3296

Mehringer + Warren, 1976

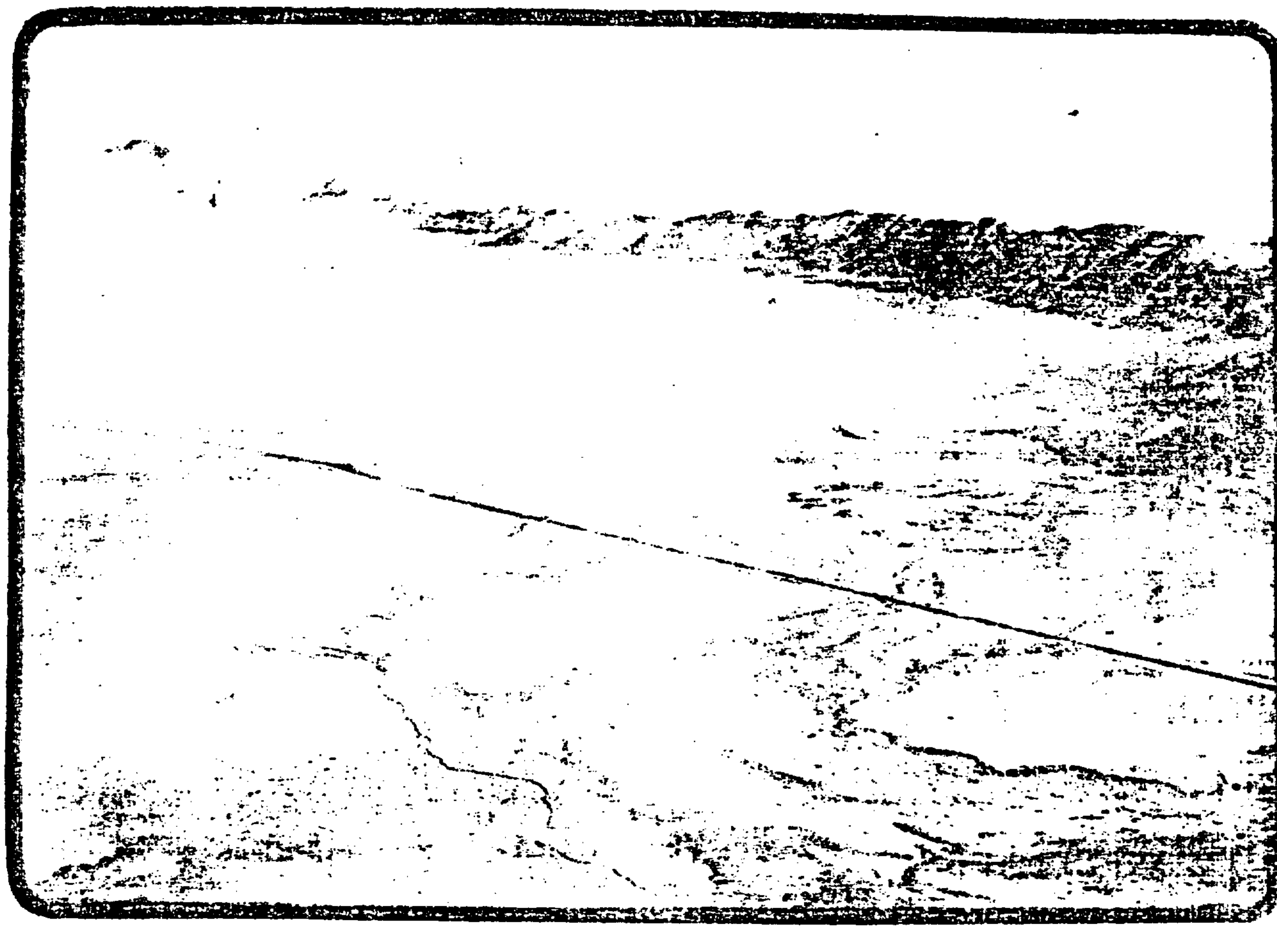
NEVADA ARCHEOLOGICAL SURVEY

RESEARCH PAPER NO. 6

JULY, 1976 RENO

3296

HOLOCENE ENVIRONMENTAL CHANGE IN THE GREAT BASIN



EDITED BY ROBERT ELSTON

MARSH, DUNE AND ARCHAEOLOGICAL CHRONOLOGY, ASH MEADOWS, AMARGOSA DESERT, NEVADA

By

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INTRODUCTION

Little is known about the post-pluvial paleoecology of the Death Valley region, primarily because of the apparent lack of well-preserved fossils in association with stratigraphically controlled and radiocarbon datable materials. However, studies of fossil records and their stratigraphic associations in the Las Vegas Valley, Nevada (Haynes 1967, Mehringer 1967a, figs. 33,34), illustrate that desert spring deposits yield datable evidence of past climates and associated phenomena. Spring-fed salt marshes are common features of the Great Basin Desert, and initial sampling of their fossil records led to the assumption that they too would be amenable to study by standard paleolimnological methods.

Research on the history of spring-fed salt marshes was begun by studying the sediments and pollen records of cores collected in Panamint Valley, Death Valley, and Soda Lake, California. Later the study was expanded to include Ash Meadows, Nevada, where the stratigraphic association of peats and other marsh sediments with dune sand provided an unusual opportunity to study dune history. Charcoal from dune campsites also furnished radiocarbon dates that contributed to the cultural, as well as to the marsh and dune, chronology of the Death Valley region.

