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Abstract

The Mescalero sand sheet that covers most of the Mescalero Plain is formed by two eolian sand bodies, the Lower and Upper units. New and revised OSL ages indicate that the Lower unit accumulated 90–50 ka and the Upper unit was deposited 18–5 ka. Both eolian units are dominated by massive, well-sorted, fine quartz sand. The Lower sand directly overlies the eroded surface of the calcic Mescalero paleosol. The top of the Lower sand incorporates the Berino paleosol, a red argillic soil that formed on the sand sheet during the comparatively wet and cool environment of the late Wisconsinan. The Lower sand and the Berino paleosol are buried by the Upper eolian sand. An unnamed Bw paleosol at the top of the Upper sand formed during the past 5 ka. Locally, archaeological sites younger than 3,000 b.c. are on the surface, whereas older sites are buried within the Upper sand. During the twentieth century, the shrub grassland vegetation of the Mescalero sand sheet was disturbed, leading to the formation of many coppice and parabolic dunes.

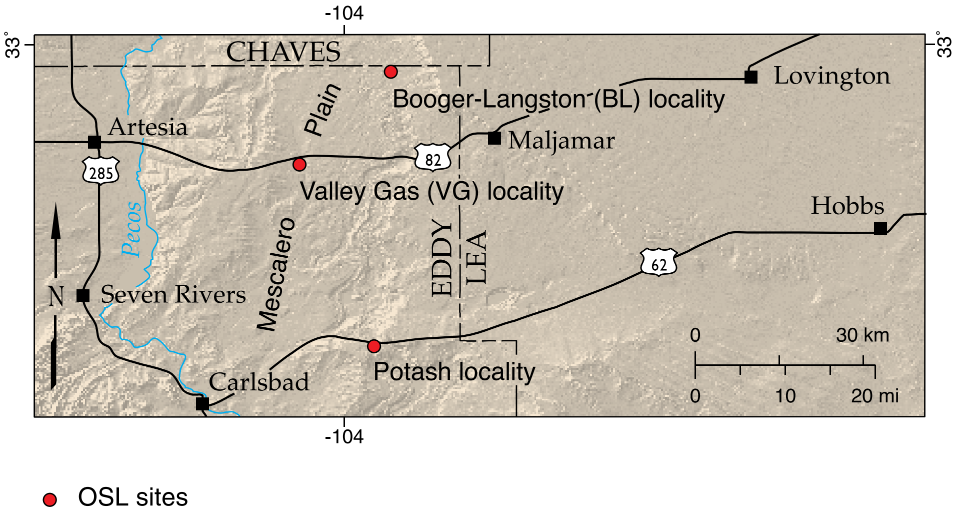

FIGURE 1—Map of southeastern New Mexico showing the Mescalero Plain and the three localities within the Mescalero sand sheet sampled and dated using optically stimulated luminescence analysis (Hall and Goble 2006 and this study).

Introduction

The Mescalero sand sheet covers most of the Mescalero Plain in southeastern New Mexico (Fig. 1). Extensive deposits of wind-deposited sand have been noted in the past by many field workers (i.e., Kelley 1971; Hendrickson and Jones 1952; Nicholson and Clebsch 1961; Chugg et al. 1971). As part of the geologic assessment of the Waste Isolation Pilot Project (WIPP) southeast of Carlsbad, Vine (1963) and Bachman (1976, 1980, 1981, 1984) investigated the local surficial geology. Bachman recognized the presence of two sand units overlying the local caliche, and he named and interpreted correctly the Mescalero and Berino paleosols. Bachman (1976, p. 145) also observed that the Mescalero eolian sand was derived from the Ogallala Formation and not from Pecos River alluvium, a conclusion later supported by the dissimilarity of the chemistry of the eolian sand and alluvium (Muhs and Holliday 2001).

In response to increased mineral extraction and oil field activity on public land in southeastern New Mexico and their impact on archaeological sites, the Bureau of Land Management (BLM) and the New Mexico Historical Preservation Division funded a series of studies that focused specifically on the surficial geology of the Mescalero Sands as related to the archaeological record. These studies led to a number of reports and articles on the geology, OSL geochronology, and archaeological geology of the Mescalero sand sheet (Hall 2002; Hall and Goble 2006, 2008; Ingbar et al. 2005; Hogan 2006). Because of the success of OSL dating of the sand sheet and the valuable information it provides on the surface geology and associated archaeological sites, the BLM has encouraged its use in ongoing studies. A new investigation of sand sheet stratigraphy, sedimentology, and OSL dating results in a significant change in the geochronology of the Mescalero sand sheet.

Methods

Sediments and paleosols

A soil pit at the Potash locality east of Carlsbad, Eddy County, exposes approximately 2.8 m (9.2 ft) of eolian sand that includes both the Lower and Upper units of the Mescalero sand sheet (Fig. 2). (The soil pit is no longer open.) Sand samples for textural and soil analyses were collected at 10-cm intervals. The samples were analyzed by the Milwaukee Soil Laboratory, and the results are presented in Table 1. Sediment textural categories follow the Wentworth scale (Folk 1968), and soil nomenclature follows Birkeland (1999). Sediment color was determined by the Munsell Soil-Color Charts (Munsell Color 2009).

OSL sample preparation/dose rate determination

Sample preparation was carried out under amber-light conditions. Samples were wet sieved to extract the 90–150 μm fraction and then treated with hydrochloric (HCl) acid to remove carbonates. Quartz and feldspar grains were extracted by flotation using a 2.7 g cm^3 sodium polytungstate solution, then treated for 75 min in 48% hydrofluoric (HF) acid, followed by 30 min in 47% HCl. Reddish sands with heavy iron oxide coatings were given an additional treatment with CBD solution (sodium citrate, sodium bicarbonate, sodium dithionate). The samples were then re-sieved, and the < 90 μm fraction discarded to remove residual feldspar grains. The etched quartz grains were mounted on the innermost 2 mm or 5 mm of 1-cm aluminum disks using Silkospray.

