REPORTS

THE STABLE- AND RADIO-ISOTOPE CHEMISTRY OF WESTERN BASKETMAKER BURIALS: IMPLICATIONS FOR EARLY PUEBLOAN DIETS AND ORIGINS

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The timing and degree of reliance on maize agriculture in the Four Corners region of the American Southwest has been a central issue in studies that examine the origins of Puebloan society. Both diffusionist (various, but see Wills 1995) and migrationist (Berry and Berry 1986; Matson 1991) models have been proposed to explain the processes responsible for the movement of maize (Zea mays) north into the Four Corners region. This paper reports bone collagen stable carbon and nitrogen isotope values with paired accelerator radiocarbon dates on a large collection of human remains from western Basketmaker II/III sites in Marsh Pass and other areas of northeastern Arizona, as well as data on a small number of Puebloan remains including Chacoan Great House burials. The results make clear that Basketmaker II people were heavily dependent on maize by 400 B.C. Moreover, their degree of dependence is similar to that of Pueblo II and III farmers of the Four Corners region. These findings and the apparent rapidity of maize dependence support a migrationist model for the origins of maize farming in the northern Southwest.

El grado y momento de dependencia de agricultura maízana en la región de las Cuatro Esquinas del sudoeste de norte américa han sido los temas centrales en los estudios que examen los orígenes de la sociedad Puebloana. Los modelos de difusionismo (varias, vea Wills 1995) y migraciónismo (Berry y Berry 1986; Matson 1991) han sido propuestos para explicar los procesos responsables del movimiento de maíz (Zea mays) al norte hacia el interior de la región de las cuatro esquinas. Este artículo presenta datos de cocientes de isótopos carbonos y nitrógenos de colágeno que ha sido radiocarbono fechado con un acelerador de una grande colección de huesos humanos de los sitios II/III de los Basketmaker del oeste en Marsh Pass y otras áreas del nordeste de Arizona, al igual que datos similares de una cantidad pequeña de huesos Puebloanos incluyendo enterramientos del Chacoan Great House. Los resultados afirman que la gente de Basketmaker II era completamente dependiente de maíz con la llegada del ano 400 a.c. Además, su grado de dependencia es semejante a la dependencia de los agricultores de los Pueblo II y III de la región de las Cuatro Esquinas. Estos resultados y aparentemente rapidez hacia la dependencia de maíz apoyan un modelo migraciónisto para explicar los orígenes del cultivo de maíz en la parte norte del sudoeste.

The origins of Basketmaker people and the importance of maize in their diets are topics of ongoing debate. To address these issues, we report accelerator radiocarbon dates and stable carbon and nitrogen isotope ratios on Basketmaker and Puebloan burials from the Four Corners region of the American Southwest and compare these data to previously published findings on Basketmaker diets at Talus Village and elsewhere in southwestern Colorado, Utah, and Arizona. Forty of the 42 burials in this study are directly dated, 33 are Basketmaker and include samples from White Dog Cave, Kinboko Cave I and other well-known early Basketmaker sites in the Marsh Pass region of northeastern Arizona (Figure 1). These data provide yet another body of evidence for relatively heavy reliance on maize prior to the beginning of the Christian era in support of previous work by other researchers at Basketmaker II sites in the region.

Between 1914 and 1923, Alfred V. Kidder, a young archaeologist with a new Ph.D., and Samuel J. Guernsey, an artist with the Peabody Museum at Harvard, explored various caves and rock shelters in the vicinity of Marsh Pass and Monument Valley in northeastern Arizona (Guernsey 1931;

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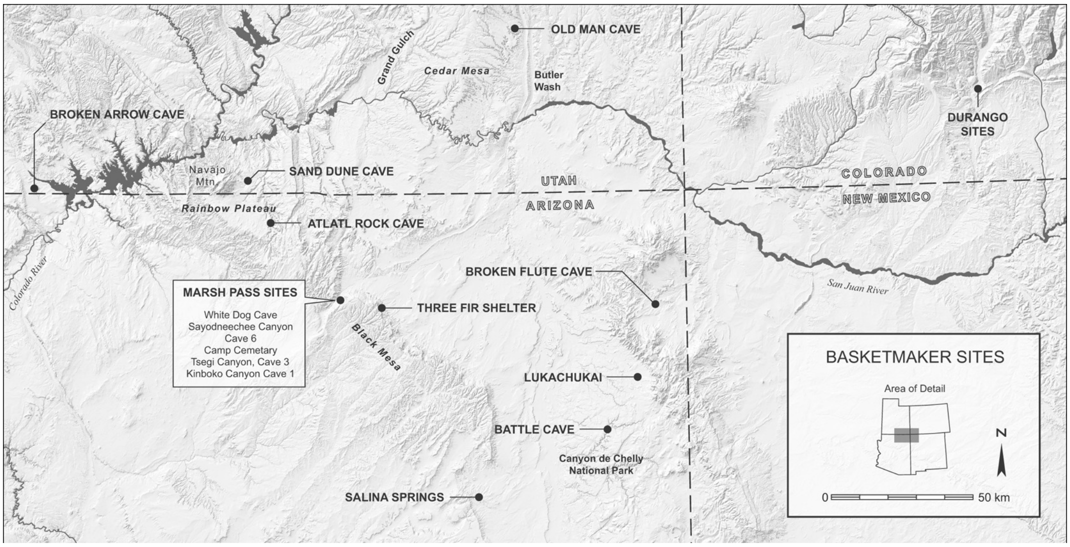


Figure 1. Map of Four Corners region of the American Southwest with sites referred to in this study.

Guernsey and Kidder 1921; Kidder 1924; Kidder and Guernsey 1919). Here early professional archaeologists investigated Puebloan origins and confirmed the existence of an aceramic farming people known as Basketmaker (see Matson 1991 for an excellent review), expanding the Wetherills' description of Basketmaker material culture first recognized in the Grand Gulch region of southeastern Utah (Atkins 1993; Blackburn and Williamson 1997; Phillips 1993). Stratigraphic evidence indicated an agricultural complex overlain by Puebloan remains and characterized by the presence of squash and maize, "however, this important cereal was less highly developed among the [Basket Makers] than among the [Cliff-dwellers]" (Kidder and Guernsey 1919:154). Beans were not present, but pinyon, acorn, and other wild foods were noted. Distinctive material traits included round pithouses (reported by Pepper [1902] for Grand Gulch, but not found by Kidder and Guernsey in Marsh Pass), sandals of yucca, cedar bark and cordage, fur cloth, finely coiled basketry, twined bags and the atlatl and dart (Kidder and Guernsey 1919:204–212). Based on excavations in Canyon del Muerto, Earl Morris (1939:11–19) expanded the trait list to include digging sticks, hide for clothing, and assorted beads and pendants including marine shell. Morris also speculated that the principle Basketmaker II food was maize supplemented by squash, small seeds, and animal protein, the latter indicated by the recovery of bone tools from elk, deer and mountain sheep, and skins from "animals of all sizes" (Morris 1939:15).

In 1927, following two decades of exploration, Kidder and his colleagues formalized a chronology for Southwestern material culture that came to be known as the Pecos Classification (see Reed 2000 for a review). This chronology followed a seemingly slow evolutionary transition from mobile foraging lifeways to full reliance on maize agriculture, beginning at 1500–2000 B.C. with the introduction of the Mexican cultigen. Basketmaker I was a preagricultural state "adumbrating [prefiguring] later developments" (Kidder 1927:490) followed by the Basketmaker II stage, a preceramic culture with introductory maize agriculture and atlatl use as identifying traits. Basketmaker III was then signaled by the introduction of "slab houses," above ground storage, ceramics and the bow and arrow (Lipe 1993). The Pecos classification was widely adopted and its nomenclature remains in common use.

In 1962, Emil Haury published a model that was in broad agreement with the Pecos chronology. Haury (1962) argued that prior to the beginning of the Christian era maize played a minor role in Basketmaker economic practices, restricted to upland settings due to the cultigen's subtropical Mexican origins and consequent low drought tolerance. The economic role of maize did not increase until after A.D. 1 coincident with the development of irrigation strategies and drought-tolerant maize variants. Increased use of radiocarbon dating further supported Haury's "gradualist" model. A widely accepted ca. 3000 B.C. radiocarbon date (Dick 1965) on uncarbonized wood and maize from Bat Cave in central New Mexico appeared to indicate that maize was present earlier and the transition to reliance on maize even slower than previously thought.

In the late 1980s, Wills (1988) questioned the stratigraphic integrity of the Bat Cave maize date favoring a younger date, more in keeping with maize dating to 2500–2000 B.P. from aceramic strata in Tularosa Cave. Subsequently Smiley (1994) reported a suite of radiocarbon dates ranging from cal 2500–1500 B.P. on Basketmaker sites in the northern Southwest that accorded nicely with Will's revision, although a Bat Cave maize date of cal 4000 B.P. is in near agreement with a subsequently acquired date on maize from Three Fir Shelter in Marsh Pass (Smiley 1994; 1997:Figure 2.3) (see also Carpenter et al. 2002).

