Late Pleistocene to Early Holocene Paleoecology of the Mr. Peat Wetland Deposit, Alamosa County, Colorado

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CHAPTER F

Abstract

The Mr. Peat wetland deposit occupies a west-trending, slightly entrenched, unnamed stream valley located about 16 km (10 mi) east of the city of Alamosa and 2 km (1.3 mi) south of U.S. Highway 160. The peats lie in a late-glacial-age paleovalley that is underlain by well-bedded fluvial sand and pea-size gravel. In the summer of 2006, we excavated four trenches in these deposits to better understand the timing, duration, and environment of peat accumulation, the age of underlying fossil-bearing alluvial deposits, and the age and origin of overlying tufaceous paleospring deposits. Radiocarbon dating of the peats show that most of the deposits accumulated from 13.4 ka cal yr B.P. to about 11.3 ka cal yr B.P., but organic accumulation continued until middle Holocene time (4.3–6.7 ka cal yr B.P.), whereas locally overlying tufaceous spring deposits started to accumulate at about 6.7 ka cal yr B.P. and continued until about 3.9 ka cal yr B.P. The deposit was mined for its peat resources during the 1970s and 1980s.

Introduction

The Mr. Peat wetland deposit is located south of U.S. Highway 160, the main highway across the San Luis Valley (fig. F–1). The pit is about 16 km (10 mi) east of the city of Alamosa and 2 km (1.3 mi) south of the highway, occupying a west-trending, slightly entrenched, unnamed stream valley. The deposit is approximately 3 km (1.9 mi) long, as much as 0.5 km (0.3 mi) wide, and it lies at an elevation of approximately 2,313 m (7,590 ft) near the geographic center of the deposit. The stream valley is incised into gently west-sloping piedmont covered by eolian dune and cover sands of late Pleistocene and Holocene age. The piedmont is largely a relict basin floor of ancient Lake Alamosa (see chapter G in this volume) of middle Pleistocene age. Shallow lacustrine and interbedded fluvial sediment that underlie the piedmont constitute the uppermost part of the Alamosa Formation (middle Pleistocene to Pliocene), which is considered to be an informal, upper

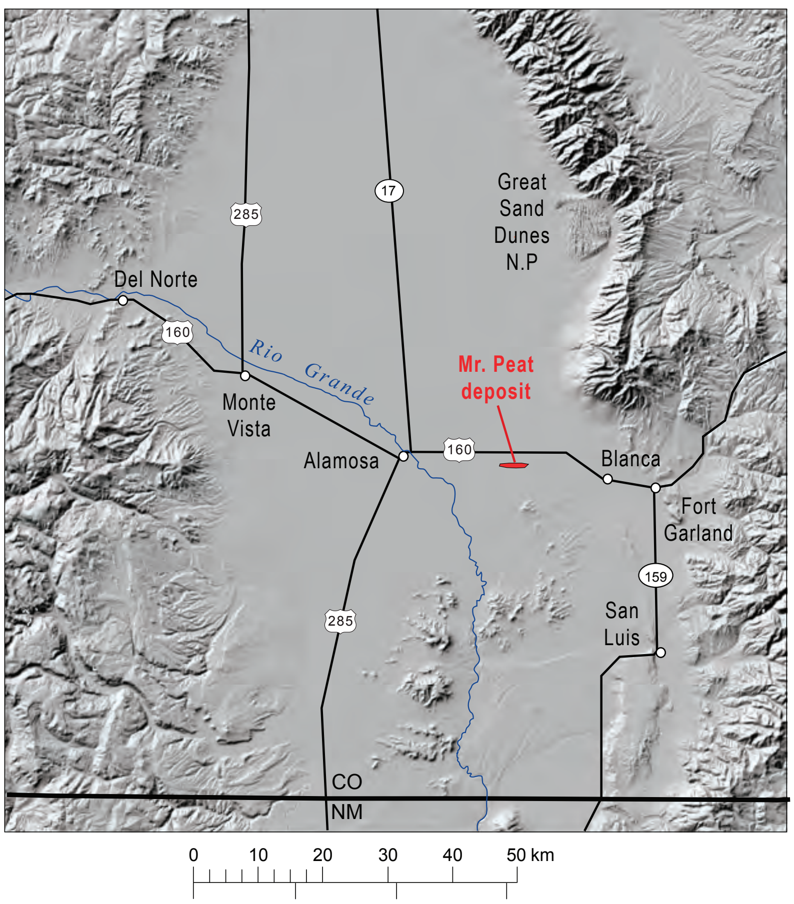

Figure F–1. Generalized map of central San Luis Valley showing location of the Mr. Peat pit.

Figure F–2. Sign at entrance to the Mr. Peat pit.

member of the Santa Fe Group (middle Pleistocene to late Oligocene; Michael Machette and Ren Thompson, unpub. mapping, 2007). The peat deposits were commercially mined in the 1970s and 1980s (fig. F–2). An examination of the geologic history of this deposit was undertaken as part of field investigations related to geologic mapping in the Alamosa 30' x 60' quadrangle.