Chemical analysis for U, Th, and K was carried out by high-resolution gamma spectrometry in the University of Nebraska-Lincoln (UNL) Luminescence Geochronology Laboratory. Dose rates were calculated using the method of Aitken (1998) and Adamiec and Aitken (1998). The cosmic contribution to the dose rate was determined using the techniques of Prescott and Hutton (1994).

Optical measurements

Optically stimulated luminescence analyses were carried out on a Risø automated OSL dating system Model TL/OSL-DA-15B/C, equipped with blue and infrared diodes, using the single aliquot regenerative dose (SAR) technique (Murray and Wintle 2000). All equivalent dose (D_e) values were determined using the central age model (Galbraith et al. 1999), unless data analysis indicated partial bleaching, in which case the minimum age model (Galbraith et al. 1999) was used. Preheat and cutheat temperatures were based upon preheat plateau tests between 180º and 280ºC, which indicated that a 240°C/10s preheat and 220°C/0s cutheat were appropriate for older samples and a 200°C/10s preheat and 180°C/0s cutheat for younger samples (< 2 Gy). Dose-recovery and thermal transfer tests were conducted (Murray and Wintle 2003). Growth curves were examined to determine whether the samples have D_e values $< 2 D_o$, the value at which the OSL signal is about 15% below the level where the dose-response curve flattens at saturation (Wintle and Murray 2006); D_o is determined from the saturating exponential equation. Optical ages were based on 38–48 accepted aliquots. Individual aliquots were monitored for insufficient count rate, poor quality fits (i.e., large error in the equivalent dose, D_e), poor recycling ratio, strong medium versus fast component, and detectable feldspar. Aliquots deemed unacceptable based upon these criteria were discarded from the data set before averaging. Averaging was carried out using the central age model (Galbraith et al. 1999) unless the D_e distribution (asymmetric distribution; skewness > $2\sigma_c$, Bailey and Arnold 2006), indicated that the minimum age model (Galbraith et al. 1999) was more appropriate. Laboratory data and associated OSL ages are presented in Table 2.

Revised OSL ages from Mescalero Sands

The first OSL ages from the Mescalero Sands were reported in Hall (2002) and Hall and Goble (2006) using data collected with a Daybreak Model 1100 TL/OSL reader. Additional aliquots were analyzed using a Risø automated OSL dating system Model TL/OSL-DA-15B/C reader. The D_e and ages for the combined data sets were recalculated using current data reduction software and are shown in Table 3.

The revised OSL ages are generally within 1σ of the previously published ages. The initial ages of the Lower sand at the Valley Gas (VG) locality were reported as 87.4 ± 4.5 ka and 81.7 ± 3.6 ka but are now revised to 90.7 ± 6.7 ka and 81.2 ± 5.7 ka, respectively. The ages of the Upper sand at the Booger-Langston (BL) locality were reported as 8.9 ± 0.3 ka and 6.3 ± 0.2 ka and are now revised to 9.39 ± 0.67 ka and 5.82 ± 0.41 ka, respectively.

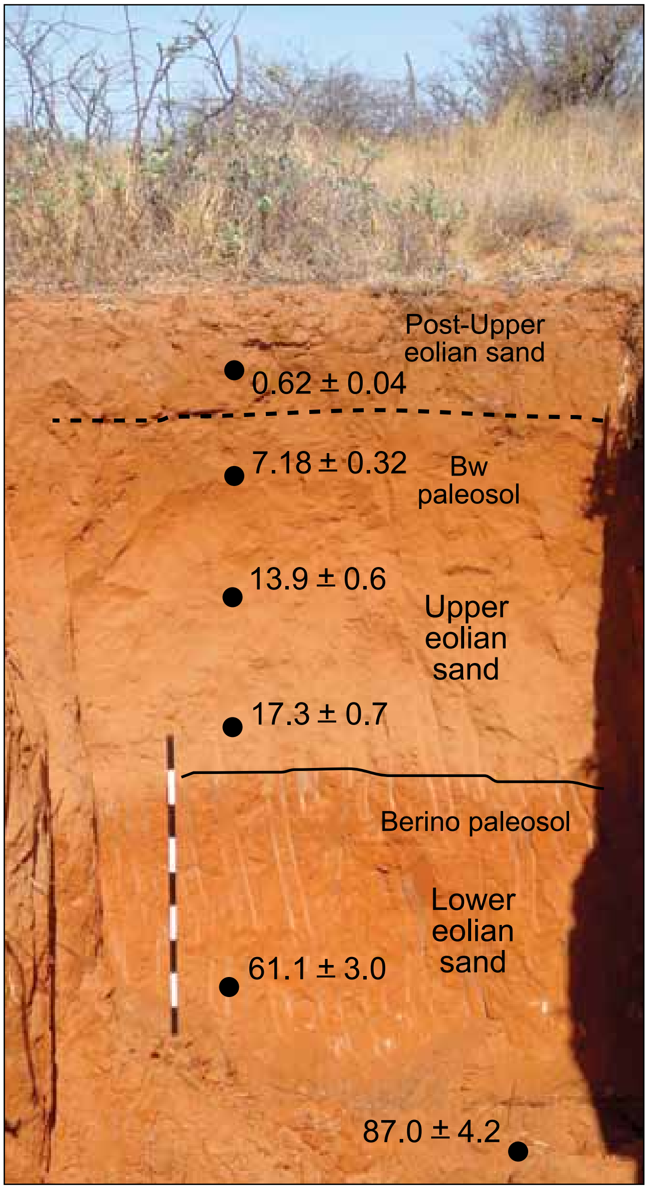

FIGURE 2—Potash locality soil pit in the Mescalero sand sheet showing stratigraphy and horizons with OSL ages; ages shown are in ka (1,000 yr) units (Table 2). The location is latitude 32° 30′ 47.9″ N, longitude 103° 57′ 7.2″ W (NAD 27), Eddy County, New Mexico; 1-m scale.

