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Dating North America's oldest petroglyphs, Winnemucca Lake subbasin, Nevada



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ABSTRACT

On the west side of the Winnemucca Lake subbasin, Nevada, distinctive deeply carved meter-scale petroglyphs are closely spaced, forming panels on boulder-sized surfaces of a partially collapsed tufa mound. The large, complex motifs at this site are formed by deeply carved lines and cupules. A carbonate crust deposited between 10 200 and 9800 calibrated years B.P. (ka) coats petroglyphs at the base of the mound between elevations of 1202 and 1206 m. Petroglyphs above the carbonate crust are carved into a branching form of carbonate that dates to 14.8 ka. Radiocarbon dates on a multiple-layered algal tufa on the east side of the basin, which formed at an elevation of 1205 m, as well as a sediment-core-based total inorganic carbon record for the period 17.0–9.5 ka indicate that water level in the Winnemucca Lake subbasin was constrained by spill over the Emerson Pass Sill (1207 m) for most of the time between 12.9 ± 0.3 and ≥9.2 ka. These and other data indicate that the lake in the Winnemucca Lake subbasin fell beneath its spill point between 14.8 and 13.2 ka and also between 11.3 and 10.5 ka (or between 11.5 and 11.1 ka), exposing the base of the collapsed tufa mound to petroglyph carving. The tufa-based ¹⁴C record supports decreased lake levels between 14.8–13.2 ka and 11.3–10.5 ka. Native American artifacts found in the Lahontan Basin date to the latter time interval. This does not rule out the possibility that petroglyph carving occurred between 14.8 and 13.2 ka when Pyramid Lake was relatively shallow and Winnemucca Lake had desiccated.

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1. Introduction

1.1. Early American art forms

Recent Paleoindian research in the Americas (Dillehay et al., 2008; Gilbert et al., 2008; Overstreet and Stafford, 1997) suggests that humans reached the Americas prior to the Clovis period, which began ~13 100 calendar years before present (hereafter 13.1 ka). The earliest art in the Americas is arguably represented by a fragmented fossil bone from Florida (Purdy et al., 2011). The bone appears to be engraved with the figure of a mammoth, whose fossil remains date no later than 13 ka in eastern North America (Faith and Surovell, 2009; Grayson and Meltzer, 2003). The earliest petroglyph in South America is a pecked anthropomorphic figure in central-eastern Brazil; it has a minimum age of ~10.6 ka and may

be as old as 12 ka (Neves et al., 2012). Prior to our study, the oldest petroglyphs in North America (Cannon and Ricks, 1986) were represented by a panel of deeply incised, tightly clustered geometric petroglyphs from a cliff face along a basalt ridge at Long Lake in south-central Oregon. These petroglyphs were subsequently partly buried by the 7.63 ka Mount Mazama tephra (Zdanowicz et al., 1999). Here we report on early Archaic/Paleoindian petroglyphs from the Winnemucca Lake subbasin, Nevada, that were carved sometime between 14.8 ± 0.2 and 10.3 ± 0.1 ka.

1.2. The Winnemucca Lake petroglyph site

The Lahontan Basin (Fig. 1A) is located on the western edge of the Great Basin of the western USA. Three subbasins occupy the western side of the Lahontan Basin, Pyramid Lake, Winnemucca Lake, and the Smoke Creek-Black Rock Desert subbasins. On the western edge of the Winnemucca Lake subbasin, Nevada, just inside the eastern boundary of the Pyramid Lake Indian Reservation (site WDL12, Fig. 1B), numerous deeply carved meter-scale

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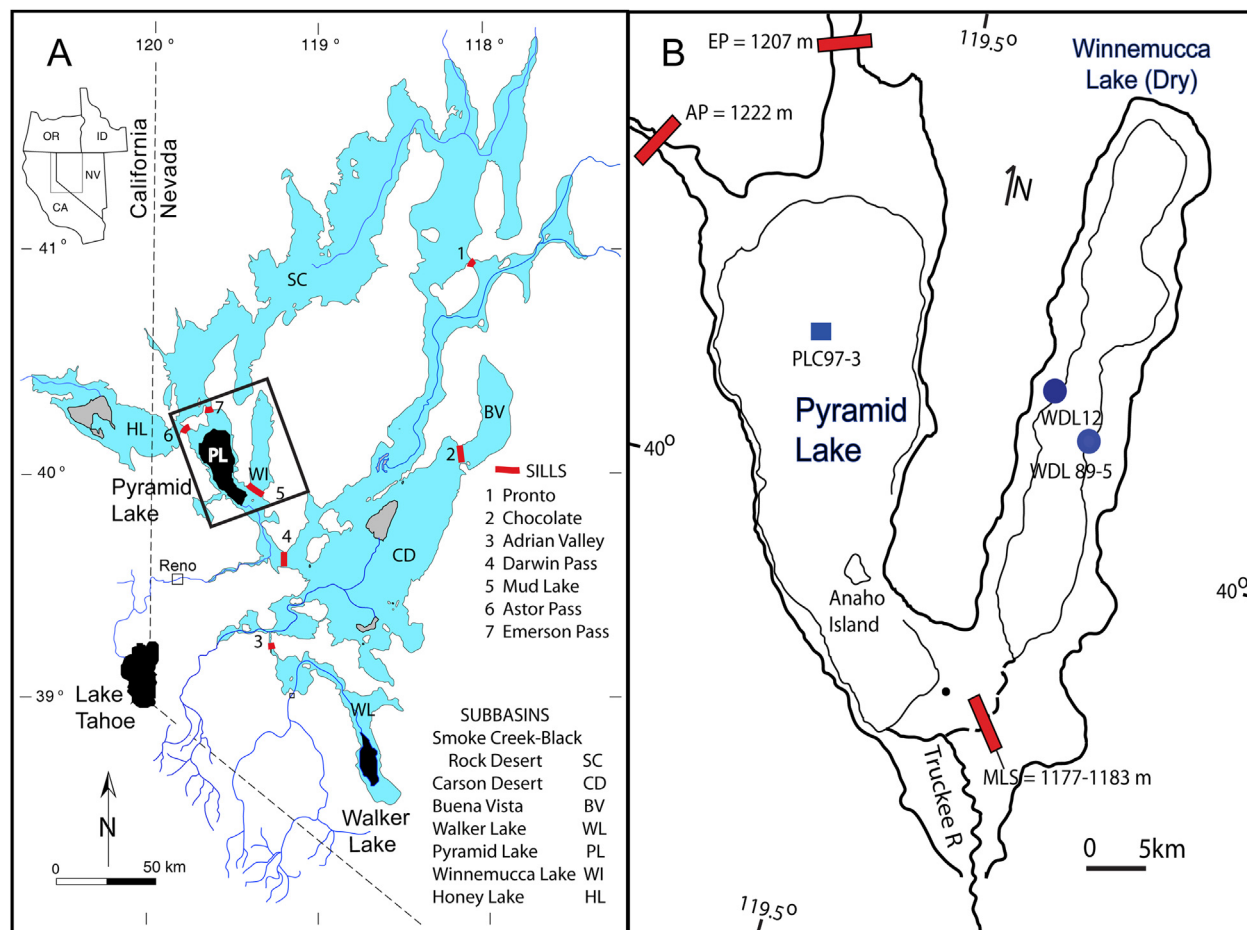


Fig. 1. A. The Lake Lahontan Basin, which contains seven lake subbasins separated by seven spill points (sills); B. The Pyramid and Winnemucca lake subbasins, Nevada. Astor Pass, Emerson Pass, and Mud Lake Slough spill points (dark red rectangles) are labeled, respectively, AP, EP, and MLS. Historic pre-irrigation surface areas of Pyramid and Winnemucca Lakes are bounded by thin black lines. WDL12 is the petroglyph site; WDL89-5 is the algal tufa site. The PLC97-3 sediment core site is shown as a blue square. Petroglyphs coated by the carbonate crust in A and B have been highlighted in [Supplementary Fig. 2](#). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

petroglyphs are closely spaced, forming panels on boulder-sized surfaces of a partially collapsed tufa mound ([Fig. 2](#), [Supplementary Fig. 1](#)).

The Winnemucca Lake petroglyph site 26Wa3329 (also known by its earlier site designation NV-Wa-29 in the University of California archaeological site files) was recognized as an unusual, and possibly, very early petroglyph site by [Connick and Connick \(1992\)](#). Their survey of Great Basin, California, and Southwestern archaeological and ethnographic literature revealed a suite of attributes that distinguished the Winnemucca Lake petroglyphs from the vast majority of other Great Basin petroglyph and pictograph sites. The motifs at this site are large and complex. Deeply carved lines (“grooves”) and dots (“cups” or cupules) form complex designs. The carvings are commonly 1–2 cm deep with cupules occurring on vertical versus horizontal surfaces. Some of the petroglyph motifs are represented elsewhere in the western Great Basin but they are neither oversized nor deeply incised. Missing from this site are some of the more common younger Great Basin petroglyph motifs, including zoomorphs, anthropomorphs, and handprints. [Connick and Connick \(1992\)](#) suggested that the Winnemucca Lake petroglyphs represented various meteorological symbols, e.g., clouds and lightning, associated with ethnographic and archaeological cultures from the American Southwest and southern California. Our analysis, however, found closer technological, chronological, and

design concordance with a site in south central Oregon, as well as other localities in the western Great Basin.