Vegetation

Vegetation in the floor of the San Luis Valley consists primarily of greasewood (*Sarcobatus vermiculatus*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and grasses such as alkali sacaton (*Sporobolus airoides*), saltgrass (*Distichlis spicata*), and Indian ricegrass (*Oryzopsis hymenoides*). The Rio Grande, other perennial streams, and regularly flooded marshes, lakes, and playas support aquatic and shoreline emergent vegetation such as pondweeds (*Potamogeton spp.*), spikerush (*Eleocharis palustris*), hardstem bulrush (*Schoenoplectus acutus*), cattail (*Typha latifolia*), and American three-square (*Scirpus pungens*). Low-lying basins or playas with irregular or short-duration flooding contain saltgrass or western wheatgrass (*Pascopyrum smithii*) or both. Narrowleaf cottonwood (*Populus angustifolia*), coyote willow (*Salix exigua*), and mountain willow (*Salix monticola*) are common along riparian areas in the valley floor.

Alluvial fans along the valley margins tend to be gravelly and support pinyon pine (*Pinus edulis*), Gambel oak (*Quercus gambelii*), needle-and-thread grass (*Stipa comata*), and short-grass steppe vegetation that reflect the greater precipitation and milder winter temperatures of this zone compared with the valley bottom. Many of the streams on these alluvial fans support riparian forests of narrowleaf cottonwood (*Populus angustifolia*), with shrub understories of willows (*Salix spp.*), western birch (*Betula occidentalis*), ocean spray (*Holodiscus discolor*), and wild rose (*Rosa woodsii*).

Vegetation of the Sangre de Cristo Mountains is typical of the southern Rocky Mountains, including mixed forests of Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*), occasional stands of white fir (*Abies concolor*) at lower elevations, and Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) at higher elevations. Aspen (*Populus tremuloides*) is present throughout the study area at elevations over 8,500 ft. (This section is summarized from Rocchio, 2004).

Stratigraphy

In the summer of 2006 we excavated four trenches (approximately 2–3 m deep and 5–7 m long and designated A through D) near the eastern end of the Mr. Peat pit, in order to better understand the depositional environments of the wetland deposits, the age of underlying fossil-bearing alluvial deposits, and the age and origin of overlying spring deposits (fig. F–3).

The wetland deposits are underlain by at least, but probably considerably more than, 3 m of poorly to moderately indurated, bedded fluvial sediments ranging from pebbly or gravelly sand (clasts commonly about 1 cm diameter, maximum 5–7 cm diameter) representing channel bed facies to finely laminated silt and clay channel-margin and overbank deposits (fig. F–4). The coarser grained layers and lenses are commonly iron stained, indicating postdepositional subsurface water throughflow. These fluvial sands underlie the wetland deposits in all four pits. The nature of the deposits and the geometry of the valley suggest that at the time of deposition, the valley was occupied by a sand-bed meandering river that headed in the Sangre de Cristo Mountains and flowed westward into the Rio Grande.

The wetland deposit overlies the fluvial sediment and has three main facies (fig. F–5). The lowermost of these comprise dark brown to black, mucky peat with abundant plant root, stem, and moss fragments, probably deposited in a shallow pond or lake environment with slow-moving or stagnant water. A fragment of *Salicaceae* (willow or cottonwood) wood was found in a sample of this unit (Puseman, 2006). The contact with the underlying fluvial deposits appears gradational in trench A but is relatively sharp in the other trenches.

Above the mucky peat is an orangish- to reddish-brown (5YR 4/4), “woody” peat that is composed almost entirely of fresh-appearing plant fragments. The contact with the underlying mucky peat is gradational except in trench A, in which the two units are separated by about 5 cm of grayish-brown, parallel-bedded silt.

A light to dark gray, low density, organic silt “black-mat” type of deposit overlies the woody peat in trenches A and B, and it overlies mucky peat in trench C. The contact between the underlying unit and the organic silt is generally sharp