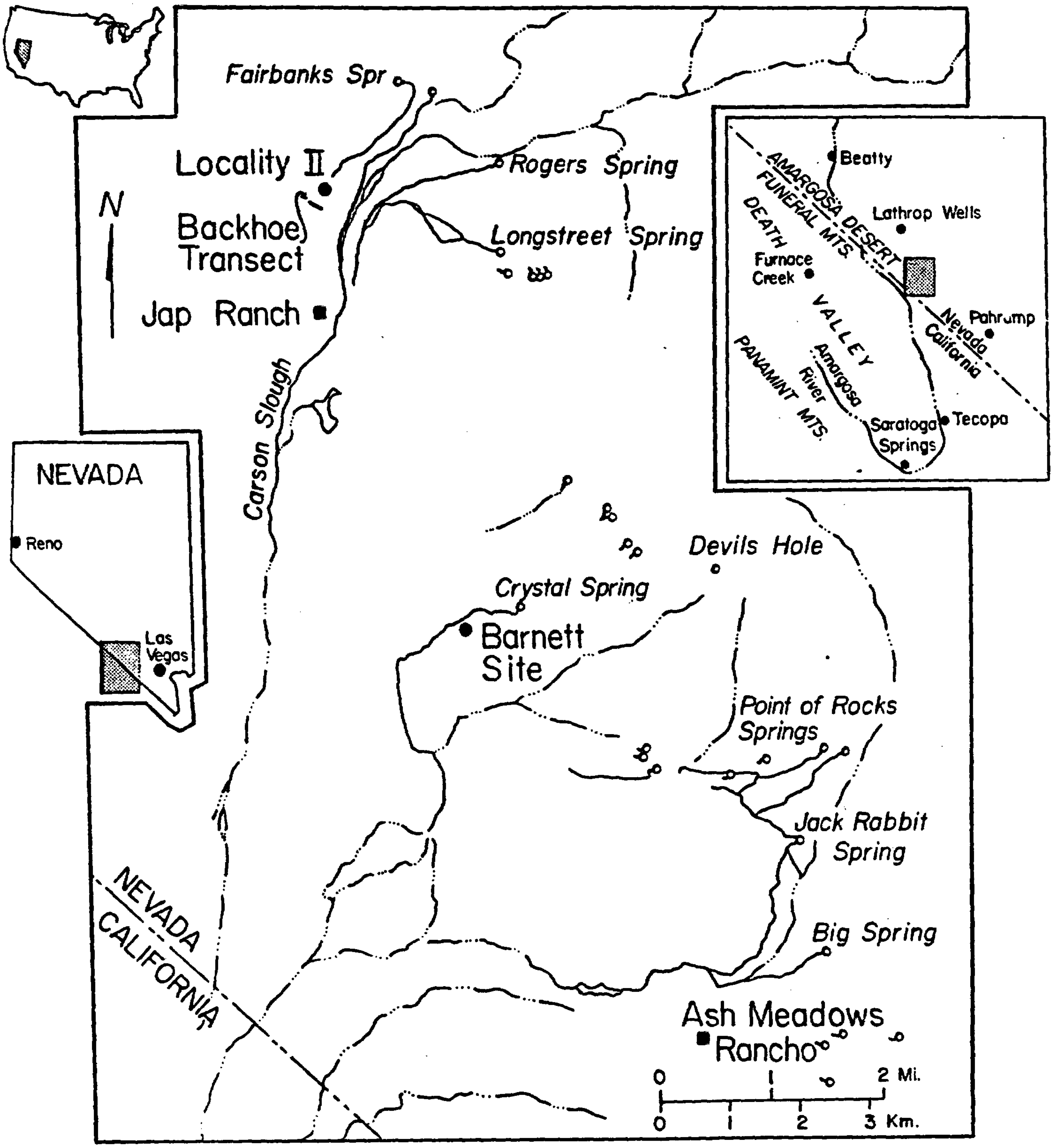

Figure 1. Map of the study area.

STUDY AREA

Ash Meadows is an area of considerable archeological, biological and geological interest. The name is said to have been derived from either the ashen color of the calcareous ground or the local abundance of native ash trees. Its unusually large springs and marshes support a variety of endemic desert minnows (Miller 1950) and are rich in ethnographically important resources. Most of this water is derived from interbasin ground water flow through a Paleozoic carbonate aquifer (Winograd 1971). Extensive mesquite groves (Prosopis pubescens), supported by a shallow water table, provide cool shade on the hottest summer days. Ash Meadows is a green oasis in one of the otherwise hottest and driest areas of North America.

All Ash Meadows dune and marsh localities discussed are within the Ash Meadows 15-minute Quadrangle between 650 and 700 meters elevation. Most field work was conducted in the former drainage from Fairbanks Spring extending to the arroyo south of Jap Ranch, and in the drainage from Crystal Spring (Fig. 1). The more important localities mentioned in the text are:

1. Ash Meadows, Carson Slough Locality II (N1/2 SE1/4 SW1/4 NW1/4, sec. 16, T. 17 S., R. 50 E.) is near the northern limit of peat mining in a marsh formerly fed by Fairbanks Spring. It includes three pits, within 15 meters of each other, that provided stratigraphic sections, microfossils and radiocarbon dates.

2. Ash Meadows, Carson Slough, Backhoe Transect (NW1/4 SW1/4, sec. 16, T. 17 S., R. 50 E.) refers to a series of ten short backhoe trenches placed across the mined peat marsh, from the eastern edge of the marsh (Trench 10) westward through the dunes and flats beyond to approximately the west boundary of section 16 (Trench 1). The transect, approximately 30° north of west, was determined by the prior existence of a leveled area through the dunes. Previous removal of dune sand permitted the backhoe to reach underlying peat deposits.

3. The Jap Ranch arroyo (NW1/4 SE1/4 SW1/4, sec. 21, T. 16 S, R. 50 E.) is about 500 meters southeast of Jap Ranch. This location refers to the west arroyo wall that served as the typical stratigraphic section and provided a radiocarbon date. Before filling during field leveling, the arroyo was a major drainage receiving spring discharge and runoff from a playa 12 kilometers to the northeast.

4. The Barnett Site (SW1/4 NE1/4 SE1/4 NW1/4, sec. 3, T. 18 S., R. 50 E.) is about 650 meters southwest of Crystal Spring. The Barnett Site is used as a reference point for other localities in its general area.

CHRONOLOGY

The chronology for the Ash Meadows area is based on radiocarbon dating and stratigraphic relationships. Radiocarbon dating presented two specific problems:

1. Dating of whole peat samples from desert salt marshes proved unreliable for establishing the age of marsh deposits. Initial dating of whole peat in Panamint Valley resulted in ages that were much too young. Observations of root systems of living marsh species revealed that roots of Scirpus olneyi, the major peat former, penetrated to greater than two meters below the surface. Most buried salt marsh peats that we have observed in the Great Basin contain these younger roots. To avoid rootlet contamination, all Ash Meadows peat dates are derived from fossil Scirpus seeds separated by wet screening and sorting.

2. Most Ash Meadows deposits lack organic carbon suitable for radiocarbon dating. However, they may contain molluscs that furnish carbonate dates. The "old" waters from Ash Meadows springs (Grove et al 1969), resulting from Pleistocene-age water and/or older carbonate from Paleozoic limestones, may result in contamination of molluscan carbonate. To establish criteria for use of molluscs, both living and fossil forms were dated. Fossil molluscs were selected from stratigraphic units containing or bracketed by dated seeds. The molluscan age studies are not yet completed; however, preliminary results indicate that depending on their habitat preferences, molluscs from marsh deposits date from 300 to 3000 years older than fossil seeds of equivalent stratigraphic position.

Charcoal, a third source of radiocarbon dates, was derived primarily from aboriginal hearths and burial pits. Charcoal lenses within dunes were also dated. They are assumed to be primarily the result of aboriginal burning even when not directly associated with artifacts. Ethnographic reports indicate that Great Basin Indians burned marshes to acquire small mammals (Hunt 1960). The practice is apparently an old one since charcoal is common to all marsh deposits studied.

Pleistocene Chronology

Denny and Drewes (1965: 32-33) suggested that the Ash Meadows basin sediments, including playa, spring and alluvial deposits, are primarily Pleistocene. They reported no evidence supporting the age or regional correlation, but noted a superficial similarity to deposits at Tecopa. In the Tecopa lake beds (dated by vertebrate fossils and tuffs) Pearlette-like ash, Type O, occurs stratigraphically above Bishop Tuff. Both tuffs are important time-stratigraphic markers in the western United States. The Bishop Tuff is radiometrically dated at about 700,000 years (Sheppard and Gude 1968; Izett et al 1970). Over a period of five years we examined many Pleistocene (?) outcrops of the Ash Meadows area without encountering specific evidence for their age. While the tuffs are easily recognized in the Tecopa beds, they were not found in Ash Meadows. The lack of vertebrate fossils is equally puzzling as they are quite commonly associated with late Pleistocene spring and marsh deposits in the Las Vegas Valley (Mawby 1967).

For lack of other data of regional chronological significance, some paleosols were examined in the process of other field work. Because of erosion, obvious paleosols were not often observed in natural exposures. However, a soil profile was observed in a backhoe trench placed through an erosional remnant that formed a knoll about 500 meters northwest of the Barnett Site. Standing water in the trench made in situ description impractical.

Continuous 10 cm bulk samples were collected from the surface to 1.80 meters; 20 cm samples were collected below 1.80 meters. Each sample was wrapped in a plastic bag to preserve its structure and moisture and returned to the laboratory for description. Kodachrome transparencies provided a stereoscopic view of the section for laboratory reference.

