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> <sup>4</sup>Accepted disks/all disks. Assumes 100% error in estimated moisture content. Field, moisture content of sample, measured at UNL lab; Est., estimate of moisture content, which may better represent moisture history of sample.

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**Table 2.** Radiocarbon sample information, <sup>14</sup>C ages<sup>1</sup>, and calibrated ages (modified from Berry and others, 2015a).

[UTM, Universal Transverse Mercator; quad, quadrangle;  $\delta^{13}$ C, delta carbon-13; ‰, per mil; <sup>14</sup>C ka B.P., carbon-14 thousand years before present; cal ka B.P., calibrated thousand years before present; P, probability; Approx., approximate; m, meter; cm, centimeter;  $\pm 1\sigma$ , represents estimates of uncertainty given at the 67 percent confidence interval;  $\pm 2\sigma$ , represents estimates of uncertainty given at the 95 percent confidence interval]

Field number	Laboratory number	7.5′ quad	UTM Easting <sup>2</sup>	UTM Northing <sup>2</sup>	Material dated	Approx. depth (m)	${\delta^{13} C \over (\%_0)^3}$	<sup>14</sup> C age ( <sup>14</sup> C ka B.P.) <sup>4</sup>	Calibrated age (cal ka B.P.) <sup>5</sup>	P <sup>6</sup>
WC-P-2	Aeon-1580	Fort Morgan	602519	4467910	Humin fraction of buried A horizon	0.8	-17.4	2.84±0.03	2.93±0.07	0.96
TIP-Wp115	Aeon-1582	Fort Morgan	602094	4468709	Bison tooth	0.9	-12.7	0.11±0.02	$0.04{\pm}0.01$ $0.10{\pm}0.04$ $0.24{\pm}0.02$	0.14 0.59 0.28
FMR-3	Aeon-2101	Fort Morgan	602339	4469163	Humin fraction of buried A horizon	1.8	-21.4	4.36±0.03	4.92±0.07	0.96
AK-1	Aeon-994	Weldona	592473	4463764	Probable Succinea (single shell)	4.7	-6.8	10.22±0.07	11.90±0.28	0.98
AK-8	Aeon-995	Weldona	592473	4463764	Probable Succinea (single shell)	3.6	-4.6	10.24±0.06	11.95±0.24	0.98
H–R–3,4,5,9	Aeon-1064	Orchard	581980	4466741	Probable <i>Succinea</i> (four shells from ~15 cm thick bed	3.7	-3.8	12.36±0.15	14.53±0.56	1.00
KC-245	Aeon-950	Orchard	577915	4464174	mostly lignite?	2.5	-23.2	39.80±3.10	43.90±5.69	1.00

<sup>1</sup>Radiocarbon (<sup>14</sup>C) activity measured by accelerator mass spectrometry (AMS). <sup>2</sup>UTM zone 13, 1927 North American Datum (NAD 27).

<sup>3</sup>Relative difference between <sup>13</sup>C/<sup>12</sup>C ratio of carbon extracted from subsample and that of Vienna Pee Dee Belemnite (VPDB) international standard.

<sup>4</sup>Conventional radiocarbon age, normalized to -25‰, based on 5,568-year half-life; uncertainty ±1σ. <sup>5</sup>Calibrated age calculated using CALIB 7.0, IntCal13 dataset (Stuiver and Reimer, 1993; Reimer and others, 2013); 0 yr B.P. = 1950 A.D.; uncertainty ±2σ. Calibrated age reported as midpoint of calibrated range. For Aeon-1582, calibration produced more than one age range with a probability of 5 percent or more; therefore, calibrated age used in discussion (0.13 cal ka B.P.) is based on the mean of the ranges weighted by their probabilities and is presented without uncertainties <sup>6</sup>Probability of calibrated age falling within reported range as calculated by CALIB.

Table 3. U-Th concentrations, U-series isotope compositions, and calculated <sup>230</sup>Th/U ages and initial <sup>234</sup>U/<sup>238</sup>U activity ratios for subsamples of *EF–Wp67 and EIC–Wp95 (from Berry and others, 2015b).* [Abbreviated version of table 1-1 in Paces (2015). Note that  $\pm 2\sigma$  represents estimates of uncertainty given at the 95 percent confidence level;  $\mu g/g$ , micrograms per gram;  $\sigma$ , sigma; ka, thousand years]