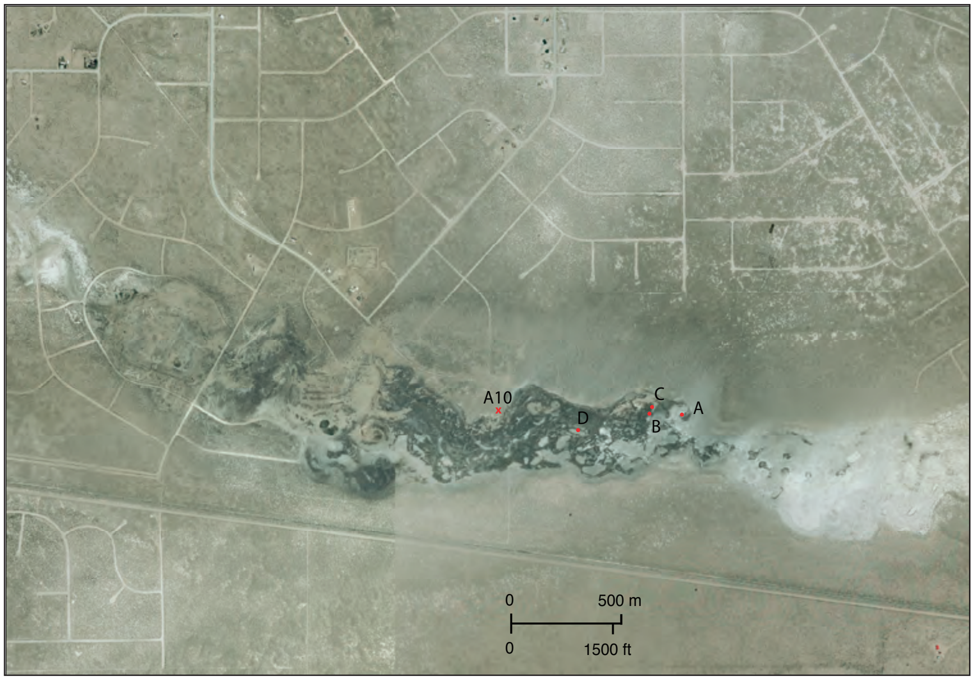

Figure F–3. Aerial photograph of the Mr. Peat deposit showing locations of trenches and stop A10.

and smooth. The silt is massive and blocky, with no visible bedding or other sedimentary structures, and it is composed largely of silt-sized quartz and feldspar grains (loess?) that are loosely cemented by organic matter. Numerous small, elongate white crystals, possibly calcite or gypsum, were also found in samples of this unit (MRP–A5, MRP–B4) (fig. F–4). This unit is commonly exposed at the surface, where it forms a topographically irregular surface marked by a subpolygonal pattern of desiccation cracks that are typically filled with windblown sand and silt (fig. F–6). Total organic carbon contained in a sample of this material (MRP–A5, fig. F–4), determined by coulometric methods, is approximately 8 percent, corresponding roughly to 15–20 percent organic matter in the unit. Organic-rich, mineral-matter-dominated layers accumulated in spring-fed environments have been termed "black mats" (Haynes, 1968, Quade and others, 1998), "sapropelic silt" (for example, Holliday, 1985), or "peaty mud" (for example, Safford, 1981). We use the term "organic silt" in this report as a generic, strictly descriptive term.

In the eastern (upstream) part of the valley, the peats are locally to widely overlain by tufa deposits. At the site of our trenching, the tufas are concentrated in round, domed mounds that are from 25 cm to as much as 1 m thick (figs. F–7 and F–8). Downstream, the tufas become thinner, less continuous, and more layer like, and they are absent altogether in the western part of the deposit. X-ray diffraction analysis of a tufa sample (MRP–A6, fig. F–4) indicates that it is composed almost entirely of calcite, with lesser amounts of intercalated quartz and feldspar, most likely introduced as windblown sand and silt (loess). A mantle of locally derived eolian deposits consisting of quartz and feldspar sands and of reworked fragments (typically granule size) of tufa and peat form a discontinuous cover over the entire area. Thickness of the eolian cover ranges from zero to as much as a meter. Eolian sand and silt commonly fills desiccation cracks in the surface of the organic silt layer and tufa mounds (fig. F–6).

Sample Analyses

Twelve samples from the Mr. Peat pit were submitted for radiocarbon dating: 2 from natural exposures and the remainder (10) from the 4 trenches (table F–1). The woody peats contained whole, fresh pieces of plant matter, which were hand picked after ultrasonic cleaning in distilled water. All of the remaining samples were separated by Kathy Puseman of Paleo Research Institute, Inc. (see chapter E in this volume). Each sample was added to approximately 3 gallons of hot water, stirred until a strong vortex formed, and then poured through a 150-micron mesh sieve. The process was repeated until all floating material was removed from the sample. The floated samples were weighed and then passed through a series of graduated screens to separate datable material and to sort the remains (Puseman, 2006).

Snail shell fragments were found in the tufa samples, whereas organic matter, wood fragments, or charcoal were concentrated from the remaining samples of organic silt and peat. All of the concentrated materials (organic and inorganic) were sent to the radiocarbon laboratory at Woods Hole Oceanographic Institute for accelerator mass spectrometry (AMS) radiocarbon dating. In addition, four samples of sand were collected for optically stimulated luminescence (OSL) dating of sediment that did not contain datable organic matter. The OSL ages were determined by Shannon A. Mahan (USGS).

Radiocarbon dating indicates that most of the peat deposits accumulated from 13.4 ka cal yr B.P. to about 11.3 ka cal yr B.P., but organic accumulation continued on until middle Holocene time (4.3–6.7 ka cal yr B.P.). The locally overlying tufaceous spring deposits started to accumulate at about 6.7 ka cal yr B.P. and continued until at least 3.9 ka cal yr B.P. (table F–1, fig. F–4), but carbonate-rich spring water was likely the major water source for the underlying organic silt deposits, as indicated by the abundant evaporite mineral fragments observed in samples of the organic silt. A thin peaty sand layer in the alluvium about 1.4 m below the base of the main peat layer in trench C (sample