The profile (Table 1) is truncated with the B horizon exposed at the surface. The parent material is layered fine-grained playa (?) sediment including calcareous clay and silt with eolian sand and frosted pebbles. The deposit below 1.80 meters appears to be a clay-clast conglomerate with irregular rounded bodies of white clay surrounded by a darker matrix of slightly coarser sediment. The soil surface is stratigraphically older than Holocene sediments at the Barnett Site. It reflects an interval of surface stability and weathering that may be traceable within the Ash Meadows area and serve as a means of regional correlation. A soil is described as appearing above "Tuff A" in Tecopa lake sediments (Sheppard and Gude 1968).

An abandoned spring channel, most probably originating from Crystal Spring or an extinct spring with an outlet channel following approximately the same course, was seen in backhoe trenches about 150 meters northwest of the Barnett Site. The channel was filled with clean, well sorted, fine sand with dispersed molluscs. The channel cross sectional area appeared to be greater than that of the present Crystal Spring outlet channel. We had planned to map the channel at a future date, but upon returning found that the water table had risen and the trench walls had collapsed. The actual channel cross sectional area was never determined. It is mentioned here because:

1. The channel could be of Pleistocene age. The only direct chronological controls are stratigraphic relationships with the Barnett Site and the previously mentioned paleosol developed on playa deposits. The channel is stratigraphically younger than the soil and older than occupation of the Barnett Site.

2. Regardless of its age, the cross sectional area should be indicative of former spring discharge. Also, channel cutting, filling and abandonment are suggestive of changes in stream competence.

The vegetation of Ash Meadows during the last pluvial period (22,000-12,000 years ago) must be extrapolated primarily from other regional paleoecological studies (Mehringer 1967a, b; Mehringer and Ferguson 1969; Wells and Berger 1967). Only one Ash Meadows Pleistocene fossil plant locality has been radiocarbon dated. An ancient packrat midden, collected from a limestone (Bonanza King Formation) rock shelter, about 2.7 kilometers east of Point of Rock Springs (NW1/4, sec. 9, T. 18 S., R. 51 E., Death Valley 1/250,000 series) at about 765 meters elevation, contained twigs and seeds of Utah juniper (Juniperus osteosperma) dated at 13,150±500 BP. (I-4237). Juniper does not now usually occur at elevations below 1700 meters on the small isolated limestone mountains of southern Nevada. The presence of junipers at 765 meters in Ash Meadows indicates a pluvial depression of xeric juniper woodland by about 1000 meters.

TABLE 1

Soil Profile from a Knoll about 500 Meters Northwest of the Barnett Site*

Soil Horizon	Depth Meters	Description
A11:	0.00-0.03	Light brown (7.5YR 6/4D) to light yellowish brown (10YR 6/4M) clay; weak fine platy structure; hard when dry, very sticky and very plastic when wet; many fine discontinuous random exped open vesicular pores; strongly effervescent in dilute HCl; salt efflorescence on ped surfaces; abrupt smooth boundary.
A12:	0.03-0.30	Pinkish gray (7.5YR 7/2D) to brown (7.5YR 5/4M) sandy clay; moderate to strong subangular blocky breaking to weak fine granular structure; very hard when dry, very sticky and very plastic when wet; many fine to medium continuous random exped dendritic interstitial pores; strongly effervescent; salt efflorescence on ped faces; clear smooth boundary.
B21:	0.30-0.40	Pinkish gray (7.5YR 7/2D) to light brown (7.5YR 6/4M) clay loam; moderate to strong coarse to medium angular blocky breaking to moderate medium subangular blocky structure; very hard when dry, extremely firm when moist, sticky and very plastic when wet; many very fine and fine, and few medium continuous random inped dendritic tubular pores; strongly effervescent; salt efflorescence on ped surfaces; clear smooth boundary.
B22t:	0.40-0.70	Light brown (7.5YR 6/4D) to light yellowish brown (10YR 6/4M) clay loam; strong medium prismatic breaking to moderate medium angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet, somewhat brittle; many very fine and fine continuous inped and exped tubular pores; few to common thin to moderately thick ped face clay films, common to many moderately thick clay films lining pores; strongly effervescent; clear smooth boundary.

*The knoll is in the SW 1/4, NW 1/4, NW 1/4, sec. 3, T. 18 S., R. 50 E. The soil was described by Jonathan O. Davis, following the Soil Survey Manual (Soil Survey Staff, 1951).

TABLE I (Continued)

Soil Horizon	Depth Meters	Description
Cca:	0.70-0.90	White to light gray (2.5Y 8/1D, 7/2M) silty clay loam; weak coarse prismatic breaking to weak medium subangular blocky structure; firm when moist, sticky and plastic when wet; many micro to medium continuous inped simple tubular pores; violently effervescent; clear smooth boundary.
C:	0.90-1.40	White (2.5Y 9/1D, 8/2M) sandy silt loam; massive (possibly breaking to weak moderate subangular blocky structure); slightly hard when dry, firm when moist, sticky and plastic when wet; common micro to fine continuous simple tubular pores; strongly effervescent; sand is well sorted, well rounded, frosted quartz; clear smooth boundary.
	1.40-1.80	White (2.5Y 9/1D, 8/2M) gravelly sandy clay to gravelly sandy clay loam; massive (possibly breaking to weak medium subangular blocky structure); hard when dry, firm when moist, sticky to very sticky and plastic to very plastic when wet; common micro to fine continuous horizontal simple tubular pores; strongly effervescent; pebbles are angular frosted quartzite; clear smooth boundary.
	1.80-2.60+	White (2.5Y 9/1D&M) clay clasts in a light gray (2.5Y 7/2D, 6/2M) silty clay matrix: Clasts: Weak fine platy structure (plates in adjacent clasts are not parallel): hard when dry, firm when moist, very sticky and very plastic when wet; common very fine and fine continuous exped simple tubular pores; many thin clay films lining pores; strongly effervescent above 220 cm., no reaction below; clasts have rounded irregular shapes, about 5 cm. in diameter; very abrupt irregular boundary. Matrix: Strong fine granular structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine continuous exped and inped simple tubular pores; many thin clay films lining pores; slickensides on ped faces; very slightly effervescent above 220 cm., no reaction below.

Archeological Chronology

Occupational chronology in Ash Meadows is important because no other sites within the Amargosa drainage, including those in Death Valley, have previously been radiocarbon dated; yet their occupations have been used chronologically. Because Death Valley III sites are found in dunes that overlie evidence for a 9-meter deep lake in Death Valley, Hunt (1960) has suggested a moist period prior to 2000 years ago with dune formation apparently following shortly thereafter. This chronology was also used to estimate rates of tilting in Death Valley (Hunt et al 1966).

Use of human occupation and artifacts to date climatic or geologic events is obviously complex. It is apparent from radiocarbon dating in Ash Meadows that dunes have been sporadically active over the last 5000 years, but, with the exception of a single quartzite flake embedded in vesicular carbonate (Backhoe Transect, Trench 1; 2.80 m depth) artifacts were not recovered and hearths are apparently rare in dunes radiocarbon dated at >2000 BP. However, seven radiocarbon dates from hearths in dunes at Corn Creek, Las Vegas Valley, range from 5200±100 to 4030±100 BP. Three of the dates are from hearths exposed by deflation (Williams and Orlins 1963). Prehistoric inhabitants of the Death Valley area may have used dune campsites less often before Death Valley III times for cultural reasons unrelated to the presence of dunes. In any case, artifacts in a dune give only a minimum age for its initial formation.