Eolian sand stratigraphy and sedimentology

The two eolian sand bodies that make up the Mescalero sand sheet are called the Lower and Upper units (Hall and Goble 2006). The Lower unit extends broadly across the Mescalero Plain and rests directly on the caliche of the Mescalero paleosol. The top of the Lower sand is generally missing due to erosion. In many places the Lower sand unit is entirely absent where either it was never deposited or has been removed completely by late Pleistocene erosion. The Upper sand unit commonly overlies the Lower sand. In many areas of the sand sheet, however, the Upper sand unit was never deposited, and the Lower unit forms the present-day surface. Where present, the Upper sand is generally thickest in the core areas of the sand sheet. Coppice and parabolic dunes have formed on the present-day surface of the sand sheet. Coppice dunes are around shrubs of Torrey mesquite (*Prosopis glandulosa torreyana*) and are most abundant in areas where the Lower unit is exposed at the surface. Parabolic dunes are exclusively on the Upper unit sand and are associated with shinnery oak (*Quercus havardii*). The coppice and parabolic dunes formed during the twentieth century (Hall and Goble 2006).

Lower eolian sand unit

The Lower unit at the Potash locality is approximately 140 cm (4.5 ft) thick and consists of yellowish-red (5YR 5/8) to red (2.5YR 4/6-8) fine-to-medium quartz sand (Fig. 3). The red color, especially pronounced in the field in the upper 40 cm (16 inches), is a consequence of the presence of the argillic Berino paleosol. The eolian sand is massive, hard, and well sorted. The sand grains are commonly subrounded and exhibit polish. Insect burrow fills are common in the upper 30 cm (12 inches) of the Lower sand (and Berino paleosol). The burrow fills are visible in the field because they are either darker or lighter in color than the surrounding sediment

TABLE 1—Sediment data from the Potash locality, Eddy County, New Mexico. Numbers are percentages; Wentworth scale; OC = % organic carbon determined by Walkley-Black method; % carbonate determined by Chittick method; numbers in parentheses are centimeters depth; dry color from Munsell® Soil-Color Chart; analyses by Milwaukee Soil Laboratory, 6917 W. Oklahoma Ave., Milwaukee, Wisconsin 53219. *10-cm interval (130–140 cm depth) at Lower/Upper unit boundary not collected.

	Sand (mm)					Recalculated					
Field sample no. (cm)	2.0–1.0 very coarse	1.0–0.5 coarse	0.5–0.25 medium	0.25–0.125 fine	0.125–0.0625 very fine	Sand	Silt	Clay < 3.9 μm	OC (%)	$CaCO_3$ (%)	Dry color
Post-Upper eolian sand											
1 (0–10)	0.0	1.0	24.5	56.0	18.5	94	2	4	0.16	0.8	5YR 4/4
2 (10–20)	0.0	1.3	27.1	53.8	17.8	93	2	5	0.29	0.7	2.5YR 4/4
3 (20–30)	0.0	1.5	25.8	52.4	20.3	91	3	6	0.18	0.8	2.5YR 4/4
4 (30–40)	0.1	1.5	26.1	52.6	19.7	92	2	6	0.15	0.8	2.5YR 4/4
Upper eolian sand											
5 (40–50)	0.0	1.5	27.1	53.0	18.4	92	3	5	0.13	0.8	2.5YR 4/6
6 (50–60)	0.0	1.3	26.2	54.5	18.0	92	2	6	0.10	0.9	2.5YR 4/6
7 (60–70)	0.0	1.3	26.2	54.9	17.6	92	1	7	0.08	1.0	2.5YR 4/6
8 (70–80)	0.0	1.2	25.3	54.9	18.6	92	2	6	0.06	0.9	5YR 4/6
9 (80–90)	0.0	1.3	24.9	53.8	20.0	93	2	5	0.06	0.8	5YR 4/6
10 (90–100)	0.0	1.5	25.1	52.6	20.8	92	3	5	0.04	0.7	5YR 4/6
11 (100–110)	0.0	1.3	24.4	52.4	21.9	92	4	4	0.04	0.6	5YR 5/6
12 (110–120)	0.0	1.6	25.1	51.6	21.7	91	6	3	0.03	0.6	5YR 5/6
13 (120–130)	0.0	1.5	24.6	51.0	22.9	92	5	3	0.03	0.7	5YR 5/6
Lower eolian sand											
14 (140–150)*	0.0	2.0	30.7	48.1	19.2	73	4	23	0.07	3.1	2.5YR 4/8
15 (150–160)	0.0	2.5	32.9	46.4	18.2	71	4	25	0.09	3.5	2.5YR 4/6
16 (160–170)	0.0	2.4	32.8	46.4	18.4	76	4	20	0.06	2.7	2.5YR 4/6
17 (170–180)	0.0	2.3	32.4	47.0	18.3	81	4	15	0.04	1.9	2.5YR 4/6
18 (180–190)	0.0	2.4	32.2	47.4	18.0	83	5	12	0.02	1.6	2.5YR 4/8
19 (190–200)	0.0	2.4	32.5	47.8	17.3	86	4	10	0.02	1.3	2.5YR 4/8
20 (200–210)	0.0	2.5	33.9	48.1	15.5	88	4	8	0.02	1.2	2.5YR 4/6
21 (210–220)	0.0	2.4	38.2	48.4	11.0	87	5	8	0.02	1.4	2.5YR 4/8
22 (220–230)	0.0	2.5	38.8	48.3	10.4	86	5	9	0.04	1.5	2.5YR 4/8
23 (230–240)	0.1	2.6	40.9	47.8	8.6	87	5	8	0.00	1.1	2.5YR 4/6
24 (240–250)	0.0	2.4	41.4	48.7	7.5	91	3	6	0.03	1.1	2.5YR 4/6
25 (250–260)	0.0	2.1	42.4	49.4	6.1	93	2	5	0.01	0.8	2.5YR 4/6
26 (260–270)	0.0	2.3	41.4	49.5	6.8	91	3	6	0.01	0.8	5YR 5/8

matrix. The burrow fills are approximately 10–13 mm diameter, and the surfaces of many burrows have clay coats. Some small rootlet pores 2–3 mm in diameter are present in the upper 20 cm (8 inches) of the unit. Pebbles are absent from the sand unit. Rounded sand-sized grains of carbonate are a rare component, less than 1%, and may be derived from deflation of nearby caliche outcrops of the Mescalero paleosol. The base of the unit is not exposed in the Potash soil pit, although nearby the sand rests on the Mescalero paleosol.