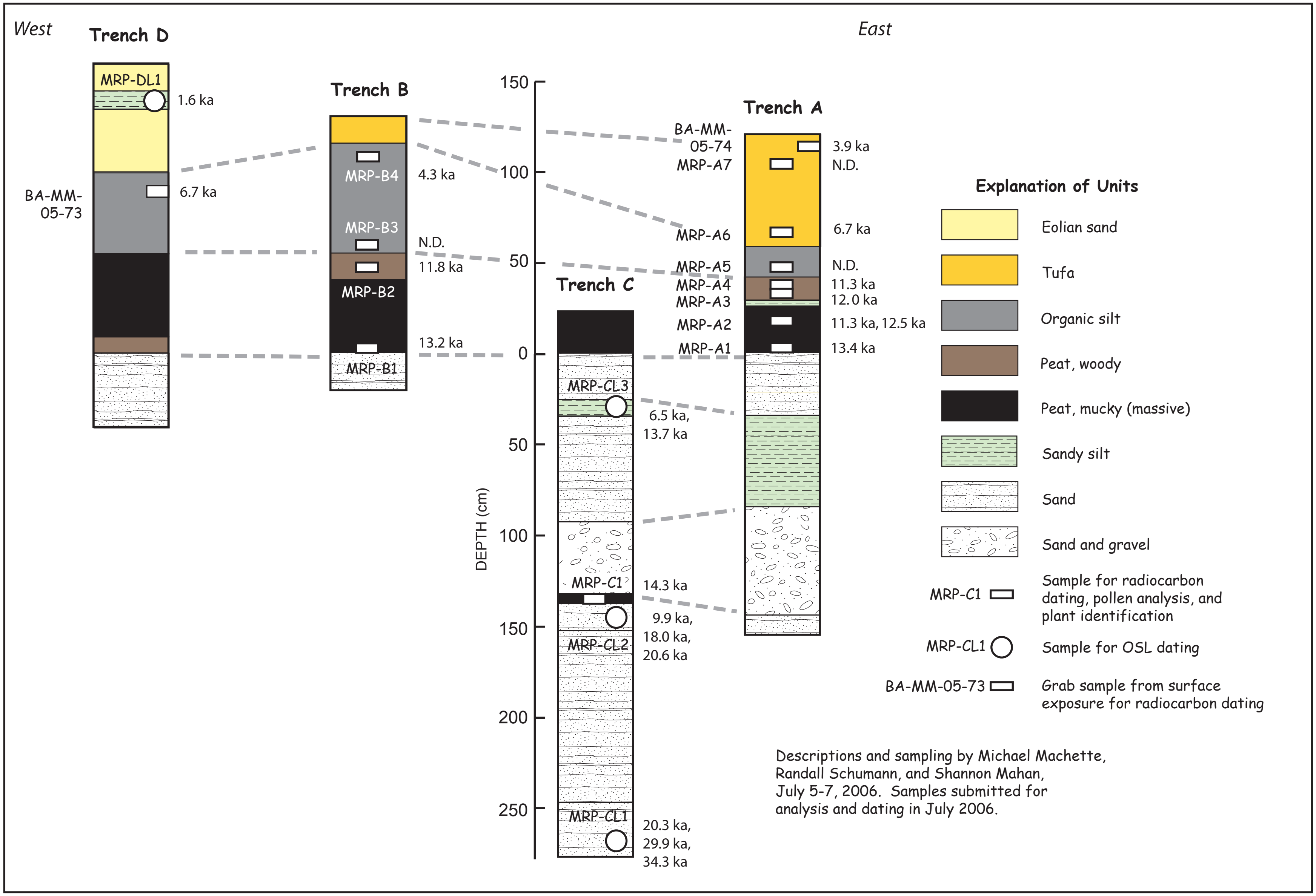

Figure F–4. Sampled stratigraphic sections at the Mr. Peat pit, Alamosa, Colorado. Radiocarbon and luminescence ages are in ka (thousands of years ago). Abbreviation: N.D., not dated.

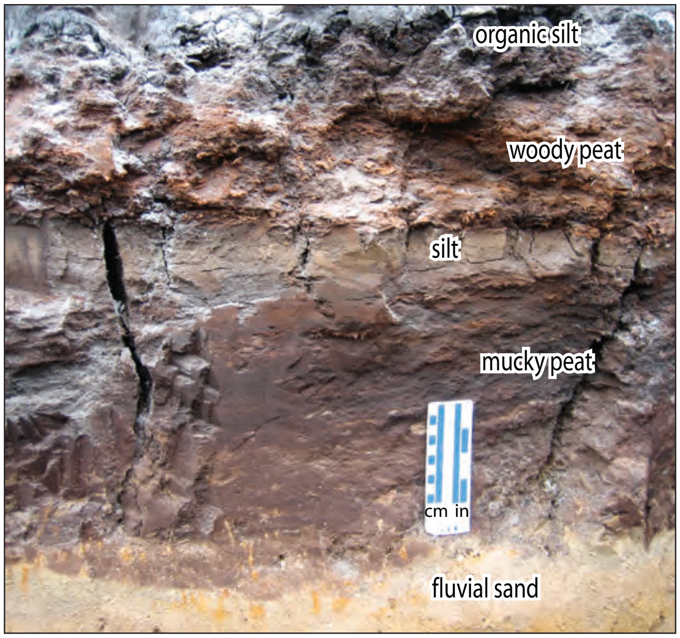

Figure F–5. Major units in trench A. Similar units are present in the other trenches. Each black bar at far left of scale is 1 cm; each black bar at far right is 1 in.