The Barnett Site (Muto, Mehringer and Warren, in press) was first brought to our attention by Mr. Russell Hulse who made a surface collection while fields were being leveled. The site lacked pottery but contained artifacts typical of Hunt's (1960) Late Death Valley II stage, including Humboldt Basal Notch projectile points. Several radiocarbon dates on charcoal from burial pits and associated midden averaged 1950±100 BP (A-1015, A-1020, A-1021, A-1023, A-1024, A-1025). Prior disturbance precluded exact stratigraphic control. However, several observations were possible:

1. The site was primarily located on an erosion surface beneath a dune.

2. Burial pits had been dug through the eroded and weathered surface into marsh sediments.

3. The pits had been burned with mesquite wood (*Prosopis*) prior to their use for interment.

Two dates were obtained from an extensive occupation area southwest of the Barnett Site (E1/2 SE1/4, Sec. 9, T. 18 S., R. 50 E). The first (Fig. 2), although lacking direct association with diagnostic artifacts, is from an area with many exposed sites containing Virgin Branch Ansazi pottery and artifacts typical of Hunt's (1960) Death Valley III stage. It was dated at 1280±110BP (A-1016), and gives a minimum age for initiation of dune formation and a maximum age for deposition of approximately four meters of overlying sand. The second hearth was dated because of its direct association with Paiute pottery; the date of 220±100 BP (A-1137) indicates use of dune campsites in recent pre-contact times.

Figure 2. Charcoal lens in dune (October 1968). The lateral extent of charcoal, dated at 1280±110 BP (A-1016), is delimited by trench shovels (handle length 0.50 meters). Note the prehistoric campsite debris deflated to a hard surface that lies stratigraphically beneath the dune remnant (view to the northeast.

One other date, 440±280 BP (A-1161), is not directly associated with artifacts but most probably resulted from occupation on, and working of charcoal a few centimeters downward into, a weathered surface within a dune. The weathered zone was exposed in a backhoe trench placed in dunes (SW1/4 SE1/4 SW1/4 NW1/4, sec. 3, T. 18 S., R 50 E) formally located about 400 meters west of the Barnett Site. Below the weathered zone no charcoal or artifacts were observed, while above it Paiute and historic artifacts were common. The date most probably applies to occupation on a surface separating two distinct periods of sand accumulation. The surface, where observed, is gently sloping. Thus, weathering occurred on dune sand after an older dune was reduced to low relief. A report on salvage excavations and artifact inventories for the sites mentioned here is in preparation by C. N. Warren, P. H. Mehringer and A. Long.

CARSON SLOUGH MARSH AND DUNE DEPOSITS

Augering subsequent to commercial peat mining in 1966 revealed three buried peats east of the dunes in Carson Slough. Marsh draining and overburden removal during mining allowed a detailed study of the peat sequence (Figs. 3, 4). Stratigraphic control was established with test pits and backhoe trenches; radiocarbon dates provided chronological control. Apparently, older marsh and dune deposits are present below the water table, but additional heavy equipment and pumping would be required to expose and study sediments underlying those reported here.

Stratigraphy and Chronology

The Carson Slough sequence is most simply described as four peats separated by clay, silt and/or dune sand; the peats are designated by Roman numerals I through IV (Tables 2, 3, 4). The youngest, Peat IV, was removed to gain access to Peat III which was mined. Undisturbed remnants on the marsh perimeter were used to establish the stratigraphic positions of Peats III and IV. Three stratigraphic sections (Fig. 5) summarize the major features of marsh and dune deposits (Fig. 6) at the northern limits of peat mining (Locality II; Fig. 4), beneath the present dune (Backhoe Transect, Trench 5; Fig. 7), and west of the dune (Backhoe Transect, Trench 1).

All deposits, including the peats, contain some sand. The silty sands separating the peats are calcareous, clayey, and contain fossil molluscs. Clayey silt bands, shown as solid lines within the major stratigraphic units (Fig. 5), proved valuable as stratigraphic markers. These bands, east of the dune front, possibly resulted from flooding from the northeast at times when the historic arroyo draining that area was filled. Paired bands present in all Peat II exposures are traceable onto the former dune slip face. The position of the buried slip faces are recorded by peat deposits formed by plants that grew on the lower dune front, with their roots penetrating to the zone of saturation or capillary fringe. The distinct clayey silt bands east of the dune front (Table 4) probably resulted from local flooding, intermittent ponds, and/or brief rises in the Carson Slough water table.

TABLE IV

Description of Stratigraphic Section and Radiocarbon Dates, Carson Slough Backhoe Transect, Trench 5 (east face).

Depth Meters		Description	Depths and Radiocarbon Years BP
0.00-130		Light gray (10YR 7/1) dune sand; loose below 1.25 m, becoming hard and cemented above; approx. 1 m of dune overburden removed (see Table 5).	
1.30-2.00		Grayish black (N 2) peaty sand.	
2.00-2.77	Peat II:	Grayish black (N 2) to brownish black (5YR 2/1) hard, compact, fibrous peat; includes light olive gray (5Y 6/1) clayey silt bands (1 cm thick) at 2.36 and 2.42 m and grayish olive (10Y 4/2) fine sandy silt band (2 cm thick) at 2.70 m.	2.00-2.10, 3720±200 (A-1172) 2.30-2.40, 3740±100 (A-1173) 2.57-2.67, 3980±130 (A-1174)
2.77-2.87		Yellowish gray (5Y 7/2) silty sand.	
2.87-3.65	Peat I:	Grayish black (N 2) to brownish black (5YR 2/1) hard, compact, fibrous peat; includes light olive gray bands (5Y 5/2) clayey silt bands (1 cm thick) at 3.10, 3.40 and 3.47 m. Base of peat observed at 3.65 m, silty sand beneath not observed in section.	2.90-3.00, 4450±110 (A-1175) 3.25-3.40, 4810±80 (A-1176) 3.55-3.65, 5320±70 (A-1177)

Figure 3. Site of peat mining south of Fairbanks Spring (February 1968). A large marsh was drained and up to 2 meters of peat removed (view to the northeast).

Figure 4. Carson Slough, Locality II (February 1968). Peat III was exposed at the surface after removal of about 50 centimeters of overburden. This surface is now covered by a tamarisk thicket. The dune ridge in the midground, partially obscured by the litter of peat mining, covers the peats encountered in the backhoe trenches (view to the west).

