clovis ages, using multiple ^{14}C analyses, independent age assignments with CR dating, and confirmatory-correlated dating based on varnish microstratigraphy and morphology. We believe our evidence is sufficient to support the hypothesis of a pre-Clovis occupation in the drylands of far western North America.

DISCUSSION AND CONCLUSIONS

The single most widely accepted assumption in the Clovis vs. pre-Clovis debate is land entry through Beringia and colonization of North before South America. The discovery and dating of South American sites such as Monte Verde and Pedra Furada question this received knowledge when juxtaposed against the continuing absence—or at least strong denial—of plausible North American pre-Clovis sites (cf. Dillehay et al. 1992; Dixon 1993; Guidon and Arnaud 1991). Our analysis of "accepted" South American Paleoindian sites in light of realistic migration and colonization rates further emphasizes this anomaly. There is simply no conceivable way, based on all existing demographic studies of hunter–gatherers, that a Clovis-first migration of Paleoindians could have entered northernmost South America from a Beringian point of entry before approximately 10,200 B.P., even while there are at least 12 South American sites with radiocarbon ages between 10,200 and 11,500 B.P. (cf. Lynch 1990). Do we then discard the Beringian hypothesis and look to transpacific migrations, or search for additional North American data?

We concur with Butzer (1988, 1991) that one of the difficulties in discovering pre-Clovis sites in North America results from late Pleistocene geomorphological processes that were unfavorable for the preservation of archaeological deposits; processes, notably, that changed to favor site preservation

in many regions at essentially the beginning of Clovis times (cf. Haynes 1991a:Figure 6). This is a circumstance that we do not view as coincidental.

Still, there are stable geomorphological surfaces older than 11,200 B.P. that contain chronometrically datable archaeological remains. Surface-artifact dating techniques have yielded archaeological specimens with pre-Clovis age assignments from these geomorphological contexts. This evidence does not provide absolute or unequivocal "proof" of a pre-Clovis occupation of North America. However, these data provide plausible support, from a number of different sites, using different dating techniques to provide (in some cases) replicate and independent ages. And, in the case of the petroglyph ages, we can state with confidence that certain of our dated specimens are *unequivocally* human in manufacture. In light of these ages, as well as our analysis of migration rates and South American sites, we argue that there is still plausible support for a Beringian first entry, albeit only for one that occurred in pre-Clovis but not Clovis/Nenana times.

Adjudicating the Competing Hypotheses

One final issue is raised by our study: Why the Clovis vs. pre-Clovis debate has not yet been resolved. For some, this is straightforward—the requisite and unequivocal site, stratigraphy, and dates have not been presented that "prove" the pre-Clovis hypothesis. For Haynes (1969:714) and Meltzer (1989), historical analogy provides the key here. Resolution will occur, just as it did for Folsom, when an equivalent site and context is discovered; that is, *if* there really was a pre-Clovis migration.

Haynes and Meltzer may be right in the sense that it might require a site as dramatic as Folsom to convince the discipline that a pre-Clovis migration truly occurred. Certainly the evidential criteria of unequivocal site/artifact, stratigraphy, and dates are widely cited in the literature. However, we ascribe to the belief that scientific method and analytical techniques have advanced considerably since the 1920s, and that we no longer require evidence so obvious that amateurs could recognize it, as in the Folsom case, to scientifically demonstrate a valid pre-Clovis find. Nor do we believe that we are necessarily limited solely to stratigraphic evidence, inasmuch as we now have a variety of techniques for dating surface artifacts. Moreover, we also contend that the debate has been misstated, and that it is this misinterpretation that has, as much as anything else, impeded its resolution.

The Clovis vs. pre-Clovis debate has been widely perceived almost exclusively as a cultural-historical problem in chronology. Emphasis has focused on critiquing key empirical cases, taken only as putative pre-Clovis sites, to "test" the pre-Clovis theory. The general perception then is that the pre-Clovis hypothesis will only be accepted, and the debate resolved, with the presentation of "unequivocal" pre-Clovis evidence on a site-specific basis (e.g., Grayson 1988:114; Meltzer 1989: 474). This position appears tied to the belief that "The post-12,000 B.P. occupation in North America is a *solved* issue, a pre-12,000 B.P. occupation is not" (Meltzer 1989:480; emphasis in original). From this perspective, the Clovis side of the cultural-historical debate is resolved, and the issue is then thought to turn solely on its competing hypothesis, the pre-Clovis theory.

This, however, is argument by equivocation, and it misses the point. The debate rightly concerns a cultural *process* that has two competing hypotheses, neither of which is necessarily "solved": whether the *first migration and colonization* were pre-Clovis or, alternatively, Clovis first. *Both* of these hypotheses make a series of empirical claims that can be tested in the archaeological record. Accounting for the geographical and temporal distribution of sites in South America with a realistic model of migration and colonization, as we discussed above, is one of the empirical problems that the competing hypotheses must address when the debate is viewed in terms of culture process, rather than simply culture history. The presence of Clovis-age sites, on the other hand, is only one of the many test implications of *each* of the competing theories. That is, accepted Clovis-age sites provide necessary support for the Clovis-first *and* pre-Clovis hypotheses, but this is not sufficient evidence for the acceptance of either theory. We argue that the empirical claims and test implications of the Clovis-first migration and colonization hypothesis are entirely unproven, regardless of our acceptance of a Clovis occupation. And, if we approach the debate with any claim to scientific rigor, then we

must acknowledge that the logical coherency and empirical fit of *both* competing hypotheses are equally subject to scrutiny.