Upper eolian sand unit

The Upper unit at the Potash locality consists of 97 cm (3.2 ft) of yellowish-red (5YR 4-5/6) to red (2.5YR 4/6) fine-to-medium quartz sand. The 2.5YR red color is due to the presence of a Bw soil in the upper 30 cm (12 inches) of the sediment column. The texture of the eolian sand unit is remarkably homogeneous throughout. The sand is massive and well sorted; sand grains are rounded to subrounded and have polish. Sand grains associated with the Bw soil have very weak iron oxide coats. Although carbonate content ranges from 0.6 to 1.0%, visible carbonate is absent. Pebbles were not observed anywhere in the section or at the basal unconformity. The base of the Upper sand unit and its contact with the underlying Lower unit is not sharp. Instead, the unconformity is a 2–3-cm zone of mixed Lower unit sediment, probably a consequence of bioturbation before its burial by the Upper eolian sand.

Post-Upper eolian sand unit

The upper 40 cm (16 inches) of the sediment column at the Potash locality represents a combination of sand that has been mixed by prehistoric cultural activity (the archaeological site footprint) and sand that was deposited at the site after it was abandoned (Fig. 4). The sediment is reddish-brown (5YR 4/4–2.5YR 4/4) fine-to-medium quartz sand. The grains are rounded to subrounded and have polish with very weak iron oxide coats. The sand is massive

TABLE 2—OSL laboratory data and ages from eolian sand, Potash locality, Eddy County, southeastern New Mexico.

UNL sample no.	Field no.	Burial depth (m)	H_2O (%)*	K_2O (%)	U (ppm)	Th (ppm)
Upper eolian sand unit						
UNL-2623	Potash-1	0.23	0.3	0.78 ± 0.03	1.33 ± 0.05	3.07 ± 0.20
UNL-2622	Potash-2	0.55	0.4	0.69 ± 0.03	1.29 ± 0.05	2.77 ± 0.20
UNL-2621	Potash-3	0.89	0.4	0.71 ± 0.03	0.99 ± 0.04	2.54 ± 0.20
UNL-2620	Potash-4	1.27	0.6	0.83 ± 0.03	1.21 ± 0.05	3.07 ± 0.20
Lower eolian sand unit						
UNL-2625	Potash-5	2.08	0.6	0.76 ± 0.04	1.55 ± 0.06	3.43 ± 0.24
UNL-2624	Potash-6	2.68	0.5	0.54 ± 0.03	1.22 ± 0.05	2.33 ± 0.19

UNL sample no. (cont.)	Cosmic (Gy)	Dose rate (Gy/ka)	D_e (Gy)†	No. of aliquots§	Age (ka)‡
Upper eolian sand unit					
UNL-2623	0.25	1.43 ± 0.06	2.04 ± 0.16	48/60	1.43 ± 0.13
			0.89 ± 0.04	48/60	0.62 ± 0.04§§
UNL-2622	0.24	1.31 ± 0.05	9.38 ± 0.23	45/60	7.18 ± 0.32
UNL-2621	0.22	1.22 ± 0.05	17.0 ± 0.40	48/48	13.9 ± 0.60
UNL-2620	0.21	1.40 ± 0.05	24.2 ± 0.50	47/48	17.3 ± 0.70
Lower eolian sand unit					
UNL-2625	0.19	1.43 ± 0.05	87.2 ± 2.70	42/63	61.1 ± 3.00
UNL-2624	0.18	1.07 ± 0.04	93.3 ± 2.70	38/54	87.0 ± 4.20

Note: Samples collected in 2009 and prepared in 2010.
*In situ moisture content.
†Error on D_e is 1 standard error.
§Accepted/total.
‡Ages are 1σ; error on age includes random and systematic errors calculated in quadrature.
§§Minimum age model (Galbraith et al. 1999).

and well sorted. Insect burrow fills are common. Carbonate is 0.7–0.8% and not visibly present on grains or in the deposit. Organic carbon is 0.15–0.29%, the highest amounts in the sediment column and likely because of the archaeological site (Table 1). Two AMS radiocarbon ages on charcoal from the site are 2,700 ± 40 and 2,450 ± 40 ^{14}C yrs b.p. (D. Boggess, pers. comm.). An OSL sample from 23 cm below the present-day surface shows evidence of partial bleaching, and its age, 0.62 ± 0.04 ka, was calculated using the minimum age model of Galbraith et al. (1999). The texture of the sand from the upper 40 cm (16 inches) is similar to the texture of the Upper unit, although it is less red than the Upper sand and accompanying Bw soil horizon (Fig. 3). The distinction of sediments from the Upper eolian sand unit, the archaeological site footprint, and the post-site eolian sand was not clear in the field. This situation illustrates the importance of geologic sampling at some distance from prehistoric sites in order to avoid culturally disturbed sediments and deposits associated with sites (Hall and Rittenour 2010).

Paleosols

Mescalero paleosol

The Mescalero paleosol is present throughout southeastern New Mexico and is developed directly on the eroded surface of Permian and Triassic red beds and on the late Cenozoic Gatuña Formation. It was called the Mescalero caliche by Bachman (1976) and has a stage III carbonate morphology. Throughout the Mescalero Plain, the top of the Mescalero paleosol is largely missing due to erosion. The resistant caliche forms low escarpments in southeastern New Mexico. The Lower unit of the Mescalero sand sheet was deposited directly on the eroded surface of the paleosol.