During an early trip to the petroglyph site, the senior author noticed that some petroglyphs on an east facing panel near the base of the tufa mound were partially coated with a thin white carbonate crust that reached an elevation of ~1206 m ([Fig. 3](#)), the approximate elevation of the northern spill point (Emerson Pass at ~1207 m) of the Winnemucca and Pyramid lake subbasins to the Smoke Creek-Black Rock Desert subbasin ([Fig. 1](#)). Above the carbonate crust, it is apparent that the petroglyphs were originally carved into a branching form of tufa ([Benson, 1994](#)), which was deposited between 16.2 and 14.8 ka ([Supplementary Table 1](#), BT samples in [Fig. 4](#)). In some instances, the lower portions of several elements on this panel are coated by the carbonate crust while the upper portions of the same elements remain uncoated or are only lightly coated because they are situated above the boundary for the zone of carbonate precipitation at ~1206 m. Some petroglyph elements on these panels are partially or entirely covered by varying thicknesses of the carbonate crust and motif details obscured.

The carbonate crust appears to thin in an upward direction, probably indicating deposition during differing overflow velocities; the higher the overflow velocity the higher the elevation of carbonate deposition at the petroglyph site which lies far south of the



Fig. 2. Petroglyph site WDL12 (archaeological site 26Wa3329) on the west side of the Winnemucca Lake subbasin. The tree-form petroglyph near the left side of the collapsed tufa mound is ~70 cm in length.

Emerson Pass spill point. Petroglyphs covered by the carbonate crust below the 1206-m line can be seen in Fig. 2A and B. These petroglyphs have also been highlighted in Supplementary Fig. 2.

On the northernmost boulder (Supplementary Fig. 2A), motifs that exhibit thicker carbonate crust on their lowermost segments include the following from south to north on the east facing panel: four stacked rows of short, vertical parallel lines; a series of vertical chain-like petroglyphs comprised of oval- to diamond-shaped elements, some of which exhibit enhanced interiors by use of circles and perforation of the outer tufa layer; a very deeply incised set of three curved, diagonal lines; and a complex design comprised of series of very deeply incised vertical, straight and sinuous lines bordered by a lower horizontal line.

Another tufa boulder (Supplementary Fig. 2B) exhibits the following motifs: horizontal diamond and circular elements joined to each other or linked by lines; additional, single circular-, diamond- and ovoid-shaped motifs; and lowermost motif comprised of four or more, short vertical lines atop a horizontal line. A complex rayed motif occupies the northern end of this panel. Similar vertical, chain-like motifs and variants of the rayed motif occur elsewhere at the Winnemucca Lake site, and variants of the short vertical line motif and the very deeply incised, paired diagonal curved line motif also occur at Long Lake as Great Basin Carved Abstract style petroglyphs.

The objective of this study is to ascertain the age of the Winnemucca Lake petroglyphs. We do this by first bracketing their time of carving by dating (^{14}C) the branching-form carbonate into which they were carved and the thin layer of carbonate that coats them. The tufa mound was accessible to petroglyph carving only when lake level fell below its spill point to the Smoke Creek-Black Rock Desert subbasin; i.e., below 1207 m. In order to determine when the lake was at its 1207-m spill level, we dated two layered algal tufas that formed in shallow water at an elevation of ~1206 m on the eastern side of the Winnemucca Lake subbasin. We also obtained a continuous record of total inorganic carbon (TIC) deposition between 17.0 and ~9.5 ka from a Pyramid Lake sediment core (PLC97-3) which was used to determine when the lake fell below its spill level.

2. Methods

2.1. Sediment coring and TIC measurement

Pyramid Lake core PLC97-3 was recovered in 94 m of water (Fig. 1B). Given evidence of shallow-water conditions and erosive activity above a sediment depth of 1.95 m, PLC97-3 was sampled starting at 1.95 m at the top of a laminated sedimentary unit. Continuous 10-mm-thick samples were taken from the 2.43 m of sediment below the 1.95 m depth. Parts of the core, which contained turbidites and slumped sediments, were subtracted from the core and its length readjusted to 4.0 m. Age models for this core (Fig. 5) were based on continuous measurements of paleomagnetic secular variation (PSV) that were matched to a well-dated PSV type curve, which had been correlated via marine sedimentary records to the GISP2 ice core (Benson et al., 2012; Lund, 1996, 2001a,b). Each 10-mm-thick sample averages a time span of 55 years. Each sample was combined with deionized water, shaken, and centrifuged for 15 min at 20 000 rpm using a Sorval Superspeed RC2B. After centrifugation, the conductivity of the supernatant was measured and the supernatant discarded. This procedure was repeated until the specific conductivity of the supernatant was <3 times the conductivity of Boulder, Colorado, tap water. Samples were then freeze-dried and homogenized. Values of TIC were determined at the USGS Boulder Laboratory using a UIC Model 5012 carbon dioxide coulometer. A detailed sedimentologic description of PLC97-3 can be found in Benson et al. (2002).

The elevation (1207 m) of the bedrock sill at Emerson Pass was obtained by surveying (Mifflin and Wheat, 1971). The elevation (1205) of the algal tufa (WDL89-5) on the eastern side of the Winnemucca Lake subbasin (Fig. 1) was estimated using a digital altimeter and was reported in Supplementary Table 7 of Benson et al. (2012).

The elevation of the top of the white carbonate crust (1206 m) at the Winnemucca Lake petroglyph site was measured using a Garmin GPSmap 60CSx. The accuracy of the elevations at each of these sites is estimated to be, respectively, <1 m, ± 3 m and ± 2 m.

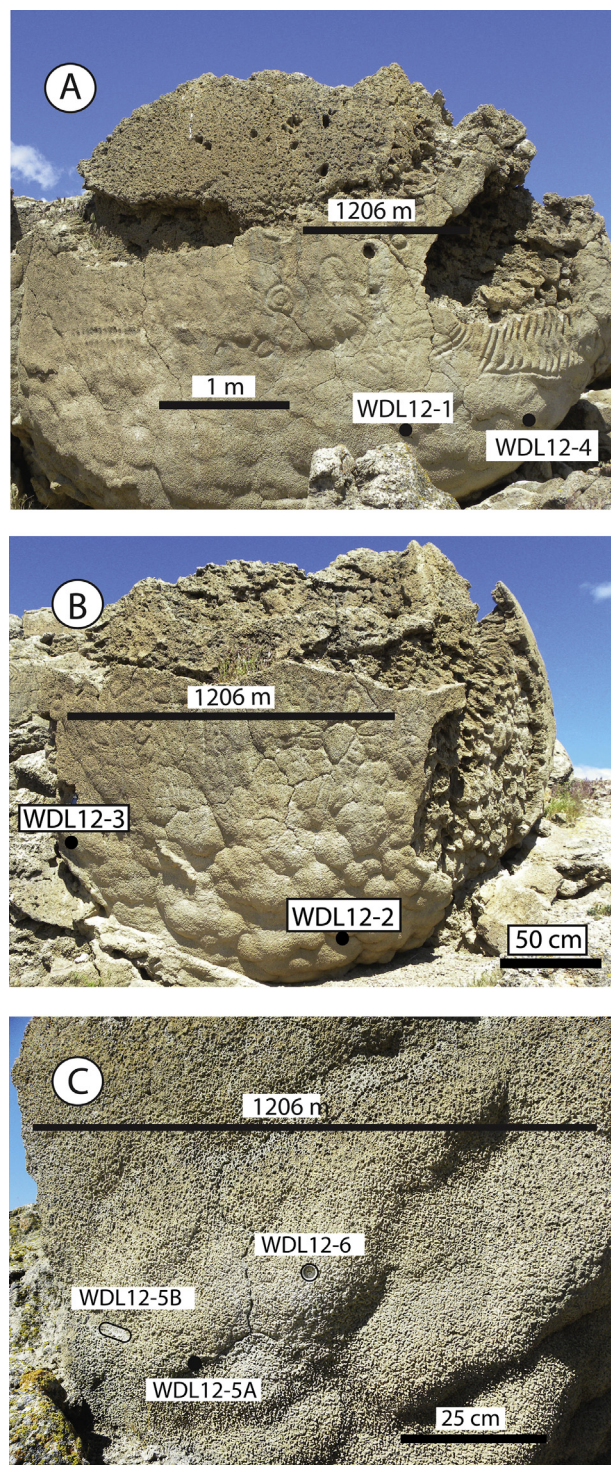


Fig. 3. Location of samples taken from three carbonate coated tufa boulders. The line at 1206 m indicates the upper limit of the carbonate coating. Sample WDL12-5B was peeled from the surface of the carbonate coating; WDL 12-6 was a short core taken through the coating. All other samples were taken by abrading the surface of the carbonate coating with a Dremel diamond bit.