Furthermore, there are a number of reasons why the traditional cultural-historical approach, emphasizing exclusively the skeptical critique of putative pre-Clovis sites, is methodologically weak. First, nontrivial scientific committments can rarely be made on crucial, singular tests (Copi 1982: 491; Polanyi 1958:92), partly because it is often only in retrospect that we recognize what constitutes a crucial test for a theory anyway (Lakatos 1969), and partly due to the fact that "there exists both confirming and disconfirming evidence for many important hypotheses" (Salmon 1982:37–38). Second, the establishment of "unequivocal proof," as required by Clovis-first advocates, rightly only pertains to theoretical endeavors such as logic and mathematics, and is widely recognized as unobtainable in empirical sciences like archaeology (Copi 1982:468; Hesse 1991:112; Kelley and Hanen 1988:241; Lewis-Williams and Loubser 1986:281; Rudner 1966:76; Salmon 1982:37). With this we do not question the need for rational skepticism and critical evaluations of controversial claims, including critical evaluations of putative pre-Clovis sites and dates. Instead, as we believe the debate over Monte Verde II demonstrates, efforts to establish "unequivocal proof," *based solely on critiquing single cases*, easily reduce to nothing more that differences of professional opinion.

We contend that to more scientifically, objectively, and rigorously evaluate the Clovis vs. pre-Clovis debate we should turn to well-established and widely accepted means for the adjudication of competing hypotheses, rather than exclusively to critical considerations of putative pre-Clovis data. When the evidence is considered by these means the result is an inference to the best hypothesis, as Kelley and Hanen (1988) have noted. Numerous philosophers of science have listed criteria used to confirm scientific hypotheses (e.g., Copi 1982:470–475; Farr 1983:165; Hempel 1966:33–46; Newton-Smith 1981:226–230; Popper 1966:268). They typically include: (i) quantity of data explained; (ii) diversity of different kinds of data explained; (iii) consistency of a hypothesis with established theoretical frameworks and accepted theories; (iv) predictive capabilities; (v) relevance; (vi) plausibility; and (vii) simplicity.

Comparing the Hypotheses

When the Clovis vs. pre-Clovis debate is considered in these terms, and viewed as a cultural process to be explained by one of two competing theories rather than simply as a chronological problem in culture history, the pre-Clovis hypothesis has the following *empirical* evidence in its favor:

(a) there is plausible support for (but not unequivocal proof of) a pre-Clovis occupation in sites such as Monte Verde II and Pedra Furada, our varnish dates from western North America, as well as other sites;

(b) only a pre-Clovis migration and colonization can realistically account for the temporal and geographic distribution of skeptically evaluated and *accepted South American Paleoindian sites*, whereas it is impossible to reconcile the Clovis-first hypothesis with empirical evidence accepted by its own advocates; and

(c) the pre-Clovis hypothesis is supported by recent mitochondrial DNA reconstructions of the timing of the genetic divergences of the Amerindian population (Torroni et al. 1992).

The competing Clovis-first hypothesis has, in its favor, the fact that no sites have been accepted, *by Clovis-first advocates*, as "unequivocal proof" of a pre-Clovis occupation of the hemisphere.

The pre-Clovis hypothesis, therefore, explains more empirical data, and more kinds of data than the Clovis-first hypothesis. Furthermore, it fits better with existing demographic models of human migration and colonization, as well as with recent mitochondrial DNA reconstructions. In contrast, all the Clovis-first hypothesis seems to offer is the extreme empirical skepticism of its proponents when critiquing putative pre-Clovis sites. Empirical skepticism is useful, but it does not constitute scientific evidence in favor of a preferred theory.

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NOTES

[1] A realistic migration model must accomodate the fact that first migrants could not have taken a straight-line route southwards but, instead, necessarily had barriers such as mountain ranges and paleolakes to circumvent. Moreover, planimetric measurements fail to consider real-world distances, which are invariably increased by topography. After considerable experimentation, and in order to derive migration distances that are both replicable and that allow some consideration of the topographical and hydrological contingencies that first migrants faced, we measured approximate distances to South American sites using the shortest existing roadway distances as depicted on the American Automobile Association "Mexico and Central America" and "The Caribbean and South America" maps. We take these as reasonable and conservative surrogate measures for shortest and most-feasible routes, assuming foreknowledge of the local environment on the part of the migrating population.

[2] Note that our discussion presents all ages in *radiocarbon* years B.P., although we also present the experimental calendrical calibrations of Stuiver and Reimer (1993) in Tables 1 and 2 so that the reader can compare figures and calculations.

[3] The change in depositional conditions from the late Pleistocene to Holocene is demonstrated by Meltzer and Mead's (1985) compilation of megafaunal paleontological radiocarbon ages. Of 163 North American localities (with 307 reliable ^{14}C ages) dating between 8,000 and 26,000 B.P., 11 sites date between 12,000 and 20,000 B.P. That is, only 6.7 percent of their localities fall within fully 44 percent of their considered time span—the critical pre-Clovis/Clovis interface.

[4] Although subvarnish radiocarbon ages are used to calibrate cation-ratio dates, we have not used the radiocarbon ages on the archaeological specimens dated by radiocarbon and CR in the calibration curve, thereby ensuring that the chronometric assessments obtained with these two techniques have yielded truly independent ages.

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