Although the Mescalero paleosol was not exposed in the Potash soil pit, it crops out nearby. The upper part of the caliche is weathered into irregular dense masses, nodules, and small pellets 4–20 mm diameter. The caliche pellets are reworked into eolian-colluvial deposits on some nearby slopes. The caliche is hard but contains many solution cavities, the cavity surfaces lined with thin laminar carbonate coats.

Berino paleosol

The Berino paleosol is developed at the top of the Lower eolian sand throughout the study area, giving the sand its red color. The paleosol was named and described by Bachman (1980, 1981, 1984) and is discussed by Hall and Goble (2006). In summary, the Berino is an argillic paleosol with high clay content and very little carbonate. It formed on the stable surface of the Lower sand during the comparatively cool, moist climate of the late Wisconsin Glaciation. The vegetation on the sand sheet at that time was a sagebrush grassland, based on information from regional vertebrate faunas and pollen analysis discussed by Hall and Valastro (1995), Hall (2001), and Hall and Riskind (2010).

The texture and chemistry of the Berino paleosol at the Potash locality were determined by the Milwaukee Soil Laboratory. The clay content of the Btk horizon ranges from about 8 to 25%, and carbonate content ranges from 1.1 to 3.5% (Fig. 3) (Table 1). Although comparatively moderate percentages of carbonate were measured in the upper 20 cm (8 inches), microscopic examination shows that carbonate coats on quartz grains are rare or absent throughout the entire profile of the paleosol. In the field, however, visible carbonate shows up as pronounced filaments, burrow linings, along root traces, and along fracture surfaces in the hard sand, especially at 80–110 cm (2.6–3.6 ft) below the top of the paleosol or approximately 220–250 cm (7–8 ft) depth in the measured section.

The abrupt peak in percentages of clay and carbonate at the top of the soil profile indicates that the paleosol is truncated and that several decimeters of the upper B horizon are likely missing (Fig. 3). Removal of the upper part of the Berino paleosol by erosion during the late Pleistocene seems to have been universal throughout the Mescalero sand sheet. After the formation of the Berino paleosol and a period of erosion, the Upper eolian sand was deposited beginning ca. 18 ka. Based on OSL dating presented in this paper, the development of the Berino paleosol occurred during some time interval within the broad period of 50 ka to 18 ka.

Bw paleosol

An unnamed Bw soil horizon in the upper 30 cm (12 inches) of the Upper eolian sand unit is characterized by red (2.5YR 4/6) color. The quartz sand grains exhibit weak iron oxide coats although secondary clay and carbonate are absent. Many field exposures of the Upper unit on the Mescalero sand sheet show the presence of a Bw soil horizon at the top of the sand. Based on the youngest OSL age at the Potash local-

TABLE 3—Revised OSL ages from eolian sand from the Mescalero Sands, Eddy County, southeastern New Mexico, originally reported in Hall (2002) and Hall and Goble (2006).

UNL sample no.	Field no.	Burial depth (m)	H_2O (%)[*]	K_2O (%)	U (ppm)	Th (ppm)
Upper eolian sand unit, BL locality[†]						
UNL-250	Hall-4	1.35	2.7	0.59	0.4	1.0
UNL-249	Hall-3	4.55	2.9	0.73	0.6	1.8
Lower eolian sand unit, VG locality[§]						
UNL-248	Hall-2	1.60	2.5	0.71	0.6	2.2
UNL-247	Hall-1	2.80	2.7	0.76	0.5	2.0

UNL sample no. (cont.)	Cosmic (Gy)	Dose rate (Gy/ka)	D_e (Gy)[‡]	No. of aliquots	Age (ka)[§§]
Upper eolian sand unit					
UNL-250	0.21	0.84 ± 0.05	4.90 ± 0.06	55	5.82 ± 0.41
UNL-249	0.14	0.98 ± 0.06	9.23 ± 0.17	53	9.39 ± 0.67
Lower eolian sand unit					
UNL-248	0.21	1.06 ± 0.06	86.4 ± 2.0	39	81.2 ± 5.70
UNL-247	0.18	1.03 ± 0.06	93.8 ± 2.6	42	90.7 ± 6.70

Note: Samples collected and prepared in 2001.

[*] In situ moisture content.

[†] Booger-Langston Road (BL) locality, latitude 32° 57′ 18.72″ N, longitude 103° 55′ 30.12″ W.

[§] Valley Gas (VG) locality, latitude 32° 48′ 19.66″ N, longitude 104° 04′ 19.97″ W.

[‡] Error on D_e is 1 standard error.

[§§] Ages with 1σ standard deviation; error on age includes random and systematic errors calculated in quadrature.

ity, 7.18 ± 0.32 ka, and the radiocarbon age of the intrusive archaeological site, the Upper unit may have stabilized by 5 ka. Accordingly, the Bw horizon formed during a period of no more than, and probably less than, 5 ka. The younger Loco Hills A horizon soil, radiocarbon dated less than 500 yrs b.p. (Hall and Goble 2006), is generally present throughout the Mescalero sand sheet although not at the Potash locality.

OSL geochronology

Lower eolian sand unit

The Lower unit at the Potash locality is OSL dated 87.0 ± 4.2 ka and 61.1 ± 3.0 ka (Table 2). At the VG locality at the western edge of the Mescalero sand sheet, the revised OSL ages from the Lower unit are 90.7 ± 6.7 ka and 81.2 ± 5.7 ka (Fig. 1; Table 3). The similarity of the ages of the Lower unit at the two separate places indicates that the sand accumulated during the same period of deposition, perhaps continuing somewhat later at the Potash locality. As additional OSL ages from the Lower sand become available, a clearer pattern of eolian deposition across the sand sheet will emerge.