Samples from were removed from the upper two layers of the algal tufa (WDL89-5B) using a Dremel diamond saw in order to determine whether they contained diatoms. The samples were processed using 30% hydrogen peroxide, 37% hydrochloric acid, and 70% nitric acid. The resulting solution was deflocculated using 5%

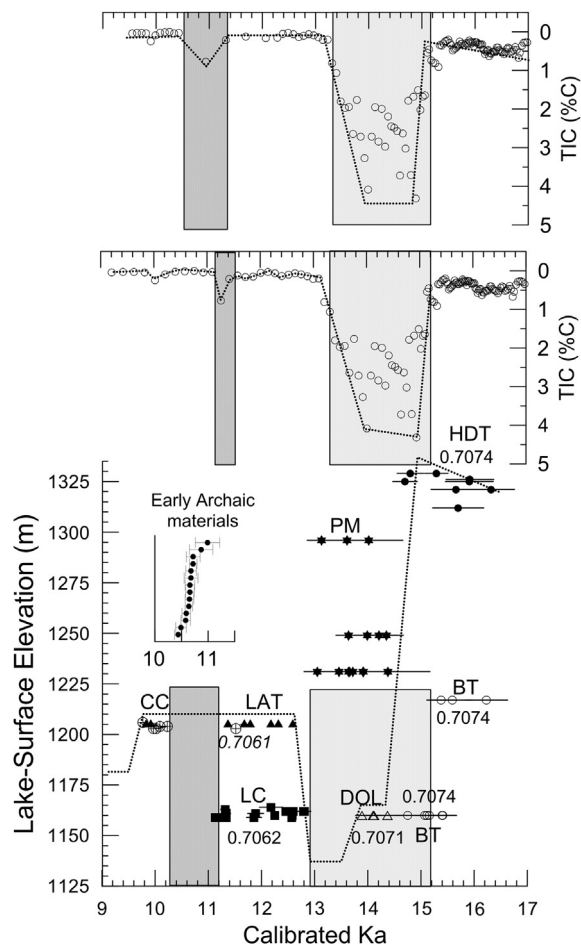


Fig. 4. Circles in the top two graphs bounded by dotted lines indicate total inorganic carbon (TIC) concentrations in core PLC97-3. Two different age models were used to construct the two graphs (see Fig. 5). The dotted line in the lower part of the figure depicts lake levels in the Pyramid Lake subbasin based on dated materials from the Pyramid and Winnemucca lake subbasins. Calibrated ^{14}C dates on Lahontan Basin Archaic materials are shown as filled dots within inset; error bars indicate 1 standard deviation. HDT, BT, PM, DOL, LC, LAT, and CC stand, respectively for highstand dense tufa, branching tufa, soluble packrat middens, dolomite, laminated calcite, layered algal tufa, and carbonate crust. Vertical shaded rectangles indicate most probable times of petroglyph carving. Mean $^{87}\text{Sr}/^{86}\text{Sr}$ values for tufa types are shown as five digit numbers. The $^{87}\text{Sr}/^{86}\text{Sr}$ value of the dense tufa underlying the carbonate crust at the petroglyph site (open circle with cross) is shown as an italicized five digit number.

sodium pyrophosphate and the residual sediment was mounted in Naphrax (r.i. -1.71). Both samples contained well-preserved *Stephanodiscus hantzschii*. This is a planktonic freshwater species found today in lakes in British Columbia.

2.2. Carbonate sampling

Seven carbonate samples were collected at the petroglyph site (WDL12). Samples were not collected from the carved lines and cupules comprising the petroglyphs. Three pairs of samples (WDL12-1 and -4, WDL12-2 and -3, WDL12-5A and -5B) of the same 2-mm-thick carbonate crust that coats the petroglyphs at the base of the site were collected from the faces of three broken tufa boulders (Fig. 3). All but WDL12-5B were sampled using a Dremel diamond grinding tool. Sample WDL12-5B was “peeled” from the tufa surface. Sample WDL-6 (Fig. 3C) is a 15-mm-long core collected from the same boulder as WDL12-5A and -5B. The core was taken in

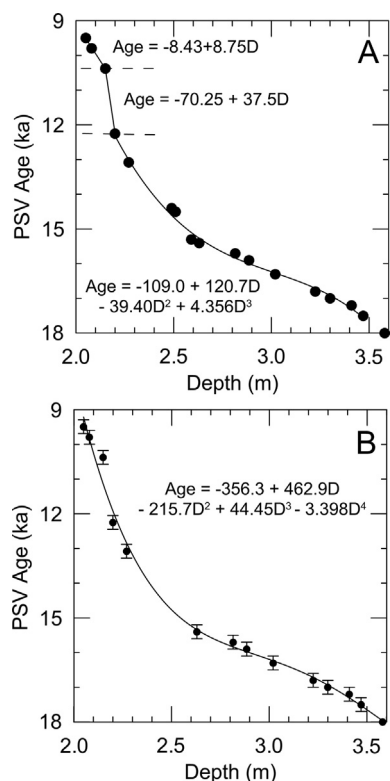


Fig. 5. Two PSV-based age models for core PLC97-3. Black dots are PSV ages acquired by matching the PSV record in PLC97-3 to the PSV record in well-dated sediment cores. Dashed lines in A, indicate the limits of each polynomial fit to PSV subsets. PSV ages are accurate within ± 200 years.

order to penetrate a dense carbonate layer (WDL12-6B) that was located beneath the carbonate crust.

Radiocarbon ages were obtained on non-archaeological tufas. Two layered algal tufas (WDL89 5B and 5C) that had been collected in 1989 from the east side of the Winnemucca Lake subbasin were subsampled using a diamond Dremel bit. Powdered samples from five layers in WDL89 5B and three layers in WDL89 5C were collected (Fig. 6). Both algal tufas were coated with a carbonate crust similar in appearance to the crust coating the base of the petroglyph site. Carbonate crusts at both sites (WDL12 and WDL89) formed at elevations slightly below 1206 m.

2.3. Processes that shift the ^{14}C age of samples from their times of deposition

All 15 carbonate samples were ^{14}C dated at the University of California-Irvine W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory. All data in this paper were calibrated using Stuiver and Reimer, 1993 (version 5.0) together with intcal09.14c.

2.3.1. The reservoir effect

In some situations, ^{14}C dates on lacustrine carbonates are subject to a “reservoir effect”, wherein, the presence of excess dead carbon can shift the apparent ^{14}C ages of carbon-bearing materials to values older than their actual dates of formation/deposition. Dead carbon can enter the lake via surface-water input as well as diffusion/advection across the sediment–water interface. Atmospheric CO_2 , containing modern carbon, can minimize and even eliminate the reservoir effect if the gas exchange rate across the air–water interface is sufficiently rapid.

The overflow of water from the Pyramid-Winnemucca Lake complex to the Smoke Creek-Black Rock Desert can lessen and even eliminate a preexisting reservoir effect. Spill across the Emerson

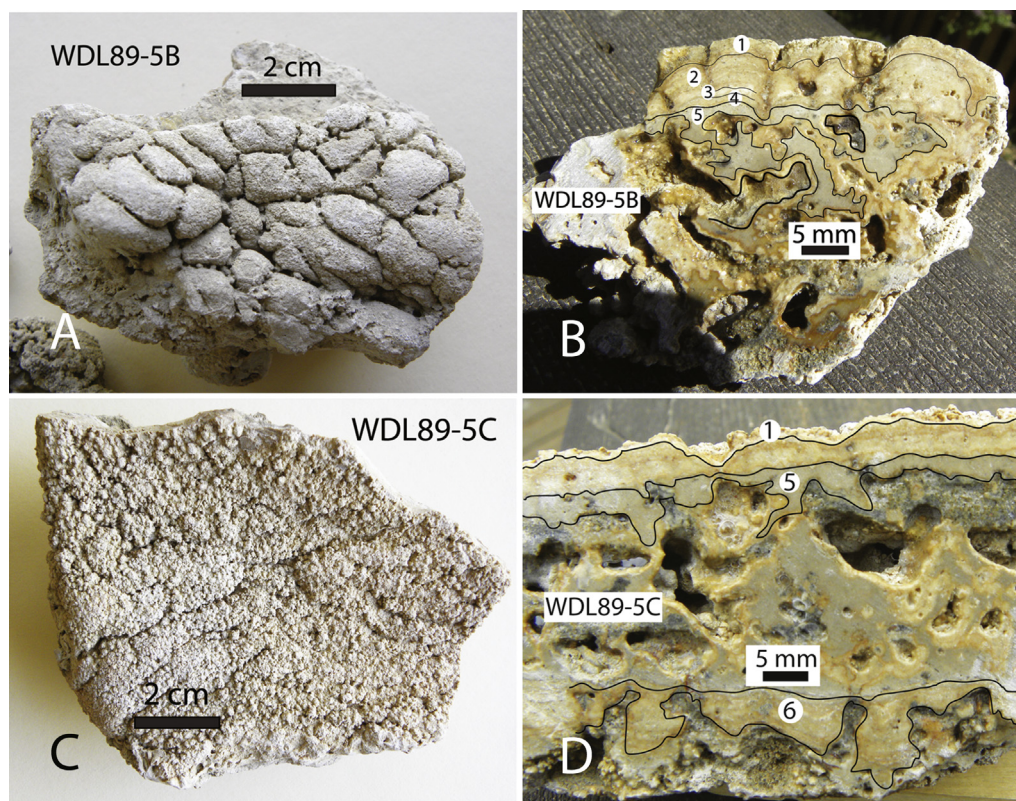


Fig. 6. A. Algal tufa sample WDL89-5B; B. cross section through WDL89-5B showing locations of five ^{14}C dated samples; C. algal tufa sample WDL89-5C; D. cross section through WDL89-5C showing locations of three ^{14}C dated samples.

Pass Sill (Fig. 1) implies that the Truckee River was discharging a large volume of water to the lake occupying the Pyramid and Winnemucca lake subbasins. The increasing fraction of modern-carbon-bearing snow-melt runoff relative to the fraction of dead-carbon-bearing groundwater in the Truckee River during times of spill over Emerson Pass resulted in declines in the fraction of dead carbon in the river as well as a reduction in the ionic strength (salinity) of lake water. Gas (CO_2) exchange operates more efficiently as the concentration of dissolved inorganic carbon (DIC) decreases, effectively removing the dead carbon dissolved in the lake. Therefore, increased stream-flow discharge to a lake and (or) increased spill from the lake to an adjacent subbasin tend to minimize a lake's reservoir effect.