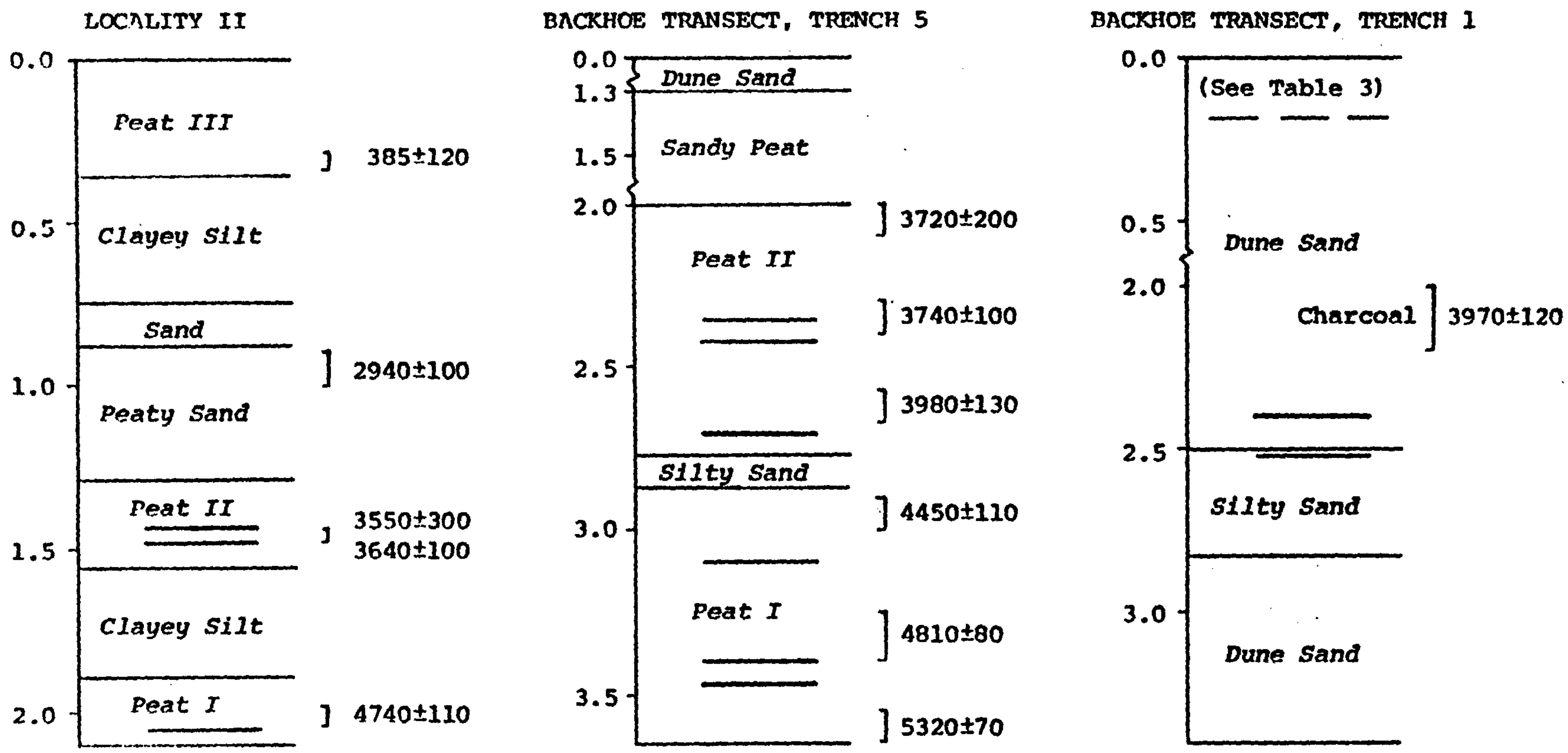

Figure 5. Summary of three stratigraphic sections and radiocarbon dates (see Tables 2, 3, 4).

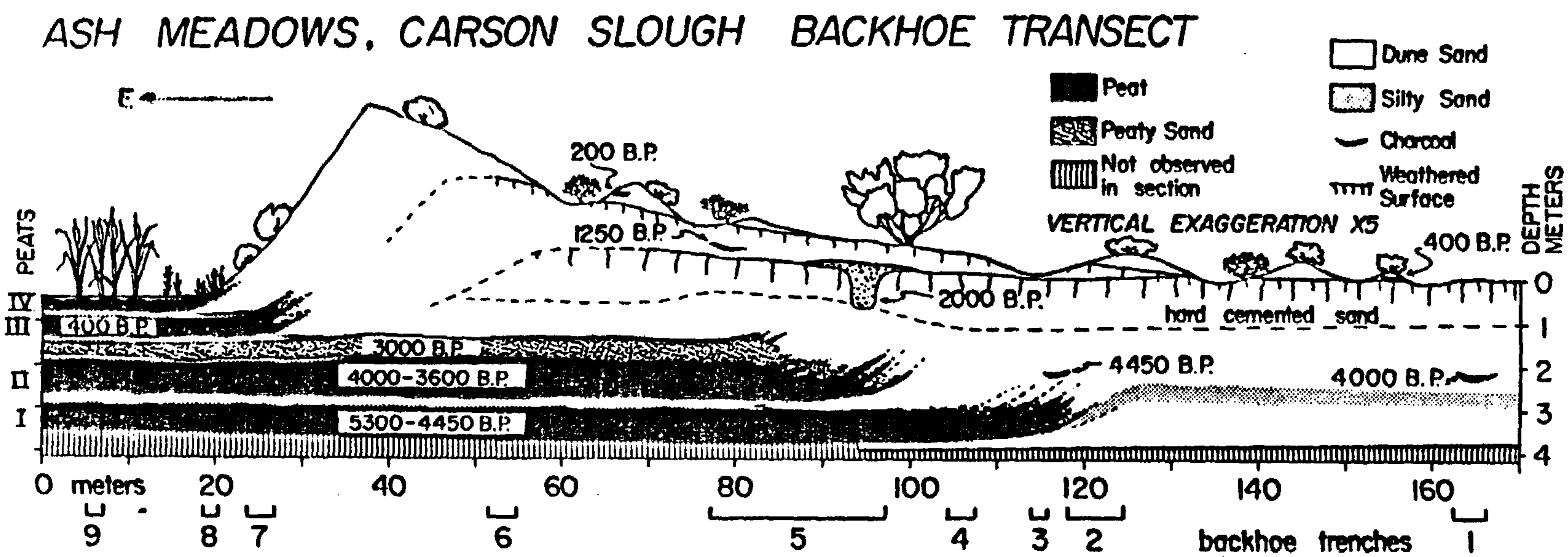

Figure 6. Generalized stratigraphic section showing the association of radiocarbon dates, and marsh and dune deposits.

Figure 7. Carson Slough, Backhoe Transect (August 1971). The photograph was taken from Trench 4 toward the east. Trench 5 is visible in the foreground; note the peat in the backdirt. The tamarisk trees in the midground mark the former marsh area east of the dunes. These trees invaded and formed a dense thicket over 2 meters tall within four years following peat mining.

Figure 8. Weathered surfaces (see Table 5) in dune 3 meters north of Carson Slough Backhoe Transect, Trench 5 (April 1972). The [illegible] meter of the section

The silty sand extending westward from Trench 2 is stratigraphically equivalent to the lower part of Peat I. It is calcareous and contains abundant snails. Snails would have thrived there and would have been preserved only if the water table was at that level just prior to or during their burial by sand. Thus, formation of Peat I was apparently initiated prior to establishment of the steep slip face near the westward limit of peat formation. Eastward dune migration followed while peat was still being deposited and buried the dispersed charcoal exposed in the east face of Trench 2. This charcoal, dated at 4450+360 BP (A-1269), included a burned seed and seed fragments of Prosopis juliflora and a pod of Prosopis pubescens (mesquites). Subsequently, Peat I was partially covered by dune sand that grades laterally into the silty sand separating Peats I and II. According to the radiocarbon dates as much as 500 years (4500 to 4000 BP) may have elapsed before deposition of Peat II.

A date of about 4000 BP (Fig. 6) on charcoal from a lens in loose reddish burned sand of Trench 1 is chronologically equivalent to the base of Peat II and elevationally below the top of Peat II. It marks a time of sand accumulation accompanying peat formation. Following formation of Peat II there was a minor hiatus in organic deposition and sandy silt was deposited at, and eastward of, Trench 7 (Fig. 6). To the west, peaty sand lies directly above the hard compact surface of Peat II. This peaty sand occurred throughout the marsh east of the dunes, where it was eventually buried by sand. Thus, there were two periods of peat formation between about 5300 and 3000 radiocarbon years ago. Each was accompanied and followed by a distinct eolian event culminating in burial of part, (Peat I) or all (Peat II) of the marsh to the east by a sand sheet. During this time the dune front moved eastward about 60 meters.