Chronological issues, along with the growing recognition that Basketmaker material culture and lifeways represented a marked departure from that of the Archaic period (e.g., Geib and Spurr 2002), have led to ongoing reconsideration of some aspects of the Pecos model (see Huckell et al. 2002 for a review). Researchers have argued that maize cultivation was not adopted slowly over four millennia by an indigenous foraging population but was a significant component of aceramic Southwest economies long before the Christian era (Chisholm and Matson 1994; Fish et al. 1986; Geib and Spurr 2000; Gilpin 1994; Huckell 1988, 1995; Lipe 1993; Mabry 1998; Martin 1999; Matson 1994, 2005; Matson and Chisholm 1991; Smiley 1993, 1994; Vivian 2000), perhaps introduced into northeastern Arizona and southeastern Utah by farmers migrating into the region at ca. 600 B.C. (e.g., Berry 1982, Berry and Berry 1986; Carpenter et al. 2002; Geib and Davidson 1994; Geib and Spurr 2000; Matson 1991, 2003, 2005). In this regard, Geib and Spurr (2002) contrasted the characteristics of typically ephemeral, Late Archaic sites on Rainbow Plateau in northeastern Arizona with those of multi-featured, open sites dating to the Basketmaker period. The former were devoid of storage features and consisted of asynchronous hearths on dune ridges in association with lithic debitage and occasional ground stone, whereas the latter contained pithouses, bell-shaped pits and other storage features, extensive midden, maize and human burials, showing little evidence for cultural continuity with the Late Archaic. Taking a slightly different approach, Huckell et al. (2002) have argued that dry farming in a highly stochastic environment such as the American Southwest necessitated a minimum investment in field size of two to three acres to mitigate against persistent shortfalls. Their argument implies that a casual investment in maize farming, such as might be undertaken by mobile foragers, had a high probability of producing yields too low to warrant the investment. This line of reasoning does not preclude the adoption of maize by Late Archaic foraging groups; however it does suggest that a slow, gradual transition to reliance on maize that entailed centuries of casual planting was unlikely, particularly in areas like Rainbow Plateau where it appears that Late Archaic and Basketmaker complexes were separated by a 400-year hiatus (Geib and Spurr 2002). An occupational hiatus is also evident on Cedar Mesa where use of Old Man Cave terminated at 5227–4846 B.C. (Geib and Davidson 1994:Table 1) with no subsequent cultural activity until ca. A.D. 4–336 when Basketmaker II groups began using the cave for storage and burials (see also Matson 1994).

The debate about an indigenous versus introduced origin for Basketmaker people has been somewhat complicated by a lack of agreement regarding what constitutes the Basketmaker complex itself. Although Kidder's (1927) initial definition still holds in a general way, the extensive research cited above has refined our understanding of this period. Central to this issue is the timing of reliance on maize. We suggest that the archaeological signature characteristic of aceramic maize farmers signals the appearance of the Basketmaker cultural complex and is decidedly different from that of foragers with either little or no maize use. As noted, the former tended to construct pithouses accompanied by volume storage and generated substantial middens indicating relatively long residential tenures (e.g., Geib and Spurr 2000). Mobile foragers, on the other hand, left more modest artifact scatters and invested less heavily in constructed features (Geib and Spurr 2002). Geib (2006) has also pointed out that cultural assemblages associated with Late Archaic foraging groups on Rainbow Plateau are distinctly different from material remains recovered at Basketmaker II occupations. These strategic and material differences suggest the arrival of an incoming farming people new to the Colorado Plateau. We return to this topic in the Discussion section.

In a recent article, Buzon and Gauer (2002) examined the paleopathology of 29 Basketmaker III (A.D. 450–550) individuals from pithouse burials at the SU site in northwestern New Mexico. Frequencies of porotic hyperostosis, caries, and enamel hypoplasias were similar to those of known agriculture groups, indicating the population experienced high levels of physiological stress commonly associated with intensive maize agriculture (see also Schollmeyer and Turner 2004). The authors concluded that "[t]he SU population appears to display higher rates of these stress indicators than typically seen at preagricultural sites and/or transitional sites" (Buzon and Gauer 2002:117) and recommended carbon isotope and trace element analysis to confirm their findings.

Bone collagen, stable isotope values and accelerator radiocarbon dates reported here speak directly to these issues with data from classic Basketmaker sites explored early in the twentieth century, sites that laid the foundation for our understanding of this cultural complex. We include data on nine Puebloan interments for comparative purposes: four from Camp Cemetery, Arizona, and five individuals from two Chacoan Great Houses. Site descriptions are followed by a brief discussion of methodology.

Site Descriptions

Marsh Pass Region

Sayodneechee Canyon, Burial Cave. During the 1914 season Kidder and Guernsey (1919:27) investigated several Puebloan "ruins" in the vicinity of Sayodneechee Canyon (Figure 1), a short canyon containing numerous caves including Burial Cave. Nearly hidden behind a falling dune, the long narrow cave contained, toward the rear, four circular cists excavated into the "hardpan." Multiple Basketmaker-age burials were found in each. Cist C was thought to contain three adults and an infant; however five adults were identified in the Peabody Museum collections and each was analyzed (Table 1). All burials were accompanied by baskets, various beads, and, in one case, an atlatl weight. Maize cobs and faunal remains were present in the overlying debris, but were not clearly associated with the Basketmaker occupation.

Kinboko, Cave I. In 1915 the Peabody group explored Caves I and II in Kinboko, a side canyon extending to the northwest from Long House Valley (Kidder and Guernsey 1919:Plate 1). Cave I is a large, north-facing cavern located approximately one-half mile up canyon. Although evidence exists for light use by Puebloan people as well as either Ute or Navajo, Basketmaker groups used the cave intensively for storage and burial purposes. Nearly 60 adobe-floored, slab-lined cists lay on the east side of the cave, 20 of which apparently contained burials prior to prehistoric looting events (Kidder and Guernsey 1919:78). Relatively intact cists typically contained more than one individual, usually an adult and one or two infants (Kidder and Guernsey 1919:83). The bodies were often encased in adobe, making removal difficult for the excavators as well as for ancient looters. In addition to human remains, a "rubbish" layer had accumulated along the east wall of the cave, presumably the result of past grave plundering, with isolated human bone, basketry, sandals, and tools. One cist contained "nearly a bushel of corncobs." Undisturbed burials included goods such as fur-cordage robes, basketry, twined bags, atlatls, sandals, hide, and beads.

Analyses focused on burials from Cists 4, 7, 10, 11, 15, 16, and 27 (Table 1). The sample included adults (4), subadults (3), and infants (3). Not all cists were described by Kidder and Guernsey (1919:78–84); however nothing observed in the Peabody collections was contrary to descriptions provided by the excavators.

White Dog Cave. White Dog Cave, visited in 1916, is among the best-known Basketmaker caves reported by Kidder and Guernsey due to its rich Basketmaker II assemblage. South-facing, the cave lies in an inconspicuous location ca. six miles north and east of Marsh Pass. The cave entrance is large, 120 ft wide and 125 ft high, and is described as occupying a "commanding position in the rounded front of a buttress-like swell of the cliff" (Guernsey and Kidder 1921:10). A massive rock fall filled much of the cave's central portion. Similar to Kinboko Cave I, numerous cists were grouped along the east wall. Multiple burials were present in a number of cists, but most had been emptied prehistorically by looters. Again, Guernsey and Kidder (1921:13) focused on "salient features of the more typical" cists rather than on an exhaustive treatment of each. Human remains from Cists 10, 22, 27, 31, and 39 were sampled here and include adults (2), subadults (2), and infants (2) (Table 1).

Cave 6. Cave 6, investigated during the 1917 field season (Guernsey and Kidder 1921:30), contained Basketmaker debris and a single slab-lined cist similar to those found in Kinboko Cave I. Like many of those in Cave I, the cist burial had been disturbed prehistorically. Guernsey and Kidder (1921:31) identified two individuals—a child and adult—although other human bone fragments were noted. Grave goods typical of those already mentioned were present as well as a squash rind fragment. We identified the remains of an infant as well as a young child and both were included in the study.

Camp Cemetery. Just north of the mouth of Kinboko on the north side of Long House Valley, Kidder and Guernsey (1919:66) excavated into a "sherd-covered slope" below Long House Ruin. Human bone on the surface suggested the presence of burials and the excavators discovered six individuals—three adult males, two adult females, and an infant—interred in "oval excavations" covered with logs and bark. All but Skeleton 6 were accompanied by burial goods, primarily whole or broken ceramic vessels, beads, and arrow points suggesting a Pueblo II/III age for these remains, substantiated by their dates (Table 1).

Tsegi Canyon, Cave 3. In 1920, Samuel Guernsey (1931) traveled back to the Marsh Pass area and sampled three caves in Tsegi Canyon. Cave 3 lies in the north-trending branch of the canyon and contained a single Basketmaker II grave in which two individuals had been interred. The upper burial had been disturbed prehistorically; but the lower burial was largely intact, the "partly mummified body of an eighteen-year-old male" wrapped in a fur-cordage robe (Guernsey 1931:13). Grave goods included atlatl weights, a "bladder stone," and bone beads.