Carbonates found at elevations slightly below 1207 m were deposited when the lake was hydrologically open and spilling across the Emerson Pass Sill. Carbon isotopes in the total organic carbon fraction (TOC) fraction of lake sediment generally have the same ratios as carbonates (e.g., tufas) deposited at the same time, given that they have the same carbon source, the DIC in lake water. We can, therefore, assess the magnitude of the reservoir effect during times of spill by comparing the PSV-based age of a sediment sample with the calibrated ^{14}C age of the TOC fraction in that sample. During the rise of Lake Lahontan (30–25 ka) and during its intermittent spill to the Carson Desert subbasin (25–18 ka) (Fig. 7A), the calibrated ^{14}C ages of the TOC fraction in four sediment samples were less than or equal to their PSV ages (Fig. 7B), demonstrating that a substantial reservoir effect was not present in Lake Lahontan during its spill to an adjacent subbasin. Therefore, the ^{14}C ages of tufas deposited

during spill over the Emerson Pass Sill should not be expected to have been offset by a substantial reservoir effect.

2.3.2. The addition of modern carbon during subaerial exposure

The addition of modern carbon during subaerial exposure can shift the age of deposition of a carbonate to younger values. Addition of modern carbon to the porous carbonate crusts that coat tufas at both WDL12 and WDL89-5 sites is likely to have occurred throughout the Holocene after the crust was subaerially exposed to low-pH precipitation. Rain water may have dissolved part of the crust and the resulting solution, which contained both old and modern carbon, would have subsequently warmed, causing CaCO_3 , containing some modern carbon, to reprecipitate within the pore spaces in the carbonate crust. To check for contamination with secondary carbon, 50% of each of eight algal layers was leached prior to AMS ^{14}C analysis. We later decided to remove (acid leach) differing amounts (20, 40, 50, 60, and 80%) of five subsamples from WDL89 5C-1 to determine how the age of the porous carbonate crust changed with amount leached. WDL89 5C-1 was chosen for this experiment, given that it was most likely to have suffered secondary contamination with modern carbon. The results of this experiment (Table 1) indicated that the age of the sample increased with the amount of sample removed. As a result, we decided to remove 80% of each sample prior to AMS ^{14}C analysis, except for WDL89 5B-5 for which insufficient material remained.

It should be noted that the ^{14}C date of WDL89 5C-1 never “leveled off” as a function of leaching (Supplementary Fig. 3). This implies the existence of a refractory carbonate contaminant in the carbonate crust and suggests that the resulting ^{14}C ages obtained on samples of the carbonate crust from both the collapsed tufa mound and the algal tufas represent minimum values.

2.4. Strontium-isotope analyses

Nine samples (five algal layers, three carbonate crusts from the petroglyph site, and the dense carbonate found below the carbonate crust at the WDL12 site) were also subjected to $^{87}\text{Sr}/^{86}\text{Sr}$ analysis. The $^{87}\text{Sr}/^{86}\text{Sr}$ analyses were done at the University of Colorado heavy-isotopes laboratory. The error in the $^{87}\text{Sr}/^{86}\text{Sr}$ analyses was <1 unit in the fifth decimal place. Previous $^{87}\text{Sr}/^{86}\text{Sr}$ analyses of Pyramid Lake tufas (Benson and Peterman, 1995) are listed in Supplementary Table 1.

3. Results and discussion

3.1. Tufa-based elevation history of Lake Lahontan

The ^{14}C -dated tufa sequence in Fig. 4 indicates that Lake Lahontan receded from its highstand between 15 and ~14.5 ka. Dolomite formed in the Pyramid Lake subbasin between ~14.4 and 13.9 ka, implying the existence of a relatively shallow, saline lake. The oldest dolomite date (14.4 ka) is considered the most reliable as the porous dolomite may have been subsequently contaminated with younger carbonate precipitated from Pyramid Lake. There is no record of carbonate deposition between 13.9 and 12.8 ka, suggesting the lake may have fallen below 1160 m at this time. Between 12.8 and 11.1 ka, laminated low-magnesium calcite was deposited on the western edge of the Pyramid Lake subbasin, indicating the presence of a deep freshwater lake.

3.2. Age of the branching tufa into which the petroglyphs were carved

Petroglyphs found above the carbonate crust have been carved into a branching form of tufa. The ages and $^{87}\text{Sr}/^{86}\text{Sr}$ values of the

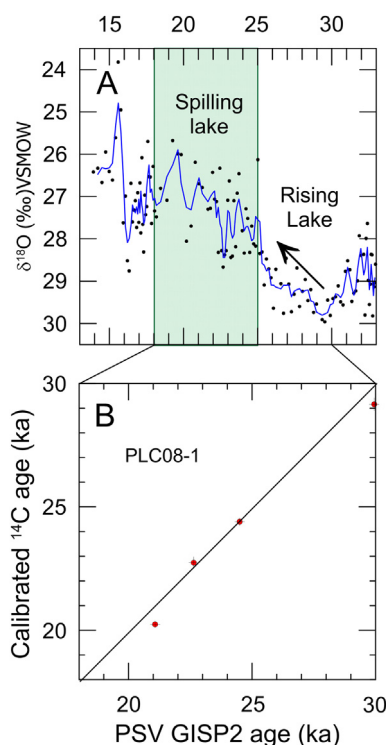


Fig. 7. A. Relative elevation of Lake Lahontan between 33 and 16 ka (Benson et al., 2012). Decreasing values of $\delta^{18}\text{O}$ in this sediment core indicate increasing lake elevation or spill rate across the Darwin Pass Sill into the Carson Desert subbasin. The arrow indicates lake-level rise between 30 and 25 ka, and the shaded area indicates an interval of intermittent spill across Darwin Pass Sill between 25 and 17 ka; B. Calibrated ^{14}C ages of four sediment samples in Pyramid Lake core PLC08-1 versus their PSV-based ages (Benson et al., 2012). The PSV-based ages have been tied to the GISP2 ice-core layer-counted chronology. The data indicate the lack of a reservoir effect when the lake in the Pyramid Lake subbasin was rising and when it was spilling to an adjacent subbasin.

Table 1Calibrated ^{14}C ages and $^{87}\text{Sr}/^{86}\text{Sr}$ analyses of carbonate samples from sites WDL89 and WDL12 on, respectively, the east and west sides of the Winnemucca Lake subbasin.

Sample name	Layer type	Ele. (m)	UCIAMS no.	Leach (%)	¹⁴ C Age (BP)	±	Calib age 1 – σ range	Area (%)	Calib age 2 – σ range	Area (%)	Calib 1 – σ age (midpt)	±	⁸⁷ Sr/ ⁸⁶ Sr (err = 0.00001)
Algal tufas from east side of Winnemucca Lake Basin													
WDL89 5B-1	2–3 mm white crust	1205	10 8535	50	8635	20	9542–9561	67	9538–9631	98	9550	10	0.70589
			10 8732	80	8800	25	9766–9898	100	9696–9917	99	9830	70	
WDL89 5B-2	3-mm stromatolite layer	1205	10 8536	50	10 030	20	11 404–11 459	33	11 393–11 641	94	11 430	30	0.70604
			10 8733	80	10 080	25	11 611–11 754	97	11 593–11 811	79	11 680	70	
WDL89 5B-3	1-mm white layer	1205	10 8537	50	9770	20	11 197–11 220	100	11 184–11 232	100	11 210	10	0.70604
			10 8734	80	9990	25	11 327–11 409	52	11 303–11 507	70	11 370	40	
WDL89 5B-4	1-mm stromatolite layer	1205	10 8538	50	10 280	25	12 004–12 008	100	11 970–12 140	100	12 050	40	0.70604
			10 8735	80	10 380	25	12 270–12 379	61	12 105–12 390	100	12 320	50	
WDL89 5B-5	2–4 mm gray layer	1205	10 8539	50	10 370	25	12 132–12 221	50	12 243–12 387	51	12 180	40	0.70622
WDL89 5C-1	1-mm white crust	1205	108 548	20	8505	20	9498–9527	100	9484–9533	100	9510	10	0.70623
			108 549	40	8565	25	9530–9543	100	9516–9550	96	9540	10	
			108 540	50	8630	25	9540–9562	65	9535–9633	96	9550	10	
			108 551	60	8680	20	9556–9630	92	9551–9680	100	9590	40	
			108 736	80	8700	20	9598–9680	95	9557–9696	100	9640	40	
			108 550	80	8985	25	10 174–10 208	100	10 153–10 230	98	10 190	20	
WDL89 5C-6	4–6 mm stromatolite layer	1205	108 542	50	10 000	25	11 429–11 495	36	11 315–11 616	100	11 460	30	0.70623
			108 738	80	10 145	25	11 756–11 828	55	11 704–11 849	55	11 790	40	
WDL89 5C-5	2–4 mm gray layer	1205	108 541	50	10 570	30	12 528–12 586	75	12 517–12 622	68	12 580	30	0.70623
			108 737	80	10 645	30	12 558–12 619	100	12 545–12 667	100	12 590	30	
Tufa coatings from west side of Winnemucca Lake Basin (petroglyph site)													
WDL12-1	Abraded white crust	1206	109 220	80	7900	15	8666–8717	68	8627–8770	98	8690	30	0.70616
WDL12-4	Abraded white crust	1206	109 221	80	8785	15	9736–9797	53	9703–9893	100	9770	30	
WDL12-2	Abraded white crust	1204	109 222	80	8860	15	10 063–10 123	60	10 052–10 154	53	10 090	30	0.70621
WDL12-3	Abraded white crust	1204	109 223	80	9075	15	10 227–10 240	100	10 215–10 247	99	10 230	10	
WDL12-5A	Abraded white crust	1203	109 224	80	8890	15	9985–10 045	44	9915–10 097	78	10 020	30	0.70623
WDL12-5B	Pieces of white crust	1203	109 225	80	8920	15	9948–9989	46	9923–9996	41	9970	20	
WDL12-6B	Carbonate below crust	1203	109 226	80	10 000	15	11 432–11 493	37	11 329–11 503	64	11 460	30	0.70606
							11 550–11 601	37			11 570	30	

Abraded white crust refers to a carbonate coating that was sampled with a dremel grinding tool. Area refers to the relative area under the probability curve. Leach to the amount of carbonate removed prior to ^{14}C analysis refers.

branching tufas are essentially the same as those of dense tufas formed during the Lahontan highstand (Table S1, Fig. 4), indicating that the petroglyphs above the carbonate crust were carved into deep-water branching tufas that formed prior to 14.8 ka.