Figure F–6. Surface exposure of “organic silt” layer with eolian sand- and silt-filled desiccation cracks.

Figure F–7. Tufa mound at top of section in trench A. Each red or white section of tape measures 20 cm.

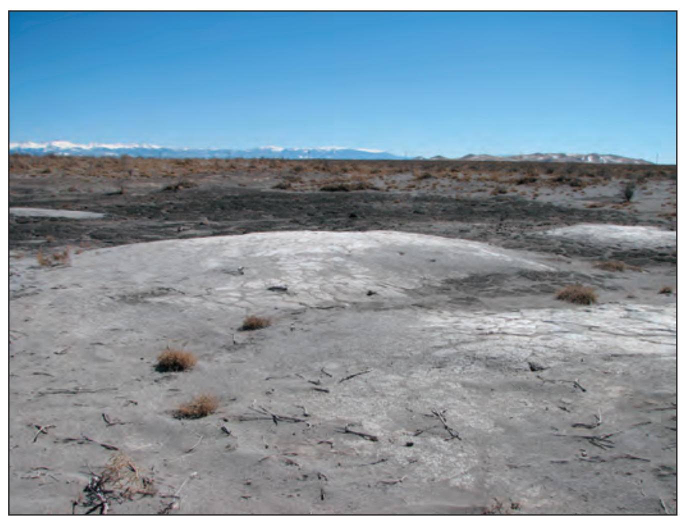

Figure F–8. Tufa mounds at surface near east end of the Mr. Peat pit.

Table F–1. Radiocarbon age determinations from samples collected at the Mr. Peat pit.

[Samples arranged in descending stratigraphic order (see fig. F–4). Reported radiocarbon ages have 1-sigma errors; calibrated ages (in calendar years) have 2-sigma errors. The radiocarbon ages were calibrated using the radiocarbon calibration program (CALIB REV. 5.1, 2005 of Stuiver and Reimer; see also Stuiver and Reimer, 1993)]

USGS sample number	Material dated	Depth	Date reported	NOSAMS accession number	$\delta^{13}C$	$\delta^{14}C$	Radiocarbon ages and errors (^{14}C yrs B.P.)	Calibrated ages and errors (cal yrs B.P.)	Ages used for discussion (ka)
BA–MM05–74	Snail shell in tufa	Grab sample	2/21/06	OS–53176	–6.72	–363.8	3580±30	3875±37	3.9
MRP–A6	Snail shell in tufa	53–60 cm	11/16/06	OS–57406	–7.25	–522.4	5880±45	6701±46	6.7
MRP–A4	Woody peat	80–85 cm	9/29/06	OS–56477	–28.93	–712.7	9960±40	11334±125	11.3
MRP–A3	Woody peat	85–90 cm	9/28/06	OS–56395	–27.9	–722.1	10250±55	12031±76	12.0
MRP–A2(2)	Moss in mucky peat	100–105 cm	12/7/06	OS–57712	–34.1	–711.6	9930±60	11322±82	11.3
MRP–A2(1)	Stems and roots in mucky peat	100–105 cm	12/6/06	OS–57672	–26.36	–733.2	10550±40	12436±35 12636±54	12.5
MRP–A1	Mucky peat	115–120 cm	12/7/06	OS–57714	–29.77	–766.2	11600±65	13428±80	13.4
MRP–B4	Organic silt	20–25 cm	1/4/07	OS– 57942	–26.15	–385.2	3850±85	4314±93	4.3
MRP–B2	Woody peat	80–85 cm	10/5/06	OS–56641	–27.53	–718.8	10150±55	11780±67 11915±59	11.8
MRP–B1	Mucky peat	125–130 cm	11/24/06	OS–57499	–25.8	–758.3	11350±45	13228±43	13.2
MRP–C1	Stems and roots in alluvium	155–160 cm	12/7/06	OS–57740	–27.82	–787.2	12350±60	14288±171	14.3
BA–MM05–73	Organic silt	Grab sample	3/22/06	OS–53707	–25.97	–522.2	5880±50	6700±49	6.7

MRP–C1) yielded an age of 14.3 ka cal yr B.P. (the oldest radiocarbon date reported for our samples), whereas luminescence dating of the alluvium in the same trench yielded both stratigraphically consistent and inconsistent ages depending on the method used (see table F–2*A*, *B*). For example, the OSL and infrared-stimulated luminescence (IRSL) analyses for sample MRP–CL–3 yielded ages of 6.5 ka and 13.7 ka average, respectively, yet the sand must date between 13.2 ka and 14.3 ka on the basis of radiocarbon analyses (table F–1). In this case, the IRSL dating approach yielded the better age. Likewise, dates from sample MRP–CL–2 range from 9.9 ka (OSL) to 20.6 ka (IRSL, table F–2), but they should be about 14.3 ka (see fig. F–4). Finally, sample MRP–CL–1 is dated at 20.3 ka (OSL) to 34.3 ka (IRSL), which is stratigraphically consistent with its position 2.8 m below the base of the peats (dated at 13.2 ka) (fig. F–4). Thus, the luminescence ages provide general limits on the latest Pleistocene fluvial sediment, and both methods yielded stratigraphically consistent (older with increasing depth) ages. However, the luminescence ages differ by method and are not consistent with the more conventional radiocarbon date of 14.3 ka.