Prayer Rock District/Red Rock Valley

Broken Flute Cave. The Prayer Rock District is east of Monument Valley and north of the Lukachukai Mountains in extreme eastern Arizona, lying within the drainage of Red Wash, a north flowing tributary of the San Juan River (Morris 1980:6). Here in 1931 Earl H. Morris, sponsored by the Carnegie Institute, intensively excavated six caves and tested several others (Morris 1980:7). The largest of these is Broken Flute Cave situated at the head of Atahonez Wash. Morris excavated 16 pithouses and many cists representing Basketmaker II and III occupations (Morris 1980:13), encountering eight burials. The individual analyzed was a Basketmaker III male adult wrapped in blankets of fur and feather cloth. No data is available on the other Red Rock Valley male adult sampled for the study; however, the site was likely excavated by Morris.

Canyon del Muerto

Battle Cave. Also referred to as Battle Cove (D. Morris 1986:14), this site is a large, shallow, north-facing alcove across Canyon del Muerto from Antelope House. Earl H. Morris excavated the site in 1929 as part of the seventh Bernheimer expedition sponsored by the American Museum of Natural History (Lister and Lister 1968:136). Thirteen Basketmaker II burials found in slab-lined cists were disarticulated and many displayed evidence of violent conflict such as crushed faces and skulls. In an area away from the cists, Morris discovered the partially mummified remains of a female adult with an arrow wound who had also received a heavy blow to the head causing massive facial damage (Carlyle 2003:74; Turner and Turner 1999:141). Overwhelming evidence of conflict led Earl Morris to name the site as he did. No data accompanied the individual analyzed here other than general provenience.

Methods

Stable Carbon Isotope Analysis

The stable carbon isotope values reported below monitor the ratio of $^{13}C/^{12}C$ in the amino acid sequences that comprise bone collagen fibrils and reflect reliance on maize for the following reasons. When CO_2 is taken up during photosynthesis, metabolic processes alter or fractionate the ratio of $^{13}C/^{12}C$, depleting plant tissues in ^{13}C relative to atmosphere (–7.7 ‰). This ratio is expressed in delta notation ($\delta^{13}C$) as parts per mil (‰) differ-

Table 1. Basketmaker and Puebloan Burials by Sample Number and Site with Radiocarbon Measurements, Stable Isotope Values and Preservation Criteria.

Sample No.	Peabody Museum Assession No.[a]	Site/Location	Field Designation	Sex	Age	AA No.	^{14}C Age BP	Sigma	Conf. Interv. Midpoint	2 Sigma Range 95% Conf. Interv.	δ^{13}C ‰	δ^{15} N ‰	Atomic C:N	% Collagen Yield
589	AMNH[b] H3671	Chaco Cyn, Pueblo Bonito	Rm 33, skl 13		adult	57713	1209	40	821	AD 690-944	-6.8	12.4	3.2	14.2
590	AMNH H5805	Chaco Cyn, Pueblo Bonito	Rm 53/56		adult	57714	925	40	1104	AD 1023-1208	-9.0	10.6	3.2	20.6
591	AMNH H3672	Chaco Cyn, Pueblo Bonito	Rm 33, skl 14	m	adult	57715	1213	40	817	AD 690-940	-7.1	11.4	3.2	15.3
592	AMNH H15010(14?)	Chaco Cyn, Kin Bineola			adult	57716	1053	43	985	AD 891-1147	-7.0	14.0	3.2	21.2
593	AMNH 99/9608	Cyn del Muerto, Battle Cave			adult	57717	2132	43	-161	BC 355-44	-6.3	8.5	3.2	19.3
595	14-5-10/59451.0.1	Sayodneechee Cave	Cist C, skl 4	f	adult	57719	2177	45	-246	BC 378-95	-7.6	8.3	3.2	17.3
596	14-5-10/59451a.1	Sayodneechee Cave	Cist C	unk	adult	61193	2208	53	-274	BC 393-117	-8.2	7.9	3.3	18.8
597	14-5-10/59451b.1	Sayodneechee Cave	Cist C	unk	adult	57720	2048	44	-58	BC 172-AD 53	-9.1	8.6	3.3	19.9
598	14-5-10/59452.0.1	Sayodneechee Cave	Cist C, skl 5	m	45+	61194	2149	58	-192	BC 375-44	-7.6	8.5	3.2	18.4
599	14-5-10/59453.0.1	Sayodneechee Cave	Cist C, skl 13	m	35-40	57721	2185	44	-258	BC 380-114	-10.1	8.4	3.2	19.9
602	14-5-10/59458.1.2	Sayodneechee Cave	Cist D, skl 1	unk	2-3	57722	2112	44	-133	BC 351-1	-9.2	7.8	3.3	2.5
603	14-5-10/59460.0.1	Sayodneechee Cave	Cist A, skl 11/12	unk	1.5 ± .5	57723	2078	44	-95	BC 201-AD 23	-6.0	10.7	3.1	13.4
604	14-5-10/59461b.1	Sayodneechee Cave	Cist B	unk	adult	61195	2200	49	-272	BC 389-117	-6.4	8.0	3.3	12.5
605	14-5-10/59461b.2	Sayodneechee Cave	Cist B	unk	adult	57724	2161	44	-212	BC 361-59	-6.6	8.1	3.3	1.9
606	14-5-10/59461d.1	Sayodneechee Cave	Cist B	unk	adult	61196	2186	49	-256	BC 383-109	-8.6	8.1	3.1	4.4
607	14-5-10/59461j.1	Sayodneechee Cave	Cist B	unk	adult	57725	2119	45	-142	BC 353-1	-7.8	8.0	3.2	19.7
609	14-5-10/59468.0.1	Camp Cemetery	Skl 1	m?	30-35	57726	853	39	1189	AD 1042-1272	-7.2	6.9	3.1	19.5
610	14-5-10/59469.0.1	Camp Cemetery	Skl 2	unk	3-4	57727	870	42	1167	AD 1039-1257	-6.2	8.7	3.3	6.1
611	14-5-10/59470.0.1	Camp Cemetery	Skl 3	f?	<35	Not dated	-	-	-	-	-7.5	8.0	3.2	15.7
612	14-5-10/59472.0.1	Camp Cemetery	Skl 5	m	40-45	57728	844	87	1174	AD 1022-1293	-7.1	7.7	3.2	19.1

613	15-11-10/59691.0.1	Kinboko Cyn, Cave 1	Cist 4/15	unk	adult	61197	2179	49	-247	BC 379-95	-9.0	7.3	3.2	13.4
614	15-11-10/59692.0.1	Kinboko Cyn, Cave 1	Cist 7/11	m?	adult	57729	2135	46	-167	BC 357-4	-8.6	7.1	3.1	12.3
615	15-11-10/59693.0.1	Kinboko Cyn, Cave 1	Cist 27	unk	infant	61198	2075	54	-93	BC 347-AD 53	-9.3	10.1	3.1	21.6
616	15-11-10/59693.0.2	Kinboko Cyn, Cave 1	Cist 27	unk	infant	57730	2052	43	-63	BC 172-AD 51	-5.9	8.1	3.1	22.9
617	15-11-10/59694.0.1	Kinboko Cyn, Cave 1		unk	adult	61199	2113	54	-138	BC 355-AD 2	-7.7	6.8	3.3	17.5
618	15-11-10/59695.0.1	Kinboko Cyn, Cave 1	Cist 16	unk	5-6	57731	2245	47	-287	BC 396-200	-7.3	8.4	3.5	21.4
619	15-11-10/59696.0.1	Kinboko Cyn, Cave 1	Cist 4/7/10	unk	5-7.5	61200	2096	54	-117	BC 352-AD 46	-8.2	7.3	3.1	10.6
620	15-11-10/59696.0.2	Kinboko Cyn, Cave 1	Cist 4/7/10	unk	infant	57732	2186	46	-258	BC 381-113	-7.8	6.2	3.4	21.2
621	15-11-10/A2385.0.1	Kinboko Cyn, Cave 1	Cist 16	unk	13-20	61201	2205	55	-271	BC 393-114	-7.6	8.0	3.3	17.5
622	15-11-10/N827.0.1	Kinboko Cyn, Cave 1	Cist 5	unk	adult	57733	2146	52	-186	BC 360-46	-6.7	6.3	3.0	27.1
623	16-9-10/A2890.0.1	White Dog Cave	Cist 27	m	18-19	57734	2288	44	-317	BC 405-204	-6.7	5.8	3.0	20.8
624	16-9-10/A2898.0.1	White Dog Cave	Cist 22	f	22-24	57735	2221	46	-282	BC 389-174	-7.2	5.6	3.2	24.4
625	16-9-10/A2899.0.1	White Dog Cave	Cist 22	m	17-20	57736	2240	44	-286	BC 393-200	-7.1	5.7	3.1	24.9
626	16-9-10/A3115.0.1	White Dog Cave	Cist 31	f	40-50	57737	2287	44	-315	BC 405-203	-8.6	5.6	3.0	22.0
627	16-9-10/A3066.0.1	White Dog Cave	Cist 39	unk	.5-1.5	57738	2228	45	-284	BC 391-178	-6.0	9.6	3.1	20.4
628	16-9-10/A3233.0.1	White Dog Cave	Cist 10	unk	.5-1.5	57739	2302	45	-364	BC 481-202	-6.5	8.7	3.1	16.7
629	17-34-10/A3503.0.1	Marsh Pass, Cave 6	Burial cist	unk	1-2	57740	2133	46	-164	BC 356-4	-11.5	7.6	2.9	22.1
630	17-34-10/A3503.0.2	Marsh Pass, Cave 6	Burial cist	unk	.5-1.5	61202	2127	46	-154	BC 355-3	-8.0	6.9	3.1	24.0
631	20-5-10/A5109.0.1	Tsegi Canyon, Cave 3	Burial 2	m	adult	57741	2306	45	-368	BC 499-202	-13.7	6.7	3.1	23.3
632	31-1-10/N252.0.1	Broken Flute Cave	Burial 2	m	40-49	57742	1373	43	659	AD 599-769	-5.8	8.4	3.2	20.2
633	35-54-10/N1267.0.1	Red Rock Valley		m	30-34	57743	1395	43	645	AD 560-759	-6.7	7.8	3.1	21.2
685	AMNH H5803	Chaco Cyn, Pueblo Bonito	Rm 53/56		adult	Not dated	-	-	-	-	-10.4	10.4	3.3	18.6