3.3. Age of the carbonate that coats the petroglyphs

To provide a minimum age for carving of the low-elevation (1202–1206 m) petroglyphs, we dated the carbonate crust that coats the petroglyphs (Fig. 3). The six carbonate-crust samples from the petroglyph site (WDL12) exhibited an age range of 10.23–9.77 ka with one outlier at 8.69 ka (Table 1). As the sample abrasion process did not always reach the inner (oldest) part of the carbonate crust, we conclude that initial deposition of the carbonate crust occurred at 10.2 ka and continued until 9.8 ka, a conjecture consistent with the TIC data discussed in Section 3.5, which indicates that lake level was constrained by overflow at 1207 m until $\sim 9.3 \pm 0.1$ ka. We, therefore, conclude that the petroglyphs were carved sometime between 14.8 and 10.2 ka.

3.4. Time of deposition of the algal tufas

We also dated individual layers within algal tufas (Fig. 5B and D) from the same approximate elevation (1205 m) on the eastern side of the Winnemucca Lake subbasin (Table 1) in order to establish discrete times during which the lake occupying the Pyramid and Winnemucca lake subbasins was spilling across Emerson Pass. Substantial deposition of carbonate occurs when the surface elevation of a lake is stabilized by spill to an adjacent subbasin. CaCO_3 , which exhibits retrograde solubility, will precipitate in the warm shallow water immediately below the spill elevation; hence the observed preferential deposition of carbonate between 1202 and 1206 m. Three pieces of this carbonate tufa (WDL89-5), not including its carbonate crust, had been previously shown to have dates ranging from 12.5 to 11.3 ka (Supplementary Table 1).

After leaching, the carbonate crusts coating the WDL89 5B-1 and 5C-1 samples produced calibrated ages of 10.2, 9.83, and 9.64 ka (Table 1). Radiocarbon analyses of the dense carbonate layers within the two WDL89-5 samples indicated a calibrated age range of 12.59–11.43 ka (Table 1), implying that the lake occupying the two subbasins had been at or near the Emerson Pass spill point (1207 m) during much of that time interval. The fact that the $^{87}\text{Sr}/^{86}\text{Sr}$ values and age ranges of the algal tufas and laminated carbonates are almost identical (Fig. 4) supports the existence of a relatively deep and freshwater lake in the Pyramid and Winnemucca subbasins much of the time between 12.8 and 11.3 ka.

3.5. TIC and the continuous record of spill from the Pyramid–Winnemucca Lake complex

Although highly informative, the tufa data are discontinuous in time and do not allow us to determine how continuous was the lake's occupation of the 1207-m spill point. This is critical because, during times of spill across Emerson Pass, the base of the tufa mound was under water and was, therefore, not accessible for the carving of petroglyphs. To address this question, we plotted the continuous set of TIC concentrations in sediment core PLC97-3 for the interval 17.0 to ~ 9.5 ka (Fig. 4). In doing this we implemented two age models for PLC97-3. The uppermost TIC record in Fig. 4 relies on the age model depicted in Fig. 5A and the lower TIC record in Fig. 4 relies on the age model depicted in Fig. 5B. The striking difference in the two TIC records between 11.5 and 10.5 ka (Fig. 4) attests to the sensitivity of the fit to the PSV ages in the upper part (<2.2 m) of PLC97-3 when sedimentation rates were extremely low.

When a lake increases in volume or overflows to an adjacent basin, the concentrations of dissolved Ca^{2+} and CO_3^{2-} decrease and, therefore, the frequency and amount of CaCO_3 precipitated also decreases. Thus, the amount of TIC recorded in lake sediment decreases during wet periods. On the other hand, when a lake exists in a hydrologically closed state or decreases in size, the relative concentration of TIC increases in its sediments (see, e.g., Benson et al., 2012). The continuous TIC records in Fig. 4 indicate that Lake Lahontan fell from its highstand level at ~ 15 ka reaching a level of ~ 1165 m at 14.5 ka and then remained hydrologically closed at low levels until ~ 13.3 ka. At that time, it rose to its 1207 m spill point and remained there for much of the time between 13.2 and ~ 9.5 ka.

The TIC records resulting from the two age models indicate that the base of the petroglyph site was subaerially exposed between 15.0 and 13.2 ka and was subject to the carving of petroglyphs. However, the TIC records resulting from the two age models indicate different times of possible subaerial exposure after 13.2 ka. One age model (Fig. 5A) indicates that the base of site WDL12 was subaerially exposed between 11.3 and 10.5 ka and the other age model (Fig. 5B) indicates that the base of site WDL12 was subaerially exposed between 11.5 and 11.1 ka.

3.6. What underlies the carbonate crust at site WDL12?

Unfortunately, we were not permitted to explore the layering history directly associated with a carbonate encrusted petroglyph. Therefore, we do not know whether some or all of the dense layers present in the WDL89-5 samples also are present beneath the carbonate crust at the petroglyph site. We also do not know whether petroglyph carving pre- or post-dated the deposition of such layers. We were allowed to collect a shallow (10-mm-long) core (WDL12-6) from a nearby carbonate-encrusted boulder that lacked petroglyphs (Fig. 3C). The core penetrated a dense carbonate layer (WDL12-6B) that underlies the carbonate crust at that locality. The dense layer had a date of ~ 11.5 ka (Table 1), which is consistent with the date (11.7 ka) of the youngest algal stromatolite layer in WDL89 5B-2. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of WDL12-6B and WDL89 5B-2 are also nearly identical, suggesting the dense carbonate layer precipitated at the same time from the same body of water. This implies that some of the carbonate deposited on the east side of the Winnemucca Lake subbasin was also deposited on the base of the carved tufa mound on the west side of the subbasin. However, we were unable to determine whether this carbonate had coated the base of the tufa mound prior to or after the petroglyphs were carved. If prior to, it would indicate that petroglyph carving occurred before 11.5 ka, which would imply that the petroglyphs were carved sometime between 14.8 and 13. ka.

3.7. Implications of the strontium-isotope record

As Lake Lahontan fell from its highstand elevation, input of radiogenic $^{87}\text{Sr}/^{86}\text{Sr}$ to the Pyramid and Winnemucca lake subbasins from the Humboldt River ceased (Benson and Peterman, 1995). Therefore, the $^{87}\text{Sr}/^{86}\text{Sr}$ of water in the latter two subbasins decreased due to the sole input of Truckee River water which contains Sr with a relatively low $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (Supplementary Table 1). The decrease in $^{87}\text{Sr}/^{86}\text{Sr}$ (0.70622–0.70589) of the algal tufa layers with decreasing age (12.18–9.83 ka) (Table 1) supports the concept that the algal layers were deposited from lake water that was being diluted with Truckee River water as the lake overflowed the Emerson Pass Sill. This finding also is consistent with the presence of freshwater diatoms in the upper two algal tufa layers which imply the existence of a spilling lake in the Winnemucca Lake subbasin.

3.8. Ages of archaic materials found in the Lahontan Basin

Calibrated ages of Lahontan Basin Archaic materials (human bone, hair, textiles, fishing line) listed in [Supplementary Table 2](#) are plotted in [Fig. 4](#). Textiles from the Winnemucca Lake subbasin date as early as 10.68 ka ([Hattori, 1982](#)). These materials range in age from 11.0 to 10.4 ka, and fall within the 11.2–10.3 ka tufa gap. The two age models ([Fig. 5](#)) indicate that the base of site WDL12 was subaerially exposed between 11.3 and 10.5 ka or between 11.5 and 11.1 ka ([Fig. 4](#)). Thus, the TIC record associated with the first age model is consistent with the tufa record and suggests that Lahontan Basin Native Americans could have been responsible for the creation of petroglyphs found at the base of the collapsed tufa mound. The TIC record associated with the second age model ([Fig. 5B](#)) suggests that there existed a very narrow window between 13.2 and ~9.5 ka when the petroglyphs could have been carved and that this window opened just prior to evidence for early Archaic Native Americans in the Lahontan Basin. We cannot rule out the possibility that petroglyph carving occurred between 14.8 and 12.8 ka when the lake in the Pyramid Lake subbasin was at low levels and Winnemucca Lake had desiccated. Paleoindians had reached the Great Basin on or before 14.4 ka ([Gilbert et al., 2008](#)) and if they also occupied the Lahontan Basin at that time, it is conceivable they witnessed the desiccation of Winnemucca Lake and created the petroglyphs at archaeological site 26Wa3329.