Upper eolian sand unit

Three OSL ages from the Upper unit at the Potash locality are 17.3 ± 0.7 ka, 13.9 ± 0.6 ka, and 7.18 ± 0.32 ka (Table 2). The stratigraphically lowest sample was collected at 127 cm (4 ft) depth, 10 cm (4 inches) above the erosional unconformity between the Lower and Upper units, indicating that the Upper sand was accumulating ca. 18 ka. The younger age from 15 cm (6 inches) below the top of the Upper unit (55 cm (2 ft) depth at the measured section) is 7.18 ± 0.32 ka. Based on extrapolation of the three OSL ages, the Upper sand was accumulating until ca. 5 ka. Thus, the age of the Upper unit at the Potash locality is estimated to be 18–5 ka.

The revised OSL ages from the Upper unit at the BL locality in the core area of the Mescalero Sands are 9.39 ± 0.67 ka and 5.82 ± 0.41 ka (Table 3). The 9.39-ka sample was collected 5 cm above the basal contact of the Upper sand with underlying late Pleistocene cienega deposits (Hall and Goble 2006). Thus, the Upper sand in the Mescalero Sands area may have been accumulating by ca. 10 ka, significantly later than the 18 ka basal age of the Upper sand observed at the Potash locality. The age of the top of the Upper unit at the BL locality is extrapolated to ca. 4.3 ka, although based on only two samples. The investigation at the Potash locality demonstrates that, as new OSL ages are becoming available, the geochronology of the sand sheet evolves and some complexity in its depositional history emerges.

Accumulation rate of the sand sheet

Depths versus OSL age relationships provide a new basis, perhaps the only basis, for calculating the rate of accumulation of eolian sand deposits. The rate of sedimentation of the Lower unit at the Potash locality, although based on only two samples, is 0.023 mm/yr. The Upper unit accumulated at a rate of 0.068 mm/yr. Both of these rates are very low (Fig. 5). Using the revised OSL ages, the Lower and Upper units in the Mescalero Sands area (VG and BL localities) have higher rates of accumulation, 0.13 and 0.90 mm/yr, respectively, although the Upper sand is comparatively thick with clay bands and represents a local area of dunes in the core of the Mescalero Sands.

Eolian sand in thin sheets in the region evidently has low sedimentation rates. For example, the Q3 eolian sand unit in the Bolson sand sheet of south-central New Mexico and adjacent Texas has OSL-dated rates of accumulation ranging from 0.067 to 0.094 mm/yr (Hall 2007; Hall et al. 2010). The late Pleistocene sand sheet on the West Mesa near Albuquerque has an accumulation rate of 0.26 mm/yr (Hall et al. 2008).

In contrast, eolian sand accumulation in dune fields appears to be more rapid. The White Sands dune field in south-central New Mexico has been cored and dated by OSL, resulting in a net accumulation rate of 1.34 mm/yr (Kocurek et al. 2007). Although OSL-dated eolian sequences are few, a pattern is emerging, indicating that eolian sand in sand sheets accumulates slowly, whereas sand aggradation in dune fields is rapid.

Slow continuous deposition

One of the new discoveries related to OSL dating of the Mescalero sand sheet is that the sand bodies, especially the Upper unit for which we have the most information, evidently accumulated slowly and continuously for many thousands of years without discernible interruption. The 97-cm-thick (3.2-ft-thick) Upper eolian sand at the Potash locality is entirely homogeneous. Field inspection and laboratory analysis of the sediments do not reveal the presence of buried soils, a disconformity, or a break in the sedimentology. Even though its net sedimentation rate is very slow, 0.068 mm/yr, the sand unit appears to have been deposited continuously from 18 ka to 5 ka without interruption. Other field localities of the Upper eolian sand on the Mescalero Plain exhibit the same homogeneity.

Texture of the eolian sand

The two eolian sand bodies at the Potash locality are dominated by fine- and medium-textured quartz sand. However, close inspection of the sediment data displays

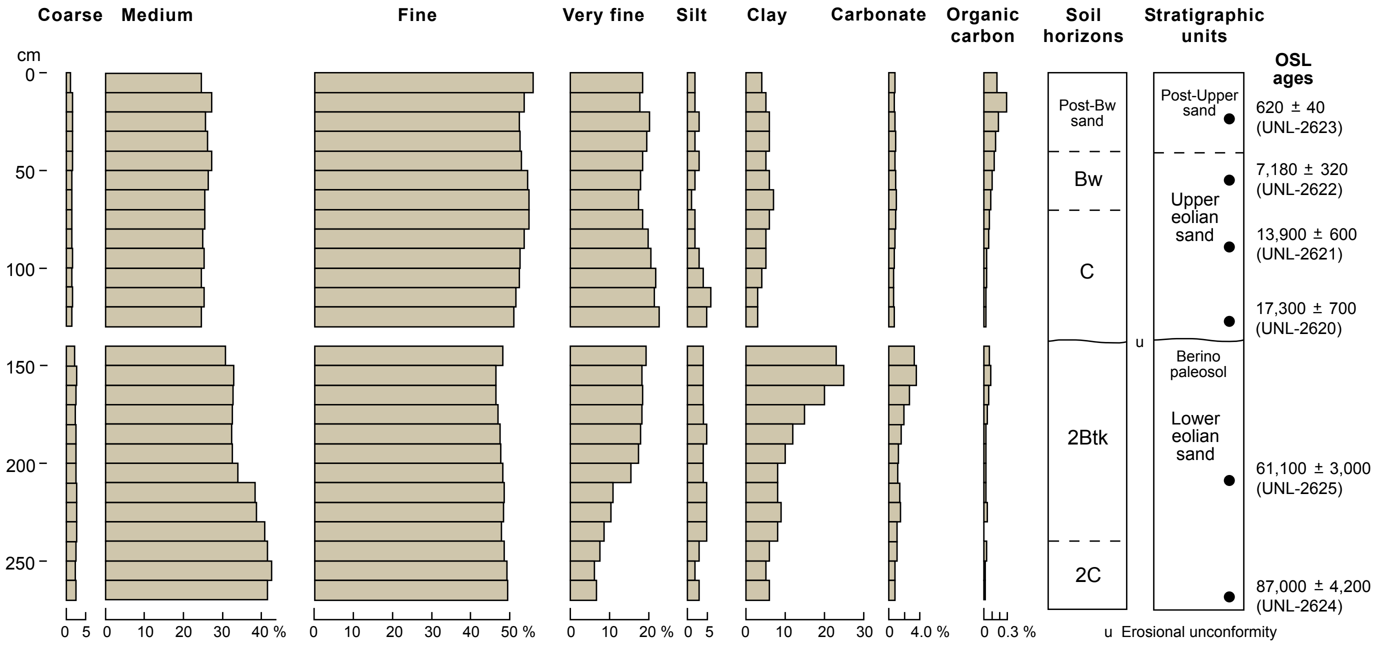

FIGURE 3—Textural and chemical data, soil horizons, and stratigraphy of eolian sand at the Potash locality, Eddy County, New Mexico; sediment data from Table 1.