[a]Unless otherwise indicated

[b]American Museum of Natural History

ence from an internationally recognized standard (PDB) assigned by definition a value of 0 ‰ and computed as follows:

$$\delta^{13}C = \frac{R_{sample} - R_{standard}}{R_{standard}} \times 1000\ ‰ \qquad (1)$$

where $R = {}^{13}C/{}^{12}C$.

The degree of fractionation associated with photosynthesis covaries with the kinetic properties of carbon uptake and enzymatic processes of carbon fixation (Farquhar et al. 1989). In terrestrial plants, carbon isotope fractionation is contingent upon which of three photosynthetic pathways (C_3, C_4, CAM) metabolizes atmospheric CO_2. Cool season grasses, trees, tubers, and most bushy plants employ C_3 photosynthetic mechanisms discriminating heavily against ^{13}C, expressing a mean $\delta^{13}C$ value of –26.7 ± 2.7 ‰ (n = 370) (Cerling et al. 1998:Figure 3). A small set of forbs and all warm-season grasses such as maize (*Zea mays*), common to regions where daytime growing-season temperature exceeds 22ºC and precipitation exceeds 25 mm (Ehleringer et al. 1997), use C_4 photosynthesis resulting in less discrimination against ^{13}C and an average $\delta^{13}C$ value of –12.5 ± 1.1 ‰ (n = 455) (Cerling et al. 1998:Figure 3). Sand dropseed (*Sporobulus cryptandrus*) is the only native C_4 grass common to archaeological assemblages in the study area, although amaranth (*Amaranthus* sp.) and saltbush (*Atriplex canescens*) have also been identified. Cacti and some members of the Agavacaea (yucca and agaves) use the CAM pathway, which alternates between C_3 and C_4 photosynthetic mechanisms and can produce isotope signatures as positive as C_4 photosynthesis. Plants grown before fossil fuel depletion of atmospheric CO_2 are enriched 1–2 ‰ relative to the above averages (Tieszen and Fagre 1993a), for example, archaeological maize cobs and kernels from sites in the northern Southwest have a mean $\delta^{13}C$ value of –10.1 ± 0.7 ‰ (n = 34), (Coltrain and Leavitt 2002:Table 5; Smiley and Robins 1997:Table A.1)

$\delta^{13}C$ values are passed from producer to consumer leaving a diagnostic signature in consumer tissues that does not covary with the skeletal element analyzed or sex of the sample independent of differences in feeding ecology (Hobson and Schwarcz 1986; Lovell et al. 1986). Fractionation between plant tissues and consumer bone collagen is 5 ‰ and approximates 1‰ at higher trophic levels. $\delta^{13}C$ values represent a weighted average of long-term dietary intake since the carbon in adult bone collagen turns over slowly, requiring ca. 30 years to replace existing carbon with an equivalent amount of carbon (Stenhouse and Baxter 1977, 1979:333; see also Harkness and Walton 1972 and Libby et al. 1964). Accordingly, the bone collagen of individuals with diets comprised primarily of wild C_3 plant foods will exhibit mean $\delta^{13}C$ values in the –22 ‰ to –19 ‰ range, while individuals heavily reliant on maize will express $\delta^{13}C$ values in the –10 ‰ to –6 ‰ range (e.g., Coltrain and Leavitt 2002; Ezzo 1993; Martin 1999; Matson and Chisholm 1991; Spielmann et al. 1990) such as those reported below. Within this range, more positive values indicate greater reliance on C_4 foods such as maize.

Work with rodents on experimental diets (Ambrose and Norr 1993; Tieszen and Fagre 1993b) has led to the impression that bone collagen $\delta^{13}C$ values are heavily biased by the $\delta^{13}C$ value of ingested animal protein. Although protein biasing occurs, it has become increasingly clear that the degree of biasing is correlated to the source of carbon used for synthesis of non-essential amino acids (neAAs) (Schwarcz 2001). Non-essential amino acids occupy two of three positions in bone collagen's cross-linked amino acids chains. If protein intake is adequate to supply both essential and neAAs, the stable carbon isotope (SCI) signature of bone collagen will reflect that of dietary protein. This is a condition seldom obtained even by carnivores, since they experience periodic resource stress and must, at least occasionally, rely on stored macronutrients for the manufacture of neAAs (Schwarcz 2001). In omnivores, the carbohydrate component of the diet may frequently supply carbon for neAA synthesis. In these cases, bone collagen $\delta^{13}C$ values more closely reflect the isotope signature of total diet. A recent study with burials from the Great Salt Lake wetlands (Coltrain and Leavitt 2002) provides inferential support for this understanding. Although dietary protein carried a C_3 or isotopically depleted signature (Coltrain and Leavitt 2002:Table 5), some individuals expressed C_4, or isotopically enriched SCI ratios. Clearly, enriched SCI ratios can reflect the carbohydrate component of sampled diets. Thus, in settings where protein intake is moderate to low, collagen $\delta^{13}C$ values provide a conservative but useful measure of maize consumption, facilitating diagnostic estimates of sampled diets for comparative purposes.

Stable Nitrogen Isotope Analysis

Stable nitrogen isotope analysis follows from the understanding that $^{15}N/^{14}N$ increases by approximately 2–4 ‰ with each increase in trophic level due primarily to fractionation during urea production, enriching the isotope signature of nitrogen available for protein synthesis (Schoeller 1999). The ratio of $^{15}N/^{14}N$ is also expressed in delta notation and calculated by substituting $R = {}^{15}N/^{14}N$ into Equation 1. Organic $\delta^{15}N$ is commonly a positive value since atmospheric nitrogen is the standard at 0 ‰. The trophic level effects of nitrogen metabolism are clearly illustrated in nursing infants whose $\delta^{15}N$ values are typically 3 ‰ above adult diets (Coltrain 1996; Coltrain and Leavitt 2002; Katzenberg 1993).

Most terrestrial plant taxa obtain nitrogen from soil ammonium (NH_4^+) or nitrate (NO_3^-) and have $\delta^{15}N$ values of 3–6 ‰ with a 0–9 ‰ range contingent upon temperature and aridity (Pate 1994). A small sample of archaeological maize cobs and kernels from sites in the northern Southwest are at the upper end of this range averaging 6.9 ± 3.7 ‰ (n = 17) (Coltrain and Leavitt 2002:Table 5). In this regard, studies indicate a general relationship between aridity and $\delta^{15}N$ values such that vegetation declines 1.0–1.3 ‰ per 100 mm of rainfall (Ambrose 1991; Gröcke et al. 1997; Heaton et al. 1986; Pate et al. 1998; Robinson 2001; Schwarcz et al. 1999). Independent of effective moisture, plants that fix atmospheric nitrogen such as legumes have a mean $\delta^{15}N$ value of 1 ‰, with a –2 to 2 ‰ range (Evans and Ehleringer 1994; Pate 1994). Low nitrogen values are also characteristic of taxa growing in association with nitrogen-fixing mycorrhizae in biological soil crusts found in arid settings throughout the Southwest. Accordingly, pinyon (*Pinus monophyla*), acorn (*Quercus* sp.) and a suite of tubers including balsam (*Balsamorhiza* sp.) and bitterroot (*Lewisia rediviva*), collected in the Great Basin and on the Colorado Plateau, have produced low $\delta^{15}N$ values (Coltrain and Leavitt 2002:Table 5). Herbivores in temperate climates typically exhibit $\delta^{15}N$ values of 6–9 ‰ (Coltrain and Leavitt 2002:Table 5), while arid-land species and non-obligate drinkers, those that recycle urea, reflect their water-conservation strategies in more positive $\delta^{15}N$ values (Ambrose 1991).