3.9. Comparison of the Winnemucca Lake petroglyph site with the Long Lake petroglyph site

The Long Lake petroglyph site is comprised of dozens of petroglyph panels pecked, painted, and deeply carved into ledges and boulders exposed along a 4-km-long, low, basalt rim overlooking ephemeral Long Lake above Warner Valley, Lake County, Oregon ([Cannon and Ricks, 1986](#)). Some of these petroglyph panels are very distinctive, and one of these panels ([Fig. 8](#)) was buried by the 7.63 ka Mount Mazama tephra. Until publication of this paper, this panel represented the oldest and best dated early archaic petroglyph panel in the Great Basin. [Cannon and Ricks \(1986\)](#) named the distinctive style of carving displayed at the Long Lake site “Great Basin Carved Abstract”. In addition to the buried panel, other panels at Long Lake share attributes with panels and petroglyphs at the Winnemucca Lake site (see, e.g., [Figs. 2 and 9](#)). The dominate projectile points at Long Lake are Great Basin stemmed and Humboldt Concave base types ([Cannon and Ricks, 2008](#)).



Fig. 8. Petroglyph panel at Long Lake, Oregon, displaying deeply incised carvings in basalt. Mount Mazama tephra originally covered lighter area on base of panel. Black vertical bar = 15 cm.



Fig. 9. Petroglyph panel at Long Lake, Oregon located ~1.2 km north of panel in [Fig. 8](#). Note motifs comprised of short vertical lines in upper part of panel and stacked chevron variants in lower left of panel. Black vertical bar = 15 cm.

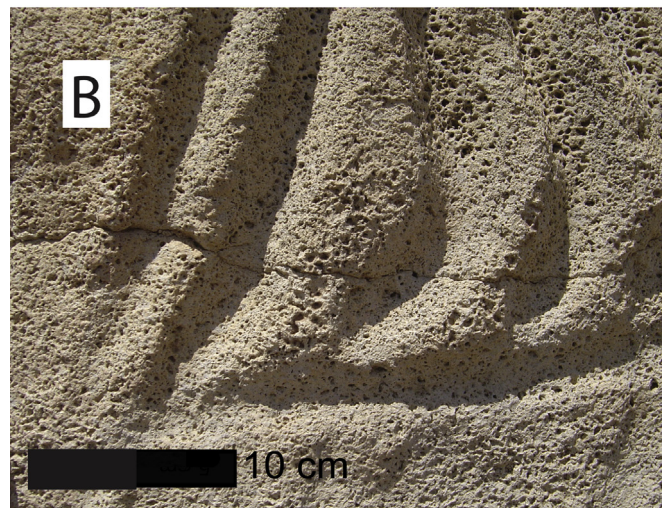
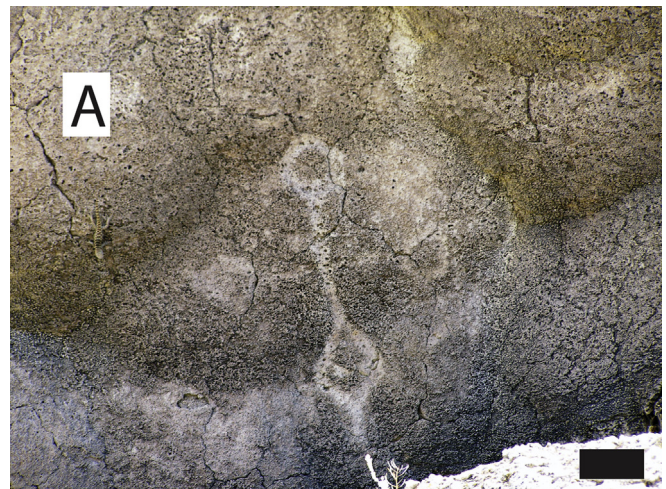


Fig. 10. A. Relatively young petroglyph from the southern end of the Winnemucca Lake subbasin. Note shallow line depth. B. Deeply carved lines in tufa at Winnemucca Lake petroglyph site. Black bars are 10 cm in length.



Fig. 11. Bisected chevron design (tree form) at the Winnemucca Lake petroglyph site. The tree form is 70 cm tall. Note additional tree form in shadow at upper left of figure.

There are distinctive design features common to both the Winnemucca Lake and Long Lake petroglyphs which also appear elsewhere in the Great Basin (Connick and Connick, 1992; Heizer and Baumhoff, 1962; Swartz, 1978). These include the following features: relatively deep carved lines; dominance of linear, curved, and circular geometric designs; symmetrical groupings of cupules on vertical faces; and relatively dense grouping of elements. Although the tufa at Winnemucca Lake is relatively soft when compared to Long Lake basalt, the vast majority of petroglyphs carved into other tufa formations in the Winnemucca and Pyramid lake subbasins are much shallower in depth than those at site 26Wa3329 (Fig. 10A and B) (Connick and Connick, 1992). Most petroglyphs assigned to the middle archaic-historic time sequence were formed by relatively shallow (<5-mm depth) carving (Heizer and Baumhoff, 1962).

Specific, distinctive design elements occur at both the Long Lake and Winnemucca Lake sites. Among these elements are “tree-form” designs comprised of series of evenly spaced, vertically oriented (sometimes arched) chevrons bisected by a vertical line (Figs. 9

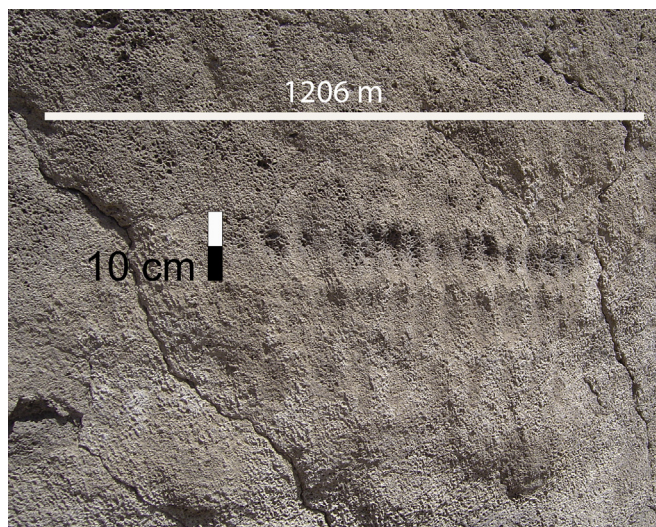


Fig. 12. Stacked set of short vertical lines at the Winnemucca Lake petroglyph site. The carbonate coating that reached 1206 m is shown as the white patchy surface in the lower half of the figure.



Fig. 13. Cupules on the vertical face of a tufa boulder at the Winnemucca Lake petroglyph site. Cupules can also be seen in Fig. 2. Vertical black bar is 50 cm in length.

and 11). Another distinctive element, with variants, that occur at both sites are deeply incised petroglyph panels with short linear sections containing vertical, parallel lines (Figs. 9 and 12). At the Winnemucca and Long lake sites, cupules are utilized as elements in the creation of patterned designs on vertical faces (Figs. 13 and 14). Cupules are shallow mortar-like pits that most commonly occur on horizontally oriented surfaces. Sometimes the pits are associated with interconnecting troughs or grooves. Heizer and Baumhoff (1962) classify the latter association as the pit and groove rock art style that they consider to be an older Great Basin petroglyph type. We consider the Winnemucca Lake petroglyphs to



Fig. 14. Heavily patinated and eroded cupules on a vertical basalt face at Long Lake, Oregon. Vertical black bar is 20 cm in length.

represent an early archaic style characterized by distinctive design elements and motifs created using deeply carved lines and cupules. It is possibly a variant of Cannon and Ricks' (1986) Great Basin Carved Abstract style.

4. Conclusions

Radiocarbon dating was used to directly bracket the time interval during which Native Americans carved an array of geometric forms into a prominent tufa mound (site 26Wa3329) on the western side of the Winnemucca Lake subbasin. The carbonate into which the petroglyphs were carved has a minimum date of 14.8 ka and the carbonate crust that coats petroglyphs near the base of the tufa mound has a maximum date of 10.2 ka. Three other data sources were used to indirectly determine when water level in the Pyramid and Winnemucca lake subbasins was held at 1207 m by overflow across the Emerson Pass Sill. When the coalesced lake system was at this level, the base of the tufa mound was not accessible for carving. The indirect data sources include: the TIC record from a lake-sediment core (PLC97-3), tufa-based data on the $^{87}\text{Sr}/^{86}\text{Sr}$ evolution of lake water, and ^{14}C ages of carbonate layers in an algal tufa deposited at 1205 m on the eastern side of the Winnemucca Lake subbasin. The indirect data sets indicate that the base of the collapsed tufa mound was subaerially exposed between 14.8 and 13.2 ka and between 11.3 and 10.5 ka or between 11.5 and 11.1 ka (depending on which age–depth model is adopted). Low lake levels in the tufa-based ^{14}C record support the 14.8–13.2 ka and 11.3–10.5 ka intervals, and Native American artifacts found in the Lahontan Basin also date to the latter time interval. However, these data do not rule out the possibility that petroglyph carving occurred between 14.8 and ~13 ka when Pyramid Lake was relatively shallow and Winnemucca Lake had desiccated.