Between 3000 and 2000 BP, after sand covered the marsh and before the Barnett Site burial pits were burned, the dunes were reduced to low relief and stabilized; weathering occurred on the resultant surface (Fig. 8). A chronologically similar surface may be represented in Jap Ranch arroyo sediments (Fig.9) above molluscs dated at 3420+100 BP (A-1205). The exact position of the hard weathered surface at its eastward extent, and subsequent surfaces within the dunes, could not be dated in continuous sections at Carson Slough. The suggested ages are based on correlation with similar dated sections at the Barnett Site and the former dunes west of the Barnett Site. These correlations are aided by radiocarbon dates that support conclusions drawn from stratigraphic relationships by confirming or limiting possible correlations among exposures.

Minimal marsh deposition during the 2500 years separating the top of the peaty sand and the base of Peat III is suggestive of a relatively low water table during at least part of this time. Peat III began to form about 400 years ago and, as with others, its westward limit is marked by a slowly advancing dune. Another minor hiatus in peat formation occurred before Peat IV formed in the historic marsh.

A weathered surface, considerably less apparent than the earlier one at 3000-2000 BP, is overlain by loose sand. It forms the base of blowouts containing Paiute pottery and historic artifacts and is responsible for easily recognized lateral root growth stratigraphically and elevationally above the older surface. It may be separated from the earlier surface by several meters to a few centimeters of sand, or they may coincide.

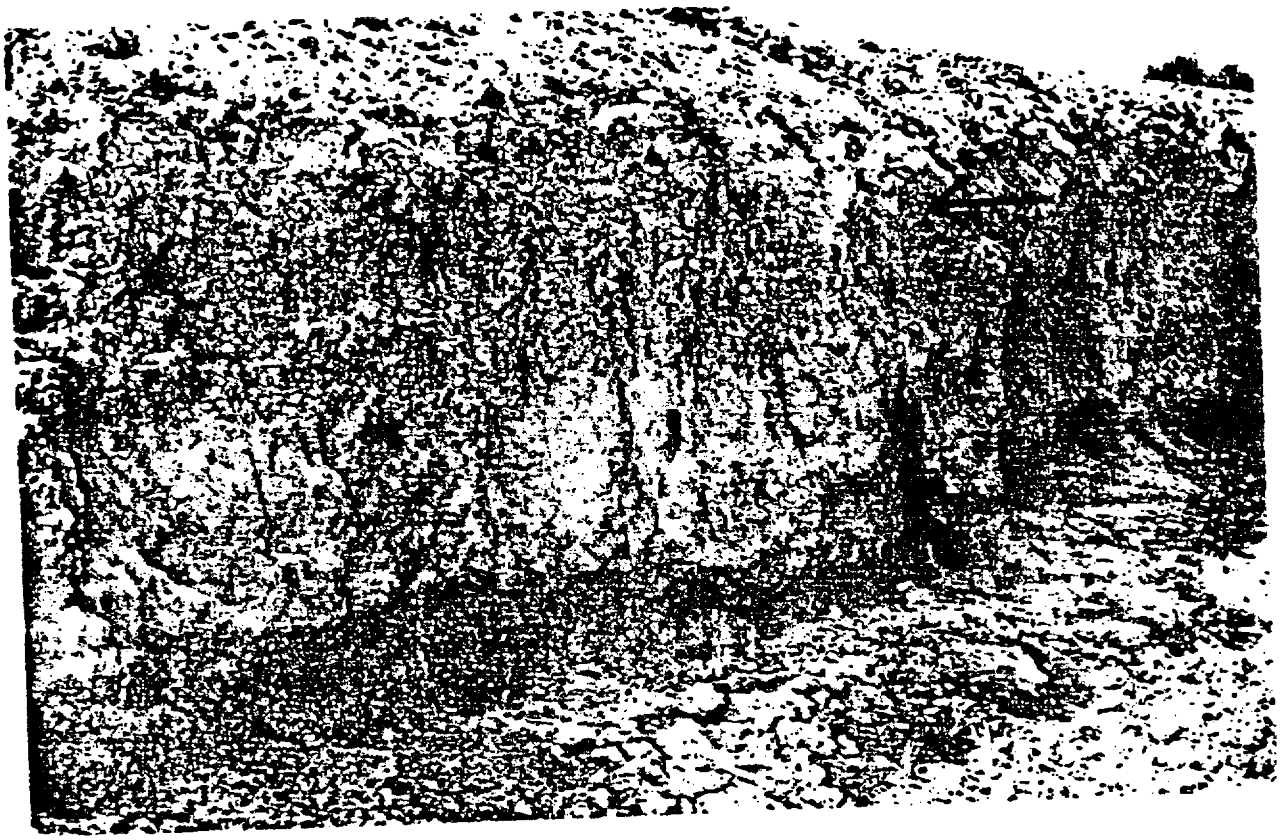

Figure 9. Jap Ranch Arroyo, east wall (June 1972). Molluscs (Lymnaea caperata) from above the obvious erosion surface near the base of the section and below a weathered zone (arrow) were dated at 3420±100 BP (A-1205).

The deposits near the surface of Trenches 1 and 5 represent two distinct weathering periods separated by silty sand (Tables 4, 5). Charcoal above the surface provides a limiting minimum date of 400 BP and Virgin Branch pottery below the surface dates from about 1000 BP.

DISCUSSION

Dunes are conspicuous features found leeward of the remnants of virtually every pluvial lake and river of the Great Basin. The position of presently active dunes results from availability of source material, topography, vegetation cover, fossil dune patterns and wind (direction, velocity and duration). These factors are illustrated in a comprehensive study of the Kelso Dunes, Mohave Desert, California (Sharp 1966).

As paleoclimatic indicators, dunes are generally treated as evidence of aridity (Smith 1967: 21). Increased eolian deposition during interlacustral phases (Morrison 1964) supports this assumption. However, examination of just one controlling factor, source material, reveals more complexity in relative dune action during the past 8000 years. For example, accumulated eolian sediments of the Great Salt Desert, Utah, include gypsum being produced through evaporation at the surface of salt flat clays (Eardley 1962:16) and oolitic sands formed in shallow water. Elsehwere the major source may be from alluvium, alluvial fans, beach sand, or playa surfaces (Denny and Drews 1965: 38; McDonald 1970: 5; Sharp 1966: 1046; Wallace 1961). At least along the Mohave and Amargosa Rivers, the sources of sand for continued or renewed dune formation would be enhanced by increased rainfall and periodic flooding. The same might apply to shallow lakes where continued fluctuations produce annual increments of deflatable sand.

With few possible exceptions (Hunt and Mabey 1966: 82), much presently active dune sand is derived from yet older dunes dating from the end of the last pluvial, a time characterized by a subsequently unequaled abundance of newly exposed and easily deflatable sediments. Since established dune patterns may influence source material, orientation and shape during reactivation(s) (Sharp 1966: 1066), later sand movement is partly preconditioned by dune history. Thus, the relative effects of wind action may reflect dune history and initial post pluvial sediment availability rather than degree of climatic change. Morrison (1964: 103) suggests that deflation of the last 4000 years in Carson Sink, Nevada, was hampered by the stabilizing effect of soil formation.

Regardless of impressive recent wind action, there is considerable evidence for former periods of greater activity, as well as greater stability (Allison 1966, table 5; Davis and Elston 1972, fig. 3; Hawley and Wilson 1965: 49; Morrison 1964: 76, 84-85; Sharp 1966: 1059; Smith 1967: 6). In the Amargosa Desert evidence includes dune migration followed by deflation, stabilization, fine-grained eolian deposition, weathering and stream dissection. Smith (1967: 16) made similar observations and also reported rock detritus, on the modified surfaces of sand aprons, overlain by fresh sand. He interprets this sequence as representing two distinct periods of eolian deposition.