In general, the radiocarbon dates are in proper stratigraphic order: the oldest dates come from the basal mucky peat and the youngest dates come from the organic silt and coeval tufa deposits. The young eolian sand that overlies peat and organic silt in trench D yielded an OSL age of 1.6 ka (late Holocene, table F–2).

Samples of organic-rich units in trenches A and B (samples MRP–A1 through A5, B1–B4; fig. F–4) were examined for pollen and microfossils by Robert S. Thompson (USGS). The samples from the mucky and woody peats contain abundant pollen from plants that flourish in wetland environments, including sedge and bulrush (Cyperaceae) and lesser amounts of shallow pond-type vegetation such as pondweed (*Potamogeton*). The mucky and woody peats also contain abundant sagebrush (*Artemisia*), saltbush (Chenopodiaceae/*Amaranthus*), ragweed (*Ambrosia* type), greasewood (*Sarcobatus*), and grass (Gramineae) pollen, indicating an open, xerophytic regional environment similar to that of today, but all of the samples contain moderate amounts of spruce (*Picea*) pollen as well, which may indicate that the climate of the valley floor was cooler and wetter than at present. Pine (*Pinus*) pollen is present in moderate amounts in all of the samples, suggesting its regional, but not necessarily local, presence. Pine pollen is relatively sturdy and can survive transport from distant sources better than many other types of pollen. The *Pinus* pollen in the organic silt sample is broken and fragmented, suggesting that either the organic silt has been highly reworked or that the pollen has been transported from a distance. The organic silt layer, which is typically above the more organic peats, does not contain abundant wetland plant pollen. However, a significant number of *Pseudoschizaea* microfossils were found in sample MRP–A5 from this unit, indicating that the organic silt accumulated in a warm, wet environment, possibly with seasonal drying (Scott, 1992).

Discussion and Conclusions

On the basis of these studies, we suggest that during the late Pleistocene, glacier- and snowmelt-runoff-fed streams flowing west into the Rio Grande entrenched and backfilled valleys. By about 20,000 years ago, these stream channels had aggraded to within 5–10 m of the surface of the piedmont through which they incised. A shift from deposition of fluvial sand and gravel to wetland deposits suggests that the surface stream ceased flowing at about 13.5 ka years ago (indicated by radiocarbon dates at the base of the wetland deposits). High water tables on the piedmont intersected the paleostream valley and probably caused persistent spring discharge that might have been localized by faulting in the underlying fine-grained sediment of the Alamosa Formation. The mucky-peat unit likely accumulated in a sluggish or stagnant water environment, with pondweed and bulrush vegetation suggesting that the paleovalley was a shallow pond or lake at the time. This environment persisted for approximately 1,000 years, giving way to a peatland environment (the woody peat facies) in which the ground was probably perennially saturated but not necessarily submerged.

Peat accumulation ceased approximately 11,000 years ago, suggesting a shift from submerged or perennially saturated wetland to a “wet meadow” that may have been seasonally dry in some years. A drying of the valley floor would have allowed mobilization of eolian sand and silt (probably derived from glacial outwash), which was blown into the wetland, but organic matter continued to accumulate owing to the input of spring water. This wetland would have been an ideal feeding and watering area for large mammals such as bison and mastodon and thus a likely hunting and camping site for early humans. Mastodon tooth and tusk fragments were found at the Mr. Peat site, and many early human campsites from the Folsom period have been identified in the San Luis Valley (Jodry and others, 1989; see also stop B5).

The presence of evaporites in the organic silt suggest that during this period the local water table may have been at or above the ground surface at some times and in the shallow subsurface at others. It is also possible that the evaporite crystals in the organic silt may have formed later if the water table remained high enough for the deposit to remain perennially wet until much later. Pollen analysis of sediments from Como Lake in the Sangre de Cristo Mountains indicates that regional treeline rose to a level approximately 200 m higher than at present about 11,000 years ago in response to significant climatic warming (Jodry and others, 1989). Additional pollen records from Head Lake, on the valley floor, suggest that the regional water table remained high until at least 9,500 years ago, probably owing in part to increased summer precipitation during this period (Jodry and others, 1989). A warmer climate would have reduced winter snowpack and glacier extents, curtailing streamflow, whereas increased summer precipitation in the valley may have helped to keep the water table high in the valley-fill sediments.

Table F–2. Gamma spectrometry, cosmic and total dose rates, equivalent doses, and ages for samples from the Mr. Peat pit, Alamosa, Colorado. *A*, Data for blue-light optically stimulated luminescence (OSL) dating of fine sand grains (250–180 micron) using the single-aliquot additive dose (SAR) technique. *B*, Data for infrared-stimulated luminescence dating (IRSL) of polymineral, fine silt grains (4–11 microns) using the multiple-aliquot additive dose (MAAD) technique.