Laboratory Procedures

Approximately 500 mg of cortical bone were cleaned of surface contaminants then demineralized whole in 0.6N HCl at 4º C; sterile ddH_2O was used throughout and glassware was baked out 3 hrs at 550º C. The collagen pseudomorph was then rinsed to neutrality, treated with 5 percent KOH to remove organic contaminants, rinsed to neutrality and lyophilized. Approximately 100 mg of lyophilized collagen were gelatinized in 5 ml of water (pH 3) for 24 hours at 120º C. Water-soluble and -insoluble phases were separated by filtration and the former was lyophilized and weighed to obtain a collagen yield. $\delta^{13}C$ and $\delta^{15}N$ values were determined by flash combustion to produce CO_2 and N_2 and measured against the appropriate reference gas on a Finnigan Delta Plus mass spectrometer with Carlo Erba EA118 CHN interface. Stable isotope measurements and weight percent C and N values were obtained from a single sample combustion. All samples met established preservation criteria (see Table 1; Ambrose 1990). Analytical precision is ± 0.1 ‰ for carbon and ± 0.2 ‰ for nitrogen. Accelerator radiocarbon dates were run on purified bone collagen, normalized with measured $\delta^{13}C$ values and calibrated with Calib 5.0.2.

Results

Accelerator Radiocarbon Dating

All individuals, with the exception of Camp Cemetery and Chacoan remains, date to the Basketmaker periods (Table 1; Figure 2). The two Red Rock Valley burials are Basketmaker III in age; the remainder are Basketmaker II. Dated Camp Cemetery burials are Pueblo II or Pueblo III in age and Chacoan burials date to the Pueblo I and Pueblo II periods. Among Basketmaker II burials, those from White Dog Cave are the oldest, dating to a two sigma range of cal 481–174 B.C. with confidence interval (CI) midpoints between cal 364–284 B.C. Sayodneechee Canyon and Kinboko burials are generally younger in age and fully contemporary

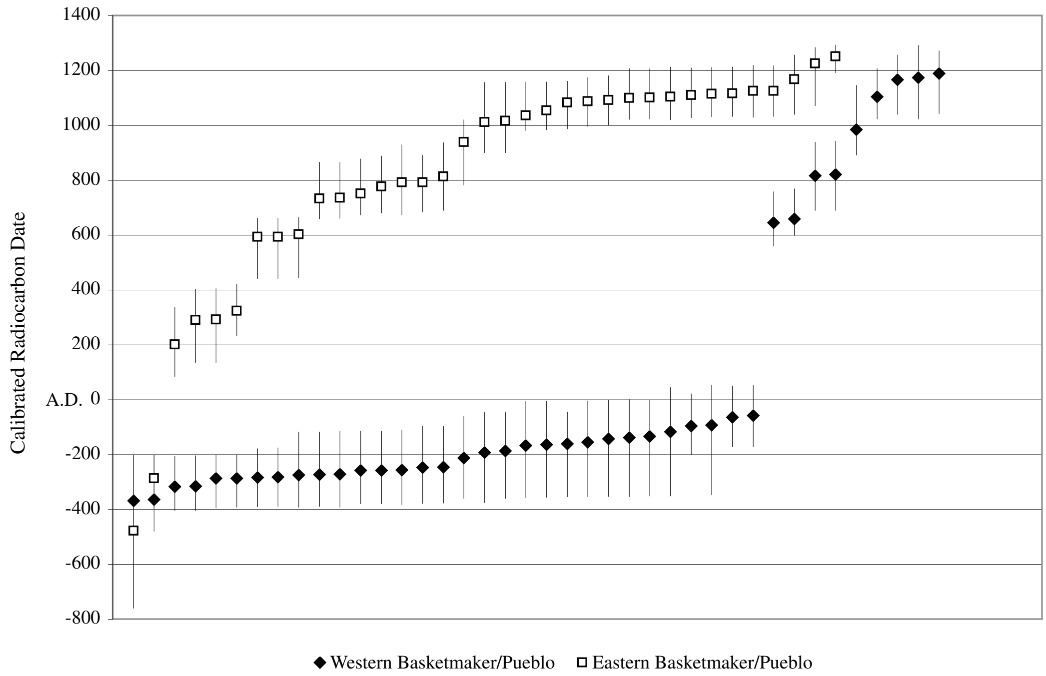


Figure 2. Calibrated accelerator radiocarbon confidence interval midpoints and two sigma ranges for all dated western Basketmaker, Puebloan and Chacoan burials reported in this study and eastern Basketmaker and Puebloan burials reported in Coltrain et al. (2006).

with virtually identical two sigma ranges (Sayodneechee cal 389 B.C.–A.D. 53, Kinboko cal 396 B.C.-A.D. 51), and CI midpoints (cal 287–58 B.C.) that slightly overlap those of White Dog Cave. The Canyon del Muerto burial and Cave 6 infants group temporally with the Sayodneechee and Kinboko Canyon burials, whereas the adult male from Tsegi Canyon Cave 3 is contemporary with the oldest White Dog Cave burial (Table 1).

$\delta^{13}C$ Values

All burials met established criteria for well-preserved bone collagen; atomic C:N ratios and collagen yields are reported in Table 1. Stable carbon isotope values range from –13.7 ‰ to –5.9 ‰ (Table 1) with a mean value of –7.8 ± 1.7 ‰ (Table 2). All $\delta^{13}C$ values are plotted in Figures 3 and 4; the former includes previously published data on eastern Basketmaker diets (Coltrain et al. 2006) for comparative purposes. Forty of 42 individuals exhibit $\delta^{13}C$ values between –10.1 ‰ and –5.9 ‰.

Basketmaker II burials are generally depleted in $\delta^{13}C$ relative to Camp Cemetery PII/III individuals; however, sample means are not significantly different ($t = 2.306$; $df = 8$; $p = .15$) and, with the exception of Caves 3 and 6 ($n = 3$), Basketmaker II site mean values are within 1 ‰ of Camp Cemetery and clearly within the range of later Formative economies (Table 2). When grouped without results from Caves 3 and 6, the mean for Basketmaker II burials is –7.5 ± 1.1 ‰. This is a more positive $\delta^{13}C$ value than mean values reported for burials from Pueblo II Virgin Anasazi sites (S. Martin 1999), Pueblo II sites on Black Mesa, AZ (Martin et al. 1991) and Basketmaker and Puebloan sites on Mesa Verde, Colorado (Decker and Tieszen 1989). This value is also as or more positive than those reported for burials from Grasshopper Pueblo, Arizona (A.D. 1275–1330) (Ezzo 1993) and Swarts Ruin, New Mexico (data in possession of the first author), as well as burials from Pecos Pueblo, New Mexico, dating to the Black-on-white period (A.D. 1200–1300) (Spielmann et al. 1990) (Table 2; see also Coltrain and Leavitt 2002). In addition, the average $\delta^{13}C$ value for all Basketmaker II burials was more positive than the Chaco Canyon mean without the elimination of outliers and virtually identical when the Chacoan outlier and Basketmaker Caves 3 and 6 burials were eliminated from calculations.

Table 2. Southwest Formative Stable Isotope Means and Standard Deviations.

Period/Location	*n*	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	Ref.[a]
Marsh Pass, Arizona	37	-7.8 ± 1.6	7.7 ± 1.2	
Basketmaker II/III	33	-7.9 ± 1.7	7.7 ± 1.2	
Basketmaker II	31	-8.0 ± 1.7	7.7 ± 1.3	
Sayodneechee Cave	11	-7.9 ± 1.3	8.4 ± .8	
Kinboko Cyn Cave 1	10	-7.8 ± 1.0	7.5 ± 1.2	
White Dog Cave	6	-7.1 ± .9	6.8 ± 1.8	
Caves 3/6	3	-11.1 ± 2.9	7.1 ± .5	
Canyon del Muerto	1	-6.3	8.5	
Basketmaker III (Red Rock Valley)	2	-6.3 ± .6	8.1 ± .4	
Pueblo III (Camp Cemetery)	4	-7.0 ± .5	7.8 ± .8	
Chaco Cyn Great Houses	5	-8.1 ± 1.6	11.8 ± 1.5	
w/o Outlier	4	-7.5 ± 1.0	12.1 ± 1.5	
Southwestern Colorado	43			1
Basketmaker II (Talus Village)	6	-8.4 ± 1.0	7.7 ± .2	
Basketmaker III/Pueblo I (Sites 22/23[b])	10	-6.6 ± .4	8.6 ± .5	1
Pueblo II/III	27	-7.1 ± .3	8.7 ± .5	1
Other Formative Sites	119			
Basketmaker II				
Black Mesa, AZ	2	-7.6 ± .3	7.5 ± .5	2
Virgin Anasazi, UT	4	-8.0 ± .2	8.8 ± .7	3
Old Man Cave, Cedar Mesa	2	-9.1 ± .7		4
Cedar Mesa, UT	4	-7.7 ± .2		5
Basketmaker III				
Virgin Anasazi, UT	2	-10.0 ± 2.9	10.3 ± 2.3	3
Pueblo I				
Virgin Anasazi, UT	2	-9.3 ± 1.4	7.6	3
Mesa Verde, CO	6	-8.9 ± .3		6
Pueblo II/III				
Black Mesa, AZ	10	-8.1 ± .8	6.1 ± .2	2
Virgin Anasazi, UT	9	-8.2 ± 1.0	8.3 ± .7	3
Cedar Mesa, UT	3	-7.3 ± .2		5
Mesa Verde, CO	24	-8.5 ± .6		6
Pueblo III				
Mancos Cyn, CO	4	-8.3 ± .4		6
Classic Mimbres A.D. 1000–1150				
Swarts Ruin, NM	4	-8.7 ± 1.4	8.6 ± .3	7
Grasshopper Pueblo, AZ				
AD 1275-1330	37	-9.2 ± .5		8
Pecos Pueblo, NM				
AD 1200-1300	8	-7.5 ± .3	9.1 ± .7	9

[a] Data from:

1. Coltrain et al. 2006:Table 1.
2. Martin et al. 1991:Table 3-6.
3. Martin 1999:Table 2.
4. Chisholm and Matson 1994:Table 2.
5. Matson and Chisholm 1991: Table 3.
6. Decker and Tieszen 1989:Table 1.
7. In possession of first author.
8. Ezzo 1993:Table 5.2.
9. Spielmann et al. 1990:Table 2.