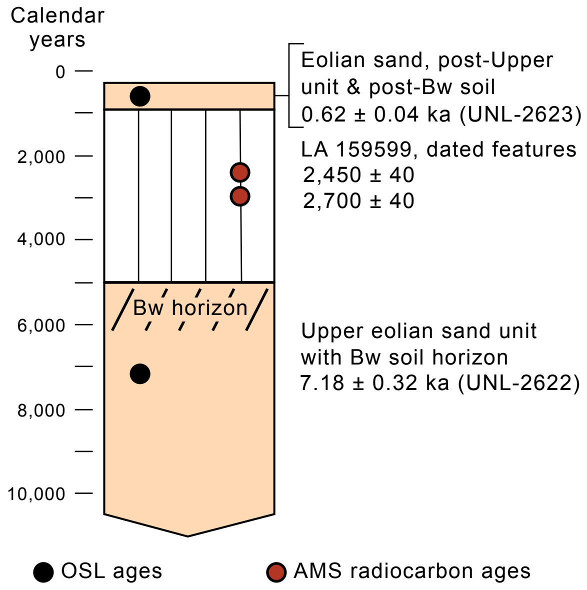

FIGURE 4—Detail of geochronology and stratigraphy of the Potash locality for the past 10,000 yrs showing chronology of archaeological site LA 159599. The AMS radiocarbon ages are shown calibrated to calendar years b.p.

some differences and patterns in the texture of the sand. Overall, the Lower unit is somewhat coarser than the Upper unit sand. The Lower unit has slightly higher percentages of coarse sand, higher percentages of medium sand, and lower percentages of very fine sand (Fig. 6). In addition, the Lower unit appears to be made up of two separate zones, based on sand texture, with the division at approximately 210 cm (6.9 ft) depth at the measured section. The zone below 210 cm depth (sample nos. 21–26) has higher percentages of medium sand and lower percentages of very fine sand, in comparison with the upper part of the Lower sand unit above 210 cm depth (sample nos. 14–20; Fig. 6). The significance of these differences and patterns is not clear at this time, although they may be related ultimately to sand source and paleowind strength and duration.

The Upper sand unit appears to be homogeneous throughout, although the percentages of fine sand increase ever-so-slightly upward. A possible noteworthy trend is exhibited by the silt content. Slightly higher amounts of silt in the lower few samples of the Upper unit may represent increased dust in the atmosphere during late-glacial time (Fig. 3). Similar higher amounts of silt in glacial-age eolian sand were observed in the Bolson sand sheet in south-central New Mexico and Texas (Hall et al. 2010).

Correlation issues

OSL dating is providing a valuable new geochronology of regional eolian deposits. Previous chronologies of dune field and sheet sands have been based largely on radiocarbon dating of associated archaeological sites and buried soils, where present. Overall, however, although it is tempting to expect that wind-deposited sediments should correlate across regions, periods of universal eolian activity may not be the case. The geomorphic conditions of the various places where eolian deposits are present may play a pivotal role in local eolian depositional history. In the Southern Plains, special geomorphic settings related to eolian geology are (a) broad plains with thin sand sheets, (b) thick dune sand in the core areas of sand sheets, (c) belts of eolian sand associated with major rivers, (d) lee dunes downwind from large playa lakes, and (e) eolian deposits in draws and small drainages. Each of these settings may have its own specific history of eolian sand deposition that may be related to fluvial and lacustrine processes as well as to regional vegetation and climatic change.

A number of studies in the southern High Plains, for example, show a divergence in the timing of local eolian deposition. The

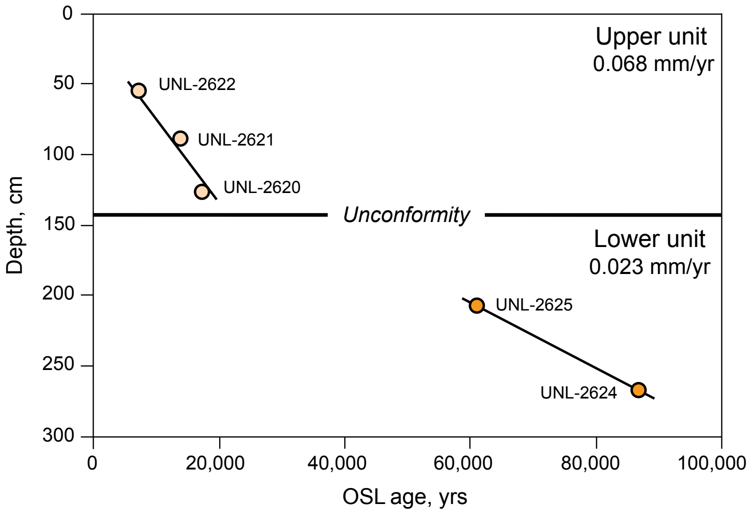

FIGURE 5—Depth versus OSL age, Mescalero sand sheet, Potash locality; OSL data in Table 2. Accumulation rates are 0.023 mm/yr for the Lower sand unit and 0.068 mm/yr for the Upper sand unit.