TABLE V

Description of Weathering Profile in Dunes 3 Meters North of Backhoe Transect, Trench 5*

Depth Meters	Description
0.00-0.05	Pinkish gray (7.5YR 6/3D, 4/4M) loamy sand; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; weak coarse prismatic breaking to weak fine to very fine subangular blocky structure; abundant micro and few very fine roots; many micro and very fine continuous horizontal inped pores, few fine continuous horizontal inped tubular pores; abrupt smooth boundary.
0.05-0.10	Light brownish gray (10YR 6/2D, 5/3M) sandy loam; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; weak coarse prismatic structure; abundant micro, plentiful very fine and medium roots; many micro to fine continuous horizontal inped vesicular pores; weakly cemented by soluble salts; abrupt irregular (bioturbated) boundary.
0.10-0.17	Pinkish gray (7.5YR 6/3D, 10YR 4/3M) sandy loam; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; weak coarse prismatic breaking to moderate fine subangular blocky structure; abundant micro, plentiful very fine and few fine and medium roots; many micro to fine continuous random inped vesicular, interstitial and tubular pores; abrupt smooth boundary. (Represents former surface of weathering.)
0.17-0.22	Brown (10YR 5/3D, 3/3M) sandy loam; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; weak fine prismatic breaking to moderate fine to medium angular blocky structure; abundant micro to fine and few medium roots; common micro to fine continuous random inped interstitial pores; very abrupt wavy boundary.
0.22-0.40	Pale brown (10YR 6/3D, 5/4M) loamy sand; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; moderate fine to medium subangular blocky structure; abundanct micro, plentiful very fine, few fine and medium roots; common micro and very fine continuous random inped interstitial pores; gastropod shell fragments; clear smooth boundary.

0.40-0.54	Light gray (10YR 7/2D, 6/3M) sand; weakly coherent when dry, very friable when moist, nonsticky and nonplastic when wet; weak fine subangular blocky structure; plentiful micro, few very fine and fine roots; common micro to fine continuous random inped interstitial pores; gradual smooth boundary.
0.54-1.08	White (2.5Y 8/2D, 10YR 7/2M) sand; weakly coherent when dry, loose when moist, nonsticky and nonplastic when wet; structureless, massive; few micro to fine roots; common micro to fine continuous random inped interstitial pores.

*The profile was described by Jonathan O. Davis from a soil monolith collected in 1972. The monolith is on file at the Laboratory of Anthropology, Washington State University.

Recurrent eolian activity in the Amargosa Desert is chronologically similar to the sequence at Corn Creek Dunes, Las Vegas Valley, Nevada (Williams and Orlins 1963, fig. 1), where hearths in dunes were radiocarbon dated between 5000 and 4000 BP. After a minor hiatus, eolian deposition resumed and was followed by stability and soil formation; the soil is partially deflated and buried by younger dunes (Haynes 1967: 60-65, fig. 18). According to Hunt (1960: 112; Hunt and Mabey 1966: 82), absence of pre-Death Valley III artifacts places a minimum age of about 2000 years on formation of some dunes in Death Valley.

Because of their ability to act as sponges, rapidly absorbing occasional rain but releasing it slowly (Sharp 1966: 1047), dunes may have been important to aboriginal occupation. Mesquite (Prosopis juliflora), an especially important resource in the arid southern Great Basin, and rice grass (Oryzopsis hymenoides), a favored food throughout the Great Basin (Steward 1933: 244; 1938: 18, 26, 28, 74, 96), may owe their existence in harvestable numbers to the presence of a semistable sand substrate. In the Death Valley region past dune activity has dammed spring-fed drainages to produce extensive marshes, thereby increasing local productivity, and waterfowl and mammal resources. Examples of such dune-dammed marshes are found in Death Valley at Saratoga Springs (Wallace and Taylor 1959), and in Ash Meadows (figs. 10, 11, 12).

Whatever climatic interpretations might be placed on the migration or stability of dunes, peat deposition, or weathering episodes, the Ash Meadows sediments represent a complex and dynamic history during the past 5300 radiocarbon years. However, the ultimate cause(s) of these changes remains uncertain. For example, it is conceivable that peat formation is primarily related to active dune movement that dammed the spring-fed drainages. Further, it is possible that dunes were breached during times of relative stability, and the marshes thereby drained. This explanation requires no change in spring discharge or Carson Slough water table, except that occurring behind dune-dams. However, there is evidence for other water table fluctuations represented by the snail rich, calcareous, silty dand exposed to the west of Trench 2 (Fig. 6). It overlies loose clean dune sand and represents a rise in the water table after the underlying sand was deposited.

Arroyo cutting and filling may also have had considerable influence on the water table and marshes in the Fairbanks Spring drainage. The Jap Ranch arroyo (Fig. 9) has cut and filled at least twice in the last few thousand years. A date of about 3500 BP was obtained from snails within a channel fill, the base of which was cut to the depth of the modern arroyo, about two meters below the present land surface. At the present time, continued headward erosion would first drain the marshes fed by Fairbanks Spring and then probably capture Longstreet and Rogers Springs as well. Lowering of the water table and reduction of marsh area would follow as a result of channeling and integration of drainages. Conversely, arroyo filling, possibly resulting from dune blockage south of Jap Ranch, would have the opposite effect. The net result would be a vast marsh extending east of a continuous dune ridge, south to the marshes fed by Crystal Spring.

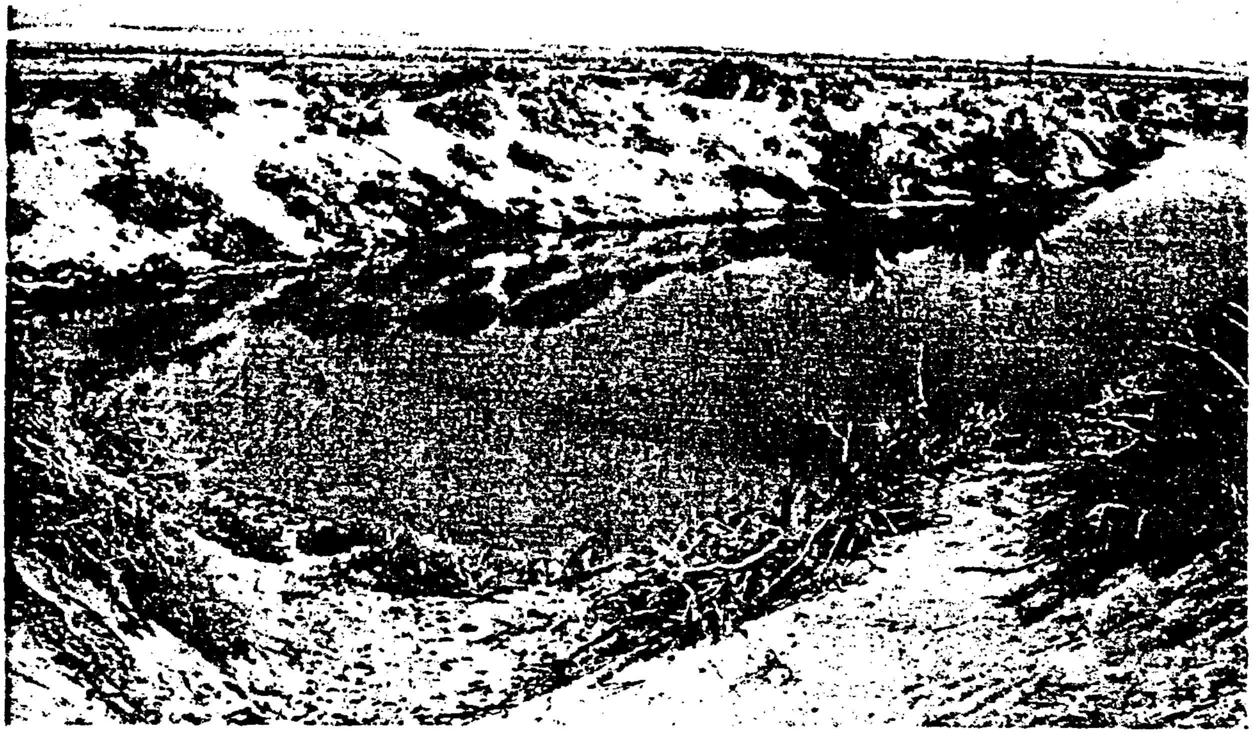

Figure 10. Dune dam (June 1972). These dunes provide a natural dam for an artificial lake south of Jap Ranch and east of Carson Slough (view to the northwest).