[b] Two sigma range spans the Basketmaker III/Pueblo I transition

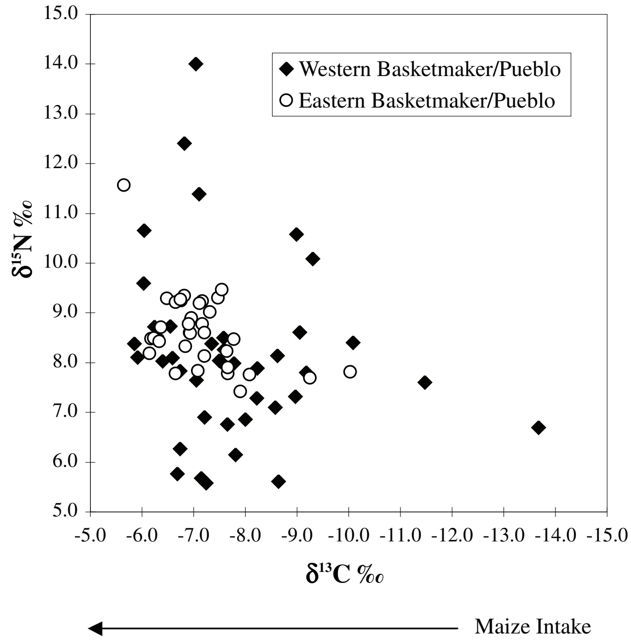


Figure 3. Individual $\delta^{15}N$ ‰ values plotted against $\delta^{13}C$ ‰ values for all western Basketmaker, Puebloan and Chacoan burials in this study and eastern Basketmaker and Puebloan burials reported in Coltrain et al. (2006).

The individual producing the most negative $\delta^{13}C$ value (–13.7 ‰), a young adult male from Tsegi Canyon Cave 3 (631) (Guernsey 1931:13–14), also produced the oldest radiocarbon date with a CI midpoint of cal 368 B.C. and two sigma range of 202–499 B.C. (Table 1; Figure 4). The second burial relatively depleted in $\delta^{13}C$ (–11.5 ‰) is a one- to two-year-old infant (629) from Marsh Pass Cave 6 (Guernsey and Kidder 1921:30–31) recovered in association with another infant (630) six-to-18 months in age whose $\delta^{13}C$ value is well within the range of the remainder of the data set. These infants may have been interred together, with calibrated CI midpoints merely a decade apart in the mid-first century B.C.

$\delta^{15}N$ Values

The mean $\delta^{15}N$ value for Basketmaker and all Marsh Pass burials is 7.7 ± 1.2 ‰, in keeping with data from later Formative sites (Table 2). $\delta^{15}N$ values range from 5.7 ‰ to 8.6 ‰, excluding nursing infants and Chacoan burials, and are plotted in Figures 3 and 5; the latter figure includes previously published data on eastern Basketmaker diets (Coltrain et al. 2006). In some cases, particularly in marine food webs, an approximate 3 ‰ spacing between the upper and lower ends of a $\delta^{15}N$ range would signify a trophic level offset in dietary intake (e.g., Coltrain et al. 2004a, 2004b); however, here other variables may have come into play. Reliance on animal protein surely varied somewhat both temporally and spatially but microclimatic variation in effective moisture may also have biased plant $\delta^{15}N$ values, as would intake of pinyon, acorn, or tubers with low $\delta^{15}N$ values characteristic of plants growing in association with nitrogen-fixing mychorrizae. No evidence exists for the cultivation of legumes during the Basketmaker II period.

Among the seven infants in this data set, four (603, 615, 627, 628) show clear trophic level enrichment characteristic of nursing (Figure 5a). Infant 616 may have subsisted on a nursing diet supplemented by weaning food such as maize gruel and thus expressed a moderately elevated $\delta^{15}N$ value, whereas infants 620 and 630 appear to have subsisted entirely on maize gruel or other weaning foods perhaps contributing to their death.

White Dog Cave produced the most depleted mean $\delta^{15}N$ value with the lowest standard deviation (5.7 ± 0.1 ‰) and the oldest suite of radiocarbon dates. The Tsegi Canyon Cave 3 burial (631) also produced a relatively depleted $\delta^{15}N$ value (6.7

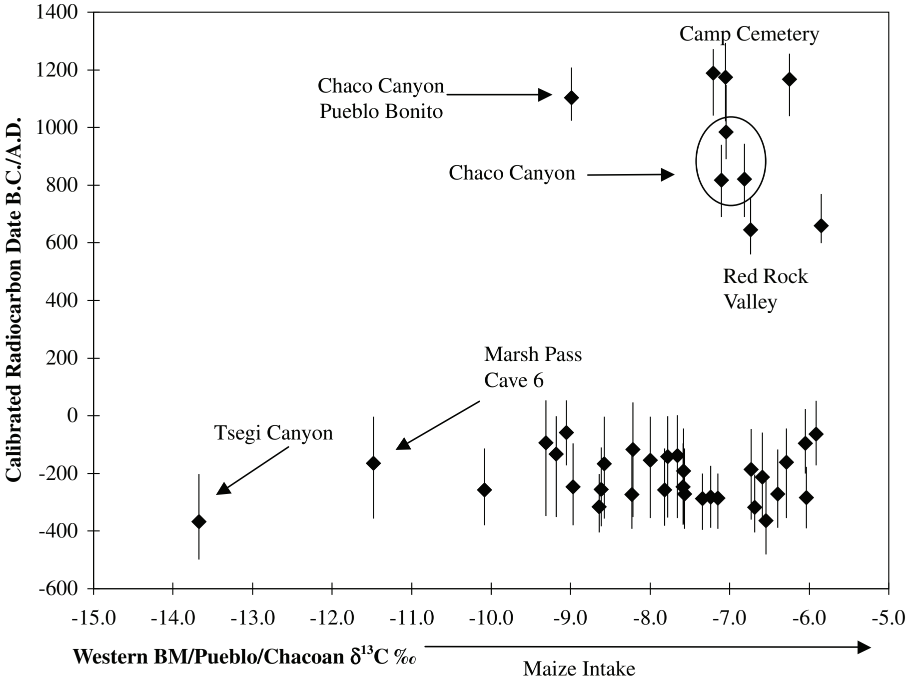


Figure 4. Calibrated accelerator radiocarbon confidence interval midpoints and two sigma ranges plotted against individual $\delta^{13}C$ ‰ values for dated western Basketmaker, Puebloan and Chacoan burials.

‰) and the oldest date in the dataset. Conversely, Chacoan Great House burials exhibited the most elevated mean $\delta^{15}N$ value at 12.1 ± 1.5 ‰, a trophic level above other individuals in the study both individually and collectively (Figure 5a).

Too few burials were confidently sexed to examine these data for sex-based dietary patterns. Likewise, with few exceptions burials were either adult or infant in age, with too few children or adolescents to determine with any confidence if age based differences in diet were present.

Discussion

This study significantly increases the number of Basketmaker II individuals both sampled for stable isotopes and securely dated to before the beginning of the Christian era. We add 31 directly dated burials with CI midpoints between ca. cal 400–50 B.C. to a previous data set of merely two Talus village individuals (Coltrain et al. 2006). Earlier studies have reported similar stable isotope values on a total of 12 Basketmaker II burials but dated those samples by association to after the beginning of the Christian era (Geib and Davidson 1994; Martin et al. 1991:243; Martin 1999:495; Matson and Chisholm 1991:449). Similarly, Basketmaker-era radiocarbon dating reported in Smiley (1997:30, Figures B.13, B.16) on yucca seed beads and a burden basket trumpline found with two Canyon del Muerto burials yielded post A.D. 1 dates. The cluster of early dates and enriched $\delta^{13}C$ values on Marsh Pass Basketmaker II burials clearly demonstrates that maize was a staple in Basketmaker II diets well before the beginning of the Christian era.