Field number	x 1 1	U concentration.	Th concentration.	Measured	Detritus-correct	ed activity ratios <sup>2</sup>	<sup>230</sup> Th/Llage	Initial $^{234}U/^{238}U AR\pm 2\sigma^{3}$	
	Lab sample name	in µg/g	in µg/g	<sup>230</sup> Th/ <sup>232</sup> Th AR <sup>1</sup>	<sup>230</sup> Th/ <sup>238</sup> U AR±2σ	$^{234}U/^{238}U~AR{\pm}2\sigma$	$\pm 2\sigma(ka)^3$		
	Carbonate rind (subst through Wp67–11). Location of EF–Wp6	sample Wp67–1) and 67: UTM 564654E., 4	layers of bone (subsa 1462502N.4	mples Wp67–2					
EF–Wp67	Wp67–1	22.5	1.64	5.7	0.117±0.011	$1.221 \pm 0.004$	11±1.1	$1.228 \pm 0.004$	
	Wp67–2	83.0	0.325	104	0.1338±0.0012	1.214±0.003	12.70±0.13	$1.221 \pm 0.003$	
	Wp67–3	107	0.044	1150	0.1520±0.0006	1.210±0.003	14.58±0.07	$1.219 \pm 0.003$	
	Wp67–5	116	0.025	2300	$0.1588 {\pm} 0.0007$	1.215±0.003	15.21±0.08	$1.224 \pm 0.003$	
	Wp67–7	115	0.028	2020	$0.1600 \pm 0.0007$	1.221±0.002	15.26±0.08	$1.231 \pm 0.003$	
	Wp67–9	116	0.032	1600	0.1458±0.0006	1.217±0.003	13.87±0.07	1.226±0.003	
	Wp67–11	104	0.124	322	0.1255±0.0006	1.217±0.003	11.82±0.06	1.225±0.003	
	Innermost carbonate UTM 567342E., 445	rinds on alluvial clas 58109N. <sup>4</sup>	ts. Location of EIC-	Wp95:					
	Wp95-A1-1	5.92	0.280	66.9	$1.040 \pm 0.008$	1.125±0.007	248±9	1.252±0.010	
	Wp95-A1-2	7.36	0.309	76.7	$1.061 \pm 0.007$	$1.084 \pm 0.003$	337±15	$1.217 \pm 0.009$	
EIC-Wp95	Wp95-A2-1	10.2	0.274	121	$1.065 \pm 0.009$	$1.085 \pm 0.003$	341±20	$1.222 \pm 0.012$	
	Wp95-A3-1	7.12	0.549	41.3	$1.048 \pm 0.009$	$1.094 \pm 0.004$	294±13	$1.216 \pm 0.008$	
	Wp95–B1	7.90	0.901	28.2	$1.057 \pm 0.01$	$1.077 \pm 0.004$	345±24	$1.205 \pm 0.012$	
	Wp95–B2	7.60	0.509	47.6	$1.048 \pm 0.007$	$1.079 \pm 0.003$	324±15	$1.197 \pm 0.008$	
	Wp95–B3	9.58	0.672	46.3	$1.069 \pm 0.007$	$1.072 \pm 0.003$	397±27	$1.221 \pm 0.014$	
	Wp95-E1	9.91	0.461	67.7	$1.037 \pm 0.006$	$1.054 \pm 0.003$	372±21	1.153±0.008	
								T	

Measured activity ratio (AR) corrected for mass fractionation, spike contributions, and procedural blank, and normalized relative to an atomic ratio value for National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) 4321B U-isotope standard of <sup>234</sup>U/<sup>238</sup>U=0.0000529. <sup>2</sup>Ratios corrected for an assumed Th-bearing detrital component having an atomic Th/U of 4 with the following activity ratios and  $2\sigma$  errors: <sup>232</sup>Th/<sup>238</sup>U=1.276±0.64; <sup>234</sup>U/<sup>238</sup>U=1.0±0.1; and <sup>230</sup>Th/<sup>238</sup>U=1.0±0.25.

<sup>230</sup>Th/U ages, initial <sup>234</sup>U/<sup>238</sup>U activity ratios (ARs), and associated errors are calculated using detritus-corrected activity ratio values. <sup>4</sup>UTM zone 13, 1927 North American Datum (NAD 27).

Table 1. Optically stimulated luminescence (OSL) age estimates with equivalent dose (D\_) and dose rate data (modified from Berry and others, 2015a). [UNL Lab, University of Nebraska–Lincoln Luminescence Geochronology Laboratory; quad, quadrangle; UTM, Universal Transverse Mercator; Approx., approximate; m, meter; U, uranium; ppm, parts per million; Th, thorium; K<sub>2</sub>O, potassium oxide; wt. %, weight percent; %, percent; Gy, gray<sup>1</sup>; Std. err., standard error; n, number; H<sub>2</sub>O, water; ka, thousand years; ±1 $\sigma$ , represents estimates of uncertainty given