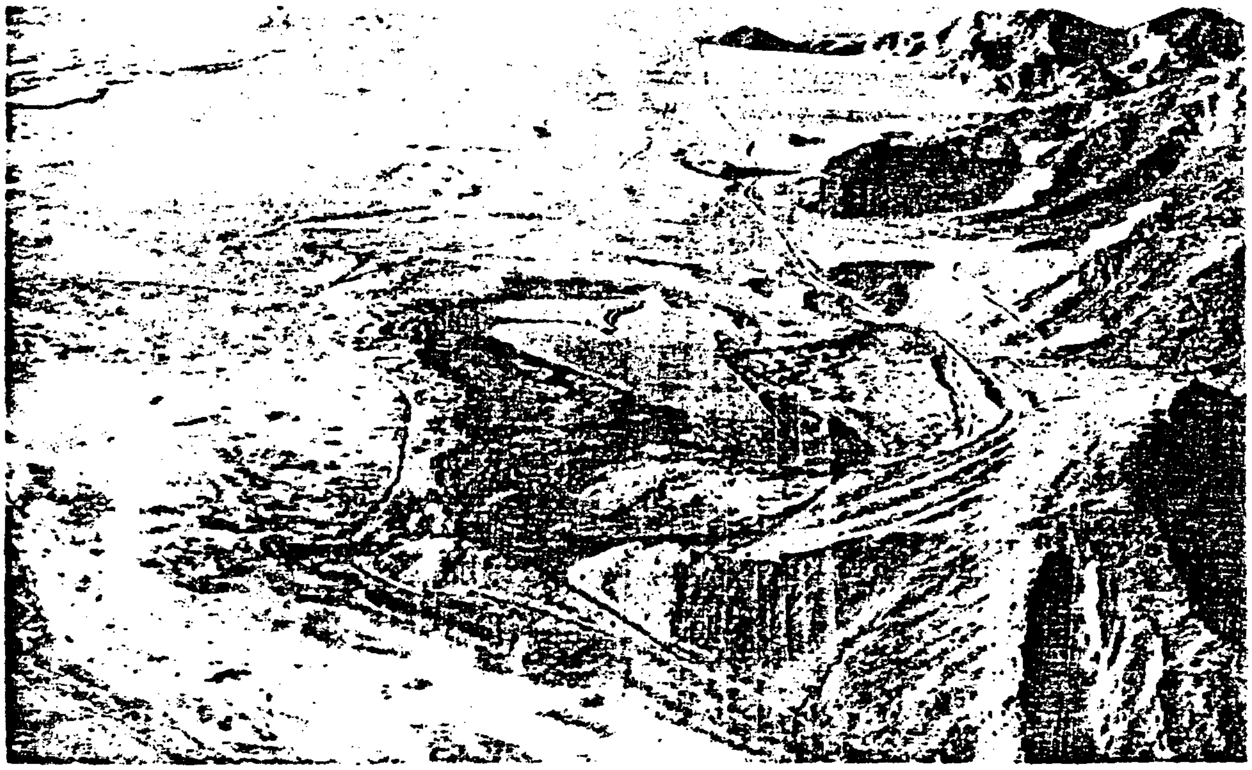

Figure 11. Saratoga Springs and the Amargosa River, Death Valley, California (November 1966). The marsh is spring-fed and dammed by dunes that isolate endemic desert pupfish (Cyprinodon) in the marsh, from those in the Amargosa River (view to the north).

Figure 12. Marsh and dunes southeast of Crystal Spring (December 1970). When the photograph was taken the marsh, formerly supporting dense sedge and cattail, had been heavily grazed. Since then the Crystal Spring outflow has been diverted and the former marsh has been plowed. A study of the marsh and dune records here would provide a comparison with those studied south of Fairbanks Spring. In both cases the dunes have limited the westward extent of marshes and diverted water toward the south (view to the south).

SUMMARY AND CONCLUSIONS

The dune, marsh and archaeological histories of Ash Meadows, Nevada were studied to determine their chronologic and stratigraphic associations. The sequence of events of the past 5300 radiocarbon years is reconstructed as follows:

1. A period of peat formation and coeval dune migration dates from about 5300 to 4500 BP and overlies yet older dune sand.

2. Following a brief hiatus (4500-4000 BP), during which part of the peat was covered by a 20-meter net movement of the dune front, peat continued to accumulate. The second period of peat growth culminated by 3000 BP; at that time the marsh was completely overridden by sand.

3. Sometime between 3000 and 2000 BP the dunes were deflated and reduced to a surface of low relief upon which fine-grained eolian material was deposited and a weathering profile developed. About 2000 BP, burial pits were dug through this surface by people who lacked pottery and offered Humboldt Basal Notch projectile points as grave goods (Muto, Mehringer and Warren, in press). These sites are covered by dunes that contain Virgin Branch Anasazi pottery dating from about 1000 BP.

4. Another weathering episode occurred before 400 radiocarbon years ago; Paiute pottery occurs on this surface.

5. About 400 BP peat deposition resumed. At this time the dune front was 50 meters east of its 3000 BP position.

6. Development of the modern marsh followed a brief hiatus in peat deposition and 5 to 10 meters of net dune migration.

7. South of Fairbanks Spring there were at least two episodes of arroyo cutting and filling that are presumably related to regional changes in factors controlling eolian activity and the water table. Arroyo cutting would also result in a lower water table.

We interpret stratigraphic relationships of peat and dune sand to indicate that major peat deposition was coeval with dune migration, and that eolian deposition continued thereafter, ultimately overriding the marshes. The dynamic sequence of deposition, erosion and weathering must have been initiated by some significant regional change in source material, vegetation cover, and/or other factors. Variation in rainfall and spring discharge might both be involved. However, any choice of an ultimate cause is difficult without more date, particularly since within the Amargosa River Valley one can find dunes that are very active or stabilized at the present time.

Artifacts and hearths are presently eroding from large areas of undisturbed dunes southeast of Crystal Spring (Fig. 12). A further study of these dunes and associated marshes could provide a more detailed chronology of Holocene events, including human occupation, and serve as a test of the assumptions and interpretations presented here. However these conclusions might be modified, it is clear that when viewed over the past 5000 years or so, the spring-fed marshes of Ash Meadows are ephemeral features that have been controlled or altered by eolian deposition.

Research was supported primarily by N.S.F. Grant GB-8646, and initiated with the aid of a University of Arizona institutional grant and by a National Park Service contract to J. E. Deacon. Funds for archaeological salvage in Ash Meadows were provided by the Arizona State Museum and an anonymous donor. Summer field work in 1971 was supported by the Desert Research Institute, University of Nevada. The single most important source of support came from Mr. B. L. Barnett, whose interest in salvaging important fossil localities made the Ash Meadows research possible. He also provided equipment and operators to expose stratigraphic sections.

Dwight W. Taylor studied molluscs, Austin Long provided most radiocarbon dates, and Janice A. and Jeanne C. Mehringer were able field assistants and companions.

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