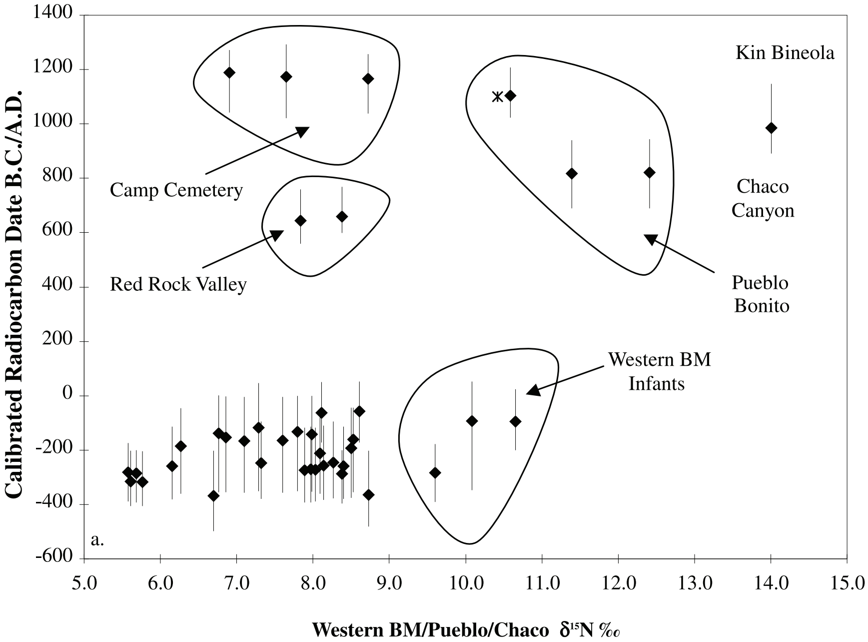
Figure 2 suggests an occupational hiatus in the northeastern Arizona Basketmaker period between ca. A.D. 50–500, bridged by dates from Talus Village in southwestern Colorado (Coltrain et al. 2006). However, radiocarbon dates from Canyon de Chelly and southeastern Utah also bridge this gap (Smiley 1997:Figure 2.3) as do data from open Basketmaker sites on Rainbow Plateau just north and west of Marsh Pass (Geib and Spurr 2000:180–183), where a tight sequence of dates, 46 of 68 on maize, document cultural continuity from 400 B.C. to A.D. 700. Taken together these chronometric data present a solid body of evidence for the presence of Basketmaker II in northeastern Arizona from ca. 500 B.C. to A.D. 400. Thus it appears that the hiatus implied in Figure 2 is an artifact of sampling, although every skeletal burial in the Peabody Basketmaker collection that could be confidently identified as a distinct individual was sampled. It is also possible that the immediate Marsh Pass locale was briefly abandoned or that cave burials became less common over time as Basketmaker groups occupied open pithouse settlements. Confirming or rejecting these possibilities would require additional data from existing collections or, perhaps additional fieldwork.

The average $\delta^{13}C$ value for Basketmaker burials indicates a diet of ca. 80 percent C_4 foods based on $\delta^{13}C$ values for plant remains reported in Smiley and Robins (1997:Table A.1). Although a small suite of C_4 wild plant foods may have contributed to isotopic enrichment, the preponderance of evidence indicates maize was the primary carbohydrate staple. In addition to maize, Kidder and Guernsey (1919:156) noted the presence of acorn, pinyon, and "dried fruit" in Basketmaker cave sites and Guernsey (1921:42) added squash, Indian rice grass (*Oryzopsis hymenioides*), and an unidentified chenopod to their inventory of plant remains. Important additional insights come from unpublished Grand Gulch coprolite studies (Aasen 1984; Lepofsky 1986) summarized by Matson (1991:92–96) and Matson and Chisolm (1991). Their results are similar to the above descriptions: maize was the staple with pinyon, small seeds (especially Indian rice grass), squash, and yucca important but supplementary components.

Faunal bone was scarce, mostly in "slivers too small for identification" but numerous fragments of deerskin and mountain sheep hide attested to hunting success (Kidder and Guernsey 1919:156), as did small pronghorn hide pouches (Guernsey 1931:74). A more thorough inventory of faunal remains from the open sites Lukachukai and Salina Springs in northeastern Arizona included rabbits, rodents, dogs or coyote and artiodactyls (Gilpin 1994). Maize and the C_3 chenopod goosefoot were the only charred seeds common to flotation samples from these sites. No C_4 plants are present among the wild foods identified by excavators; however, the unidentified chenopod in Guernsey (1921) may have been amaranth, and rabbit, rodent, or canid diets may have included some C_4 intake and thus made a slight contribution to enriched human $\delta^{13}C$ values.

Given moderately low $\delta^{15}N$ values (Figure 5; Table 2), intake of wild plants may have been biased toward tubers, pinyon, or acorn growing in association with nitrogen-fixing mycorrhizae. Animal protein intake appears to have been relatively low and was likely made up of taxa primarily reliant on C_3 forage (see Coltrain et al. 2006). Reliance on C_3 animal protein and a C_4 carbohydrate staple would tend to bias Basketmakers $\delta^{13}C$ values causing them to slightly underestimate C_4 plant consumption (see Ambrose and Norr 1993; Tieszen and Fagre 1993b). In this regard, Kidder and Guernsey (1919:156) noted the absence of turkey droppings and feathers in Basketmaker caves, in marked contrast to their ubiquity at Puebloan sites, indicating that at sites under study maize-fed turkeys were unlikely to have supplemented protein intake or contributed to elevated $\delta^{13}C$ values. In contrast, coprolites analyzed from Basketmaker II levels at Turkey Pen Cave in Grand Gulch, Utah, included turkey droppings containing maize pollen suggesting the presence of domesticated turkeys (Aasen 1984; Matson and Chisolm 1991:455). However, no clear evidence exists for the processing of turkeys for human consumption and they may have been raised primarily for feathers.

Our data strongly suggest that in the study area the presence of Basketmaker material culture signifies heavy reliance on maize. However, these data do not indicate that the appearance of maize was synonymous with the appearance of Basketmaker groups or resolve questions regarding possible farming activities among Late Archaic foragers and their relationship to the Basketmaker complex. Chronometric data on maize from the Four Corners region are also not in agreement regarding these issues. In a 1994 volume of Kiva (60:2) devoted to Anasazi origins, Gilpin (1994) reported relatively early dates on maize from Salina Springs and Lukachukai, leading him to argue that it was a staple in Basketmaker II diets by approximately 3000 B.P. In contrast, maize dates from Turkey Pen Cave placed Basketmaker occupations there to the beginning of the Christian era (Chisholm and Matson 1994; Matson 1994) and Steve Martin (1999:495), reporting the stable isotope chemistry of four Virgin Anasazi individuals, argued that they were "full-time maize agriculturalists" by A.D. 1. An additional set of dates on maize in Smiley (1997) placed farming in Canyon del Muerto at ca.



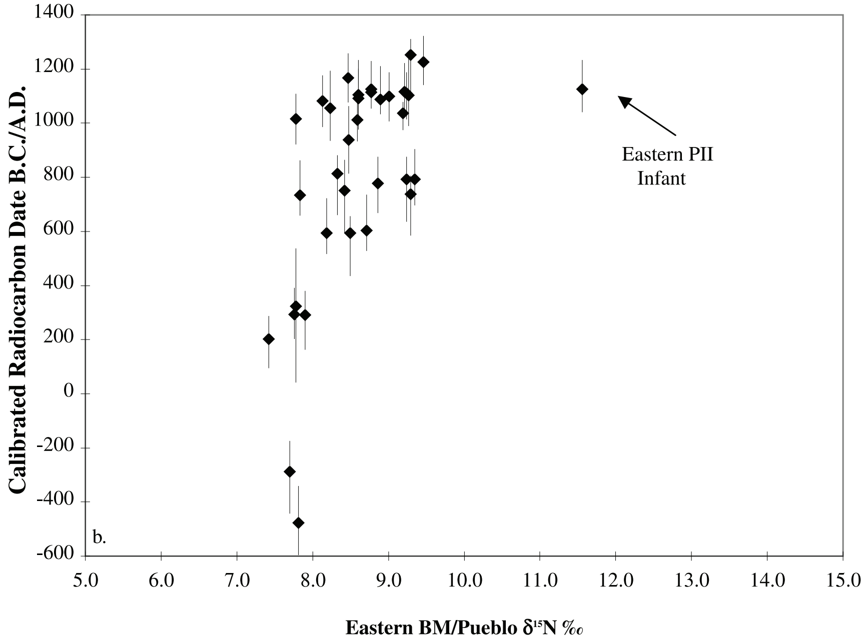


Figure 5. (a) Calibrated accelerator radiocarbon confidence interval midpoints and two sigma ranges plotted against individual $\delta^{15}N$ ‰ values for all dated western Basketmaker, Puebloan and Chacoan burials in this study. The asterisk symbol (*) represents the estimated age of undated Pueblo Bonito burial 685 recovered from the same context as dated Pueblo Bonito burial 590. (b) Calibrated accelerator radiocarbon confidence interval midpoints and two sigma ranges plotted against individual $\delta^{15}N$ ‰ values for eastern Basketmaker and Puebloan burials reported in Coltrain et al. (2006).