The carbonate crust coating both the base of the petroglyph site and algal tufa on the opposite of the subbasin indicate the persistence of a large body of water in the Lahontan Basin until ≥ 9.2 ka. The influence of such an intense and previously unrecorded post-Younger Dryas wet event in the western Great Basin on prehistoric Native American cultures remains to be determined.

The 26Wa3329 petroglyphs share a number of attributes with the Long Lake, Oregon, petroglyphs dating to at least the early archaic period. These include deeply carved lines and cupules in geometric motifs shared between the two regional sites. Deeply carved, specific motifs that are common to both Winnemucca Lake and Long Lake sites are also found elsewhere in the western Great Basin from Oregon to southeastern California.

Acknowledgments

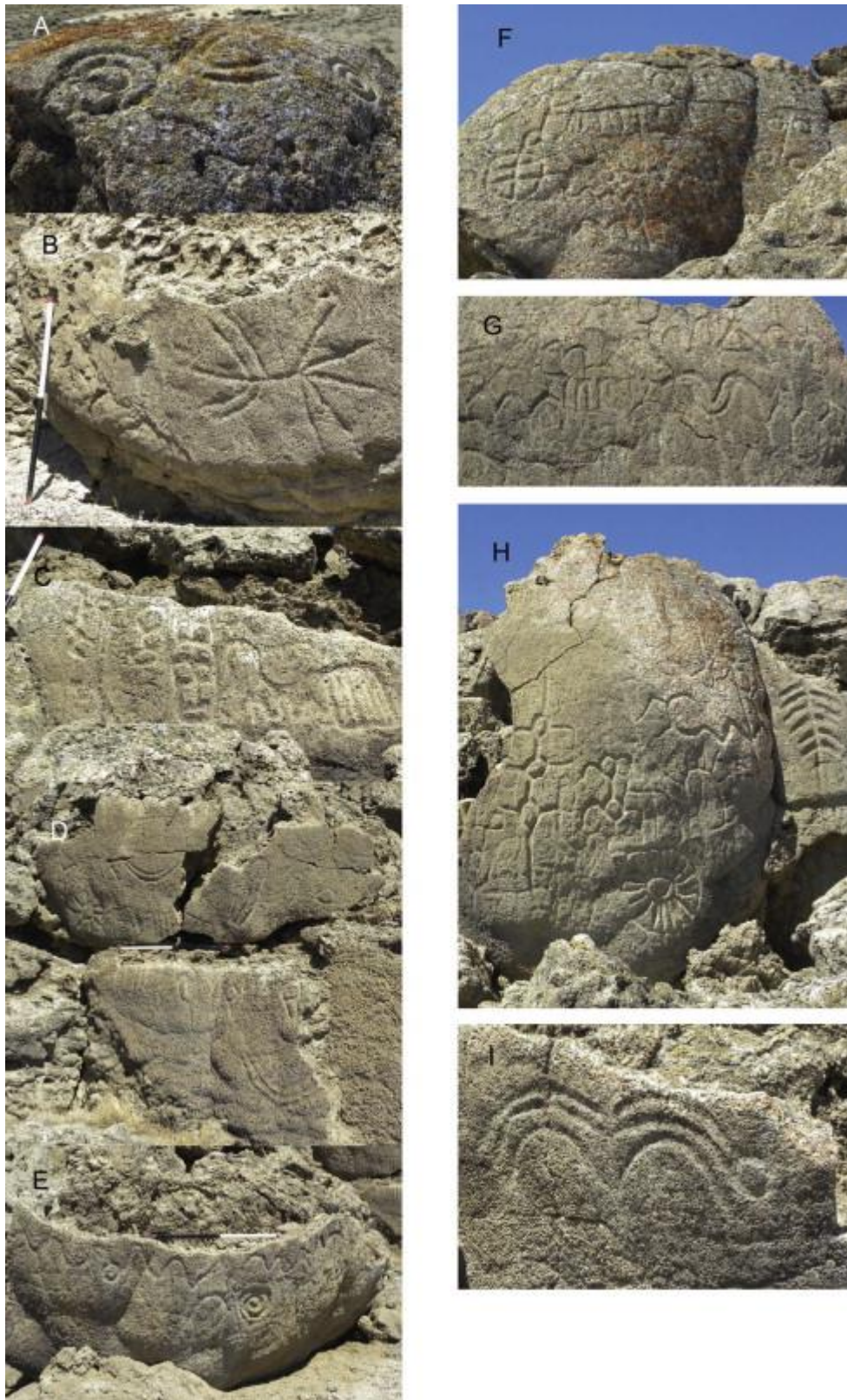
Support for this project was provided by the National Research Program of the U.S. Geological Survey. The authors thank the Pyramid Lake Tribal Council for allowing access to the Winnemucca Lake subbasin petroglyph site. Emily Verplanck at the University of Colorado performed the strontium-isotope analyses. We also thank Bill Cannon, Lakeview District BLM, and Sue Ann Monteleone, Nevada State Museum, for their technical assistance. We thank Scott Starratt of the U.S. Geological Survey who performed the diatom analyses.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jas.2013.06.022>.

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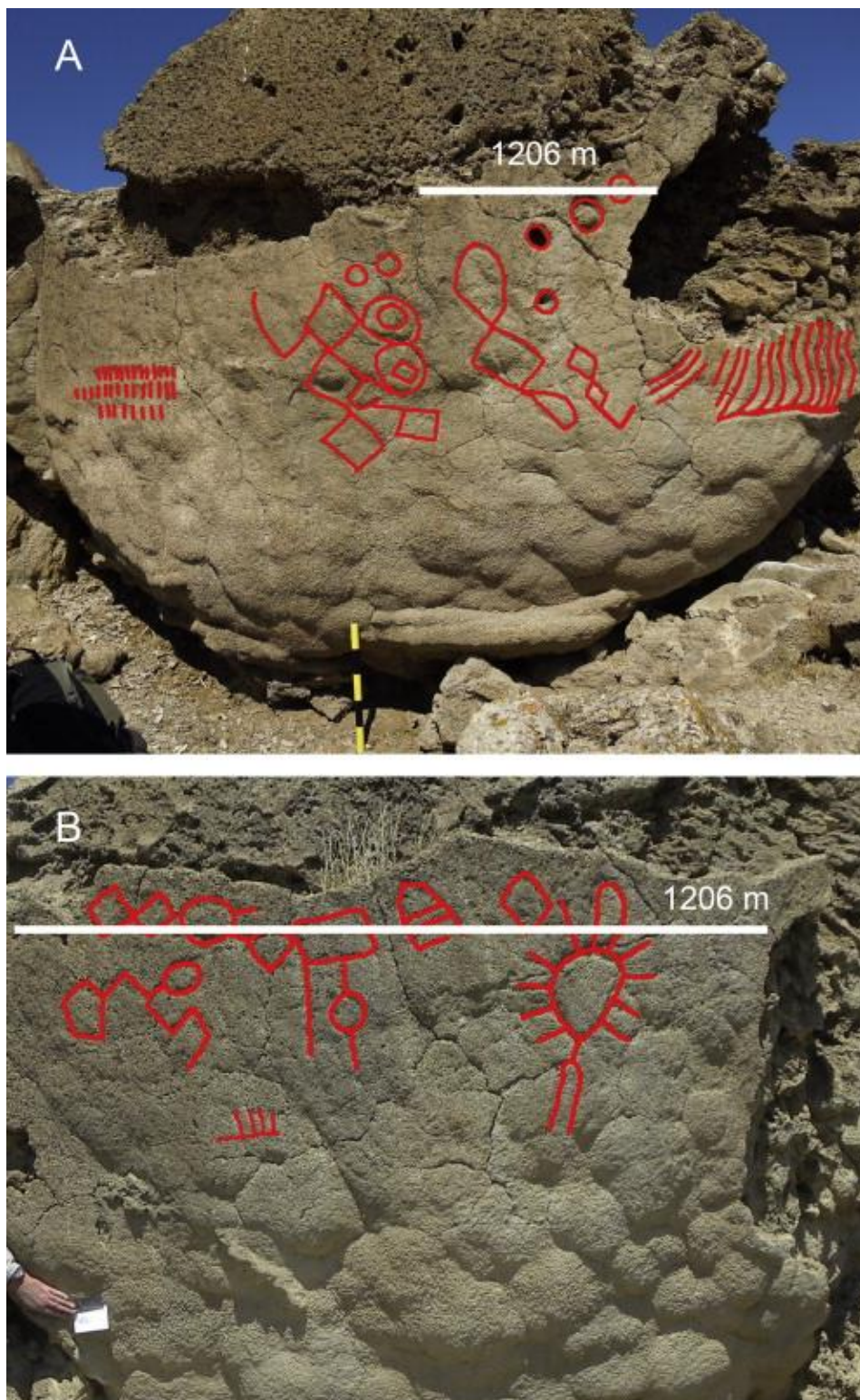
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Supplementary Fig. 1.