at the 67 percent confidence interval]																
Field number	UNL lab number	7.5′ quad	UTM Easting <sup>2</sup>	UTM Northing <sup>2</sup>	Approx. depth (m)	U (ppm)	Th (ppm)	K <sub>2</sub> O (wt.%)	$\begin{array}{c} \text{CAM } \text{D}_{e} \\ \text{(Gy)} \\ \pm 1 \text{ Std. err.}^{3} \end{array}$	Aliquots (n) <sup>4</sup>	In situ H <sub>2</sub> O field (%) <sup>5</sup>	Dose rate (Gy/ka) <sup>6</sup>	OSL age ka±1σ <sup>6</sup>	In situ H <sub>2</sub> 0 est. $(\%)^5$	Dose rate (Gy/ka) <sup>7</sup>	OSL age ka±1σ <sup>7</sup>
												In situ <sup>8</sup>			In situ <sup>8</sup>	
OSL-1-KC	UNL-3462	Orchard	577915	4464174	1.7	5.3	20.0	3.8	67.6±3.3	22/30	2.9	$5.77 \pm 0.32$	$11.7{\pm}1.0$	5.0	$5.64 \pm 0.35$	$12.0{\pm}1.1$
OSL-4-KC	UNL-3466	Orchard	577915	4464174	2.6	3.3	16.3	4.3	87.8±5.4	24/37	2.1	$5.41 \pm 0.30$	16.2±1.5	5.0	5.23±0.34	$16.8 \pm 1.7$
OSL-5-KC	UNL-3463	Orchard	577915	4464174	3.6	3.7	15.8	4.3	80.6±4.8	22/32	2.4	$5.45 \pm 0.31$	$14.8 \pm 1.4$	5.0	$5.29 \pm 0.35$	15.2±1.5
OSL-6-ER	UNL-3467	Masters	568185	4455813	0.7	2.9	11.4	3.4	109.7±5.6	20/37	5.0	4.15±0.27	26.4±2.5	5.0	4.15±0.27	$26.4 \pm 2.5$
OSL-7-ER	UNL-3468	Masters	568198	4455836	1.0	2.4	8.1	3.7	31.4±2.2	29/37	1.9	4.22±0.25	$7.4 \pm 0.7$	5.0	$4.07 \pm 0.28$	$7.7{\pm}0.8$
OSL-BC-14	UNL-3498	Weldona	585123	4459026	1.1	4.8	19.5	3.7	67.0±2.8	31/48	7.7	5.23±0.39	12.8±1.2	5.0	5.39±0.34	$12.4 \pm 1.1$
OSL-BC-13	UNL-3499	Weldona	585123	4459026	1.9	4.3	17.6	4.1	79.1±2.9	36/54	6.7	$5.33 \pm 0.38$	$14.8 \pm 1.3$	5.0	$5.43 \pm 0.35$	$14.6 \pm 1.2$
												UNL lab <sup>9</sup>			UNL lab <sup>9</sup>	
OSL-AK-10	UNL-3502	Weldona	592468	4463758	5.1	5.7	23.3	2.7	40.2±1.4	43/54	7.0	4.92±0.35	8.2±0.7	5.0	5.03±0.31	$8.0{\pm}0.7$
OSL-AK-11	UNL-3503	Weldona	592478	4463772	3.5	3.5	9.9	2.6	32.5±1.8	27/35	5.9	3.52±0.24	9.2±0.9	5.0	3.56±0.23	9.1±0.9
OSL-TK-R-12	UNL-3504	Orchard	577216	4463702	8.0	1.5	6.7	3.9	35.8±2.0	48/54	3.3	3.88±0.26	9.2±0.9	5.0	3.81±0.28	9.4±1.0

Gray is an SI unit of absorbed dose of ionizing radiation (Taylor and Thompson, 2008). <sup>2</sup>1927 North American Datum (NAD 27), zone 1

<sup>3</sup>Determined using the Central Age Model (CAM) of Galbraith and others (1999).

6Calculated using field moisture content of sample 7Calculated using 5% as estimated moisture content

8Measured in field with a portable gamma spectrometer Measured at UNL Lab using high-resolution gamma spectrometry (updated from Berry and others, 2015a, b).

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long. Photographs by M.E. Berry, June 2013.

## **Scientific Investigations Map 3408** Sheet 2 of 2



Photo 1. Views of Verdos Alluvium (Qv) in gravel-pit exposure in adjacent Brush West 7.5' quadrangle. A, Section (about 6-meters thick) of cross-bedded sandy gravel interbedded with well-sorted sand. Black manganese oxide stains gravel in lower part of photo; reddish yellow iron oxide stains gravel in middle part. Soil with well-developed K horizon (white zone) visible at top of section. *B*, Close up of soil profile. K horizon variably cemented with stage III (locally stage IV) carbonate morphology and thick coats (rinds) on clasts up to 1-centimeter thick. Shovel is 68-centimeters long. Photographs by M.E. Berry, September 2012 and June 2016.



Photo 2. Views of Nussbaum Alluvium (QNn) in a gravel-pit exposure in northwestern part of Fort Morgan 7.5' quadrangle. A, Close up of rounded cobbles in indurated conglomerate making up basal section of alluvium. Knife is 26 centimeters long. B, Variably cemented cross-bedded sands and pebbly sands. Shovel blade is 22 centimeters long. C, Quarried blocks of indurated basal conglomerate. Photographs by M.E. Berry, July 2010 and September 2012.

Photo 3. Views of eolian and alluvial deposits, undivided (Qlg). A, Erosional contact (dashed line) separates Qlg from overlying young sidestream alluvium, undivided (Qay), here made up of reworked loess and eolian sand deposited mainly by sheetwash processes. Eroded pedogenic carbonate horizon with maximum stage III carbonate morphology marks top of Qlg. *B*, Close-up view of a gravel bed within Qlg. Knife is 26 centimeters

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