2150 B.P. However, an earlier ca. 2700–2300 B.P. maize date exists from Six Toe Shelter in Butler Wash and three calibrated dates on maize from Three Fir Shelter on the northeast edge of Black Mesa (Smiley 1993, 1997) closely approach or exceed 3000 B.P., as do several calibrated dates from Bat Cave with the oldest maize dates from both contexts at or slightly exceeding 4000 B.P. (Smiley 1994:Figure 8). In sum, the earliest dates on maize indicate it was present in the study area by 4000 B.P., but no published evidence exists for cultivation, processing, or volume storage of the cultigen prior to ca. 3000 B.P., and such evidence appears even later in some areas.

Did centuries of casual farming by Archaic groups lead to heavy reliance on maize, or do isolated finds suggest early maize may have entered the study area through logistical foraging activities or trade? As noted, no published evidence exists for casual cultivation other than a handful of early dates on maize from rock shelter contexts. Archaic population densities appear to have been low and work on Rainbow Plateau, Cedar Mesa and elsewhere indicates a relatively long hiatus between Archaic and Basketmaker occupations. Moreover, the appearance of Basketmaker people was not preceded by compelling evidence for increasing reliance on small-packaged plant resources accompanied by increased sedentism and intensified storage, as is apparent in two well-researched, foraging populations in transition to full reliance on domesticates. In the Levant, pre-agricultural Natufian groups heavily dependent on wild cereal grains left substantial pithouses with hearths, grinding implements, intramural storage, and numerous burials (Bar-Yosef 1998, 2002). Similarly, the Hopewellian period in the eastern American Woodlands, during which several indigenous plant taxa were undergoing domestication, is characterized by settlements described as "small villages" with single-wall post houses, deep storage pits, extensive residential midden and burials both grouped and isolated (Smith 1992:213). The Basketmaker groups sampled here are not preceded by an Archaic record that resembles populations known to have been in transition from a foraging to an agricultural economy and, given their high intake of maize, can no longer be thought of as a transitional population themselves. Moreover, Archaic foragers left a highly ephemeral material record in the Four Corners region that is in some areas separated from Basketmaker material culture by a long occupational hiatus. Thus, there is little evidence to indicate that centuries of casual maize farming by mobile foraging groups, if it occurred, led to the appearance of Basketmaker material culture. New findings could clearly alter this view; however, given the current body of published data on this topic, parsimony dictates that Basketmaker farming groups migrated into the region fully dependent on maize-based economic strategies.

Skeletal remains that might allow us to estimate the importance of maize in Late Archaic economies are extremely rare; however, we have dated bone collagen extracted by Chisholm from the single Archaic individual whose stable carbon isotope chemistry was reported in Matson and Chisholm (1991:Table 3). Burial 2 (NA 7523) was recovered from Sand Dune Cave on Navajo Mountain, 85 km southwest of Cedar Mesa, Utah, and provenienced to the early Archaic, Desha horizon. This burial is actually younger than the Desha period (6000–8000 B.P.), directly dating to 4480 ± 60 B.P. (CAMS 10353), normalized with Chisholm's $\delta^{13}C$ value and calibrated with Calib 5.0.2 to a two sigma range of 4887–5309 B.P. with a CI midpoint of 5136 B.P., and cal 2938–3360 B.C. with a CI midpoint of 3187 B.C. Chisholm and Matson reported a $\delta^{13}C$ value of –13.9 ‰, surprisingly positive for an individual living in the study area a millennium before the earliest evidence for maize. They attributed isotopic enrichment to reliance on the succulent *Opuntia*, which is a CAM plant, the wild C_4 grass *Sporobolus* (sand dropseed) and *Amaranthus*, the only C_4 genus among the wild chenopods, estimating 40 percent reliance on wild C_4 plant foods. Archaic coprolites from Dust Devil Cave, adjacent to the site, were dominated by *Opuntia*, *Sporobolus*, chenopods and cottontail rabbit but devoid of maize, in contrast to coprolites from Turkey Pen Cave in Grand Gulch, dating to ca. 2000 B.P. and dominated by maize and pinyon (Matson and Chisholm 1991:Table 1). Whereas the isotope chemistry of this individual could be used to make an argument for partial reliance on maize during the Archaic period, the early chronometric age of the individual and relevant features of the archaeological record offer no empirical support for such an interpretation.

Finally, both the earliest and most recent burials in the data set deserve additional mention. The 18-year-old male from Tsegi Canyon Cave 3 had a $\delta^{13}C$ value very similar to that of the Sand Dune Cave Late Archaic individual reported above. This burial also produced the oldest Basketmaker CI midpoint, 368 B.C. and two-sigma range, 499–202 B.C (Figure 4). Recovered partially mummified, sitting with knees drawn up and wrapped in a fur-cordage robe, the young man wore a feather head ornament and string of cylindrical bone beads, clearly identifying him as Basketmaker. An atlatl and two dart points were positioned adjacent to his right arm (Guernsey 1931:13). Maize likely made up merely 40–50 percent of his diet in contrast to ca. 80 percent reliance on maize among the remainder of the Basketmaker data set. It could be argued, given his early chronometric date, that he represents a transitional phase in Basketmaker economic history, one in which maize was less important. However, an infant from White Dog Cave Cist 10 dating to virtually the same CI midpoint, 364 B.C., exhibited a typical Basketmaker diet, as did the 18–19 year-old male from Cist 27 with CI midpoint of 317 B.C. It might also be argued that the Tsegi Canyon male was an elite individual, but his $\delta^{15}N$ value does not indicate a diet higher in animal protein than other burials of similar age, as might be expected for a male with elite status. In fact, low $\delta^{15}N$ values characteristic of this burial and White Dog Cave in general suggest again that intake of animal protein was low and intake of wild plant foods may have been biased toward tubers or pinyon, more so than is evident among later burials. Alternatively, a larger sample of early burials might indeed indicate that maize was less important early in the Basketmaker period or that reliance on maize was less uniform, defining a transitional phase presently unsupported by our data. Addressing this issue would necessitate additional work with burials from areas such as Black Mesa, Arizona, and Grand Gulch, Cedar Mesa, and the Virgin River regions of Utah.

In contrast to the oldest burials in the data set, the Pueblo I/II burials from the Chaco Canyon Great Houses, Pueblo Bonito and Kin Bineola (Table 1), had slightly less positive mean $\delta^{13}C$ values than Basketmaker individuals but extremely positive $\delta^{15}N$ values (Figure 5a), a trophic level or more above the remainder of the adult data set. The elite burial context of the Pueblo Bonito individuals (see Pepper 1909, 1920:216) is discussed further in Carlyle et al. (2007). Elevated $\delta^{15}N$ values clearly indicate a diet considerably higher in animal protein than the Basketmaker II/III diets reported here, as well as Puebloan diets reported elsewhere (Table 2). To characterize these diets relative to other Great House burials and understand their implications would necessitate further work with Chacoan skeletal material.

Conclusion

The isotopic and chronometric data from Basketmaker burials provenienced to the Four Corners region of the American Southwest clearly indicate that maize was a staple in Basketmaker diets by 400 B.C. Our data complement those presented by Geib and Spurr (2000, 2002) for open Basketmaker sites on the Rainbow Plateau just north of Marsh Pass and for Canyon de Chelly to the east and Butler Wash to the north (Smiley 1997; Smiley and Robins 1997). Further, these findings confirm the cultural–temporal scheme presented by Matson (1991:123) in which the White Dog Phase marks the onset of the Basketmaker II period (at 500 B.C. or perhaps as early as 1000 B. C.) as an economic strategy fully focused on maize agriculture and characterized by a distinctive material culture. This position contrasts somewhat with that of Smiley (2002:42) who would extend the White Dog Phase to the fourth millennium B.P. based on considerably earlier maize dates from Three Fir Shelter (3610±170 B.P.; Smiley 1994:174) and Bat Cave (3740±70 B.P.; Wills 1988). We do not argue that earlier people were unaware of maize but the importance of farming is not clear. Dates on maize in excess of 3000 B.P. place the cultigen in the region, but no firm conclusions regarding its dietary role can be drawn given the current absence of isotopic data and evidence for increasing sedentism and volume storage. We would thus reserve use of the White Dog Phase for sites with assemblages that include evidence for heavy reliance on maize, pithouses, ample storage, atlatl weaponry, elaboration of craft items (shell and bone beads, exotic stone pipes), and, in dry sites, multiwarp, twined sandals (Geib 2006; Hays-Gilpin et al.1998:18).

These issues bear on critical questions regarding the cultural and economic processes that led to the shift to farming in the northern Southwest. The earliest burials associated with distinctive Basketmaker assemblages also reflect significant use of maize, in clear contrast to Late Archaic assemblages, arguing for a migration of farmers into the region several centuries before the Christian era. Carpenter et al. (2002) have reached a similar conclusion for processes marking the onset of farming in the southern Southwest, although that shift occurred nearly a millennium earlier.

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