[Samples arranged in descending stratigraphic order (see fig. F–4)]

A

Sample number	Unit and trench	K (percent)	Th (ppm)	U (ppm)	Water content[a] (percent)	Cosmic dose rate[b] (Gy/ka)	Total dose rate[c] (Gy/ka)	De[d] (Gy)	N[e]	Age (ka)
MRP–DL–1	Coppice dune, trench D	0.50± 0.03	1.45± 0.10	0.61± 0.04	10±1.0	0.40±0.04	1.01±0.04	1.72± 0.07	26 (35)	1.6±0.1
MRP–CL–3	Upper bed, trench C	2.73± 0.07	7.36± 0.32	2.72± 0.11	9±1.0	0.32±0.04	3.52±0.08	22.7± 0.95	24 (30)	6.5±0.3
MRP–CL–2	Middle bed, trench C	2.73± 0.12	7.08± 0.23	2.54± 0.11	10±1.0	0.27±0.03	3.42±0.07	33.9± 1.47	18 (20)	9.9±0.5
MRP–CL–1	Lower bed, trench C	2.99± 0.09	5.22± 0.22	1.57± 0.10	4±0.5	0.23±0.03	3.45±0.08	69.8± 1.71	27 (35)	20.3± .7

B

Sample number	Unit and trench	K (percent)	Th (ppm)	U (ppm)	Water content[a] (percent)	Cosmic dose rate[b] (Gy/ka)	Total dose rate[c] (Gy/ka)	De[d] (Gy)	Age (ka)
MRP–CL–3	Upper bed, trench C	2.73± 0.07	7.36± 0.32	2.72± 0.11	9±1.0	0.32±0.04	4.75±0.10	65.6±2.09	13.6±0.9
									13.8±0.9
MRP–CL–2	Middle bed, trench C	2.73± 0.12	7.08± 0.23	2.54± 0.11	10±1.0	0.27±0.03	4.59±0.09	94.5±3.67	18.0±1.1
								82.5±2.78	20.6±1.5
MRP–CL–1	Lower bed, trench C	2.99± 0.09	5.22± 0.22	1.57± 0.10	4±0.5	0.23±0.03	4.36±0.10	130±4.50	29.9±1.6
								149±4.90	34.3±1.8

[a]From field moisture; ages based on 15–20 percent moisture content (except DL1, measured at field moisture of 10 percent), mid-way between field and saturation moisture values.

[b]Cosmic doses and attenuation with depth were calculated using the methods of Prescott and Hutton (1994).

[c]Total dose rate based on 15–20 percent water content (except –DL1, measured at 10 percent).

[d]Reported at 1-sigma error, fit to exponential and linear regression curves, and calculated as a weighted mean.

[e]Number (N) of replicated equivalent dose estimates (De) used to calculate the mean. Second number is total measurements made including failed runs with unusable data.

Radiocarbon dates from samples of the organic silt and the tufa indicate that accumulation of the two units was essentially coeval. Although the tufa deposits are stratigraphically above the organic silt layer in the trenches we excavated, the tufas are not laterally continuous; they occur as localized mounds at points of spring discharge. Westward (downstream) of the tufa mounds, the organic silt is stratigraphically the uppermost unit, except where it is locally covered by younger eolian deposits (fig. F–4). The youngest sample of tufa we collected was a surface grab sample from the vicinity of trench A, dated at approximately 3875 cal yr (table F–1), indicating that springs continued to flow until at least that time. Ground-water levels probably lowered gradually in response to arid climatic conditions, but they also may have been responding to a local lowering of base level as the nearby Rio Grande River entrenched into the valley floor sediments. Ground-water withdrawals for irrigation, which began in the middle 19th Century but became quite large by the 1950s, probably accelerated lowering of the regional water table to its current level and was thus the final factor responsible for dewatering of the wetland.

Seasonally high water tables appear to have persisted in the vicinity of the Mr. Peat wetland deposit well into the 20th Century. A series of aerial photographs from the late 1930s and 1941 show standing water on the meadow surface (fig. F–9), and a description from a soil survey in which observations were made during the 1960s notes that the peat is "normally moist in the upper 2 to 3 feet" and "the water table is in the sand substratum" (Pannell and others, 1973). At that time the surface vegetation was described as mostly sedges and rushes, and the land was used for grazing; prior to the 1960s, it was used to grow hay (Pannell and others, 1973). Orthophotographs from the soil survey, flown in 1969, show that the site was used as a meadow or pastureland at that time. Another aerial photograph from 1985 depicts the postmining surface of the Mr. Peat deposit. These photographs broadly bracket the period of peat mining as beginning no earlier than 1970 and essentially ending no later than 1985. A comparison of the aerial photographs in figure F–9, combined with on-the-ground observations, indicates that the western part of the deposit was most extensively mined. The topmost soil layer was either scraped off during mining or is, in fact, the "organic silt" layer, which compacted and cracked as it dewatered.