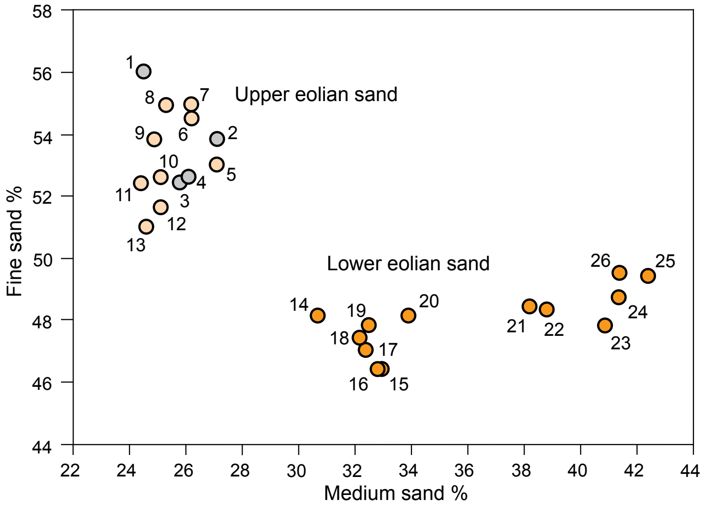

FIGURE 6—Fine sand versus medium sand, Mescalero sand sheet, Potash locality. Numbers refer to sample numbers in Table 1. The gray circles (nos. 1–4) represent post-Upper unit and post-Bw sediment.

accumulation of wind-blown sand occurred in draws during the mid-Holocene (Holliday 1989, 1995). However, on the High Plains surface, eolian sand deposition occurred predominantly later, especially during the late Holocene since 4.5 ka (Holliday 2001). Eolian deposition along the Cimarron River in Oklahoma occurred later yet during the late Holocene, mostly after 1 ka (Lepper and Scott 2005).

The above cases are in contrast to the emerging picture of eolian deposition across the Mescalero Plain of southeastern New Mexico (Fig. 7). Our study shows that the most recent period of sand sheet deposition occurred between 18 ka and 5 ka, and that eolian sand younger than 5 ka is less common. (This excludes the large volume of sand entrained and deposited as coppice and parabolic dunes during the twentieth century.) The Lower unit is OSL dated between 90 and 50 ka. This period of eolian sand deposition is seldom documented elsewhere in the south-central United States, possibly because its age is too great for routine radiocarbon dating and too early to contain prehistoric sites. The new geochronology provided by OSL dating is beginning to show that, although there are some regional correlations across the landscape, there are also significant differences in the history of eolian deposition. These differences may themselves represent local geomorphic response to coarse-scale climate and vegetation change.

Summary and conclusions

The Mescalero sand sheet is made up of two eolian sand bodies, the Lower and Upper units. OSL dating indicates that the Lower sand was deposited 90–50 ka and that the Upper sand was deposited 18–5 ka. The sand sheet rests directly on the eroded caliche of the Mescalero paleosol.

The Berino paleosol is a red argillic soil that formed on the stable surface of the Lower eolian sand during the late Wisconsinan during the broad period 50–18 ka, based on OSL dating. The paleosol gives the Lower sand its red color.

A Bw soil horizon at the top of the Upper eolian sand, formed since the end of deposition of the Upper sand ca. 5 ka.

The Lower and Upper eolian sand bodies accumulated slowly, 0.023 and 0.068 mm/yr, respectively. Each sand body accumulated slowly and continuously without discernible interruption.

Both sands are characterized by massive, well-sorted, fine-to-medium-textured quartz sand. In detail, however, the Lower sand is slightly coarser textured with significantly more medium textured and less very fine textured sand. The significance of these differences is unclear, although it may be a consequence of shifts in sand sources or wind properties.

The Lower eolian sand is too old to contain archaeology. However, the surface of the Upper eolian sand may have sites that are younger than 3,000 b.c. Sites earlier than that may be buried in the sand.

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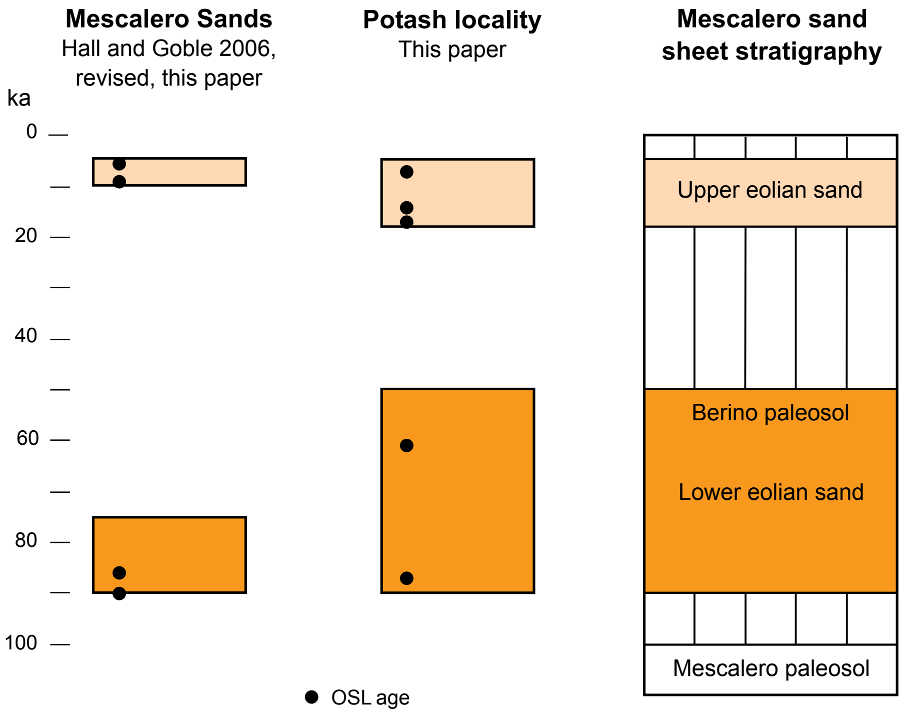

FIGURE 7—Summary stratigraphy and OSL geochronology of the Mescalero sand sheet, southeastern New Mexico.

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