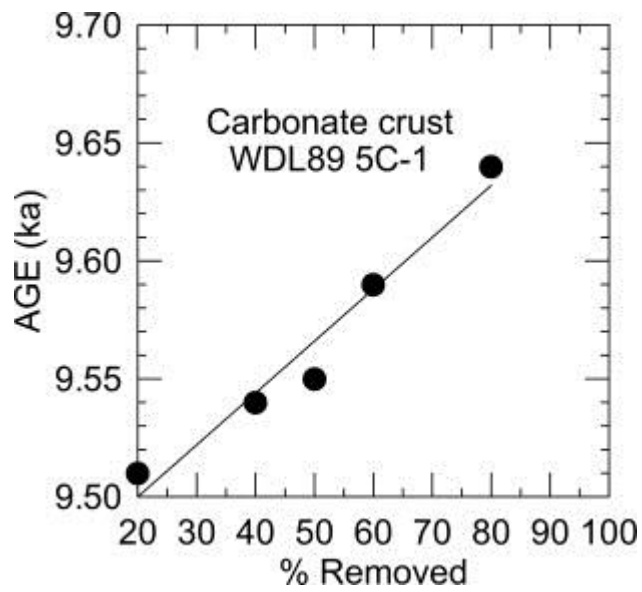
A variety of forms incised into the Winnemucca Lake petroglyph site.





Supplementary Fig. 2.

Highlighted petroglyphs coated or partially coated with a thin carbonate cement at the Winnemucca Lake subbasin site. The top of the carbonate cement extends to 1206 m.



Supplementary Fig. 3.

Calibrated age of WDL89 5C-1 as a function of acid leaching. Note that the age does not level off as a function of amount leached indicating the persistence of a refractory secondary contaminant.

Supplementary Table 1. Calibrated ages and $^{87}\text{Sr}/^{86}\text{Sr}$ values of materials from the Pyramid and Winnemucca Lake Basins.

Sample No.	Lab No.	Site	Ele	¹⁴ C age	¹⁴ C err	Calib age	Calib err	⁸⁷ Sr/ ⁸⁶ Sr
			(m)	(yr BP)	(yr BP)	(yr BP)	(yr BP)	(err = 0.00002)
Young Branching Tufa								
PLBT92-b1a	CAMS-4425	BT	1160	12 520	90	14 750	250	0.70745
PLBT92-b1b	CAMS-4426	BT	1160	12 730	90	15 070	190	
PLBT93-1e1	CAMS-5774	BT	1160	12 770	90	15 110	160	
PL90-111	CAMS-5722	BT	1160	12 810	80	15 160	130	
PLBT92-b2b	CAMS-4428	BT	1160	12 930	90	15 400	260	0.70737
PLBT92-b2a	CAMS-4427	BT	1160	12 940	90	15 410	260	
PL91-504	CAMS-5770	DH	1217	12 910	90	15 380	270	0.70742
PL91-503g	CAMS-5769	DH	1217	13 020	90	15 590	370	
PL91-503	W-6391	DH	1217	13 240	220	16 230	400	
Dolomite Coating								
PLBT92-d1b	CAMS-4424	BT	1160	12 030	110	13 890	120	0.70705
PLBT92-d2b	CAMS-4422	BT	1160	12 260	90	14 100	140	
PLBT92-d1a	CAMS-4423	BT	1160	12 270	120	14 120	160	
PLBT92-d2a	CAMS-4421	BT	1160	12 370	110	14 370	280	
Laminated Calcite Coating								
PLBT93-1a	CAMS-5905	BT	1159	9660	70	11 130	60	0.70611
PLBT93-1f1	CAMS-5907	BT	1159	9770	80	11 180	80	
PL90-1b	LDGO-1748b	BT	1163	9930	80	11 320	90	0.70597
PL90-2a	LDGO-1748c	BT	1161	9960	80	11 340	80	
PLBT93-1f2	CAMS-5908	BT	1159	9970	70	11 340	70	0.70637
PLBT93-1b	CAMS-5906	BT	1159	10 170	70	11 860	140	
PL90-2b	LDGO-1748d	BT	1161	10 180	80	11 890	150	
PLBT92-s1a	CAMS-4419	BT	1160	10 450	70	12 250	40	
PLBT93-1c	CAMS-5772	BT	1159	10 610	70	12 570	50	
PLBT92-s1b	CAMS-4420	BT	1160	10 620	80	12 580	60	
PL87-1	LDGO-1705a	PI	1164	10 300	120	12 180	220	
PLPI93-5a	CAMS-5909	PI	1162	10 560	70	12 460	40	
PLPI93-5b	CAMS-5910	PI	1162	10 670	70	12 600	50	
PLPI93-5d	CAMS-5912	PI	1162	10 920	100	12 790	120	
PLPI93-5c	CAMS-5911	PI	1162	10 960	80	12 810	120	
WDL89-5a	CAMS-4430	WD	1205	9860	80	11 280	80	0.70737
WDL89-5b	CAMS-4431	WD	1205	9990	80	11 460	160	
WDL89-5c	CAMS-4432	WD	1205	10 540	80	12 490	90	
Dense Tufa Coating Above 1308 m								
PLPC92-1	CAMS-5930	PC	1325	12 490	80	14 700	230	0.70737
PLPC92-3o	CAMS-5931	PC	1329	12 550	80	14 800	250	
PLPC92-3i	CAMS-5932	PC	1329	12 840	70	15 290	220	0.70740
PL103	I-10002	PC	1321	13 010	190	15 660	470	
PL102	I-10001	PC	1312	13 040	190	15 700	480	

PL113	I-10028	PC	1326	13 090	190	15 920	450	
PL104	I-10003	PC	1321	13 320	200	16 320	440	
PL105	I-10004	PC	1324	13 520	200	16 600	320	
PL101	I-10000	PC	1312	13 600	200	16 700	260	
PL41	I-9344	PC	1311	13 890	210	16 980	210	
PL100	I-9992	PC	1312	14 290	220	17 370	280	
PL21	I-9326	TH	1325	13 090	190	15 910	450	
PL20	I-9325	TH	1311	14 030	210	17 070	190	0.70737
Organic Samples Winnemucca Lake Basin								
Fishbone Cave	L-245	FC	1231	11 200	250	13 050	250	
Falcon Hill No. 1	I-14009	FH	1296	11 270	270	13 130	270	
Guano Cave No. 11	A-3699	GC	1231	11 580	290	13 460	290	
Falcon Hill No. 2	I-14011	FH	1296	11 770	250	13 610	250	
Crypt Cave No. P3A	I-14016	CC	1249	11 810	230	13 640	240	
Guano Cave No. 781	A-3696	GC	1231	11 810	230	13 640	240	
Guano Cave No. 2	I-14014	GC	1231	11 850	170	13 660	180	
Guano Cave No. 6A	A-3695	GC	1231	11 890	250	13 720	280	
Falcon Hill No. 2	A-3489	FH	1296	12 020	470	14 020	640	
Guano Cave No. 10	A-3698	GC	1231	12 060	260	13 910	340	
Guano Cave No. 9	A-3697	GC	1231	12 070	210	13 920	320	
Crypt Cave No. 84-28	I-14013	CC	1249	12 130	180	13 990	250	
Crypt Cave No. 1	I-14008	CC	1249	12 240	180	14 210	340	
Fishbone Cave	AA-759	FC	1231	12 280	520	14 380	790	
Crypt Cave No. 84-2A	I-14010	CC	1249	12 350	180	14 350	320	
River samples								
Truckee River								0.70527
Humboldt River								0.70951
Pyramid Lake								0.70580

Data in this table came from [Benson & Peterman 1995](#); [Benson et al. 1995](#); [Benson et al. 2012](#). Sources of the ^{14}C analysis: Laboratory Center for Accelerator Mass Spectrometry (CAMS), U.S. Geological Survey (I, W), Lamont-Doherty Geological Observatory (LDGO). Site abbreviations: Blanc Tetons (BT), Doghead Rock (DH), Pyramid Island beach (PI), Pipeline Canyon (PC), Terraced Hills (TH), Winnemucca Dry Lake Basin (WD).

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Supplementary Table 2. ¹⁴C and calibrated ages of Paleoindian materials from the Lahontan Basin ([Hattori, 1982](#); [Tuohy and Dansie 1997](#)).

Sample No.	¹⁴ C Age (yr BP)	±	Calib Age 1-σ range	Area (%)	Calib Age 2-σ range	Area (%)	Calib 1-σ Age (midpt)	±
Pyramid Lake Subbasin Wizards Beach Skeleton								
UCR3445	9515	155	10652-11094	96	10405-11225	100	10870	220
CAMS-28214	9250	60	10371-10510	76	10257-10569	100	10440	70
Pyramid Lake Subbasin Sagebrush Fishing Line								
GX-13744	9660	170	10761-11215	100	10506-11411	98	10990	230
Winnemucca Lake Subbasin Falcon Hill Basketry								
UCLA675	9450	120	10545-10805	69	10402-11166	100	10680	130
Carson Lake Subbasin Spirit Cave Man Hair								
CAMS-12353	9360	60	10508-10665	100	10406-10741	100	10590	80
CAMS-12354	9350	70	10494-10676	96	10372-10742	97	10580	90
UCR3261-2	9440	60	10582-10742	100	10511-10801	89	10660	80
Carson Lake Subbasin Spirit Cave Man Bone								
CAMS-12352	9430	60	10580-10730	100	10503-10795	93	10650	80
Carson Lake Subbasin Spirit Cave Female Bone								
UCR3475	9300	70	10392-10587	95	10272-10671	100	10490	100
Carson Lake Subbasin Spirit Cave Matting								
CAMS-24194	9410	60	10570-10713	100	10491-10788	97	10640	70
CAMS-24197	9460	60	10583-10778	100	10566-10871	83	10680	100
CAMS-24199	9430	70	10566-10756	100	10495-10832	87	10660	90
Carson Lake Subbasin Grimes Burial Cave Diamond Plaiting								
CAMS-3691	9470	60	10645-10785	73	10564-10876	79	10720	130

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