Acknowledgments

Thanks are due to Shannon Mahan, Bob Thompson, Dan Muhs, Laura Strickland, Richard Pelltier, Gary Skipp, and Josh Freeman, all from the USGS in Denver, who analyzed samples, made helpful comments and suggestions, and contributed data to this report. All but the hand-picked carbon samples were separated by Kathy Puseman of Paleo Research Institute, Inc., (Golden, Colo.). Mr. Adrian Absmeier (Alamosa, Colo.) very kindly allowed us access to the property. In addition, we appreciate the constructive and helpful comments of James Otton (USGS) and Robert Thompson (USGS), who reviewed a preliminary version of this manuscript. However, any errors that may remain are the responsibility of the authors.

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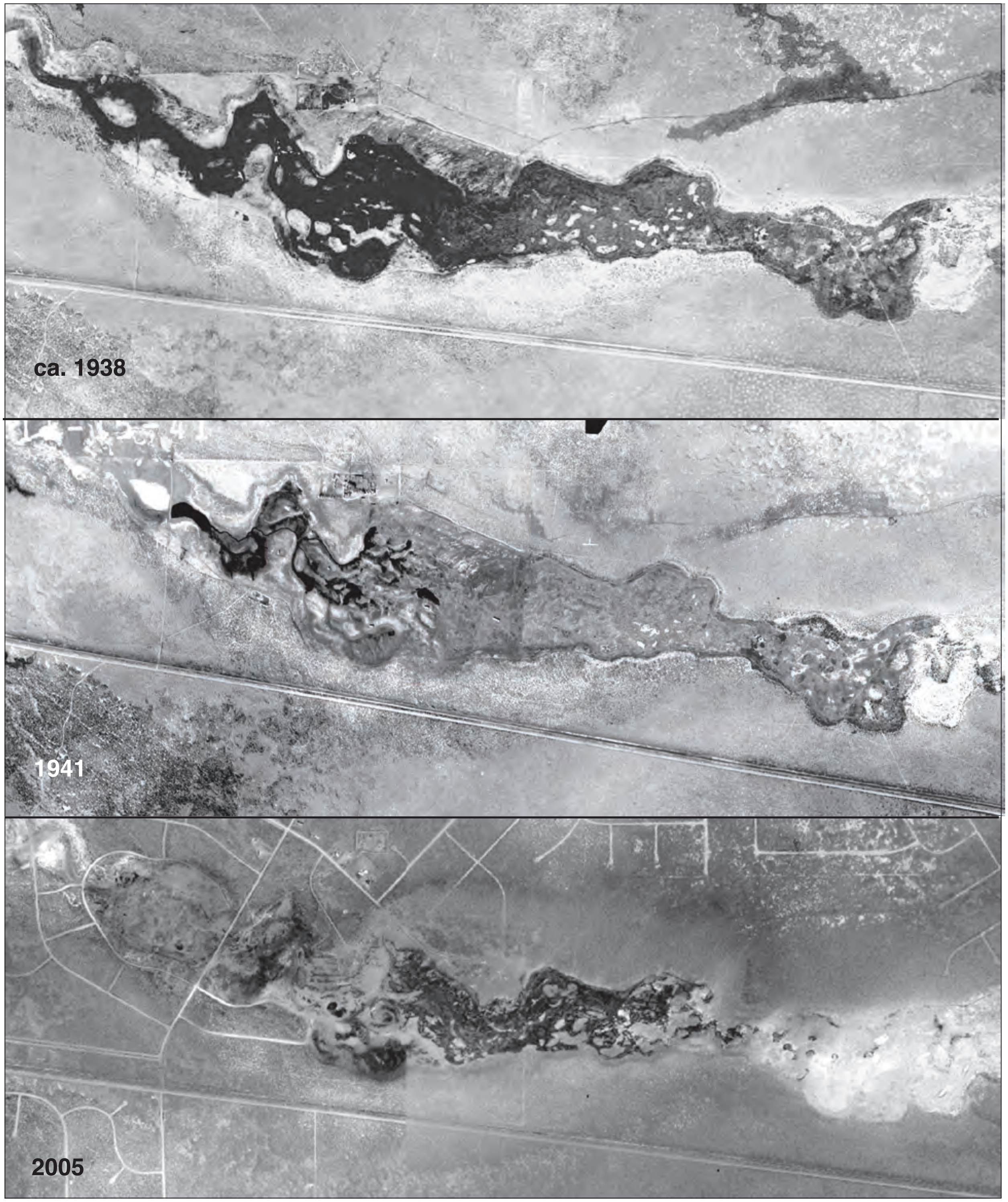

Figure F–9. Aerial photographs of the Mr. Peat deposit showing premining (ca. 1938, 1941) and postmining (2005) surfaces of the deposit. Darkest areas on the earlier two photographs appear to be standing water, whereas the dark areas on the lower photograph are the dry surface of the organic silt layer. USDA Soil Conservation Service photographs date from 1938, and 1941; 2005 photograph from USDA National Agriculture Imagery Program (NAIP). East-west width of each photograph is roughly 3 km.