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QUATERNARY SURFACES, SEDIMENTS, AND MOLLUSKS: SOUTHERN MESILLA VALLEY, NEW MEXICO AND TEXAS

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ABSTRACT

Quaternary geomorphic surfaces located chiefly in the southern Mesilla Valley of Texas and New Mexico were discussed, as well as their underlying sediments and fossil molluscan faunas contained in some of the sediments. Mention was made of faunas occurring northward in the Mesilla, Rincon, and Palomas valleys of New Mexico and a fossil fauna dated at 9,360 150 B.P. was described from Palomas Valley. Paleoecological implications were discussed and lists of Quaternary fossil and of native, living mollusks from the area were presented.

RESUMEN

Este informe discutió superficies geomórficas cuaternarias, sedimentos debajo de las superficies, y moluscos fósiles contenidos en los sedimentos. Se trató del Valle de Mesilla en los estados de Texas y de Nuevo Mexico, especialmente de la parte de este valle entre el Rio Bravo del Norte y las Montañas Franklin. Mencionó también faunas fósiles de moluscos al norte hasta el Valle de Palomas, donde se balk) una fauna con dato (radiocarbon) de 9,360 ± 150 años del presente. Implicaciones paleoecológicas fueron discutidas y listas de los moluscos cuaternarios, fósiles y existentes en la region fueron presentadas.

INTRODUCTION

This report, largely supplemental to an earlier paper (Metcalf, 1967) concerning the mollusks of the Rio Grande Valley in Dora Ana County, New Mexico, and El Paso County, Texas, stresses that part of the southern Mesilla Valley between the Franklin Mountains and the Rio Grande. The writer has been greatly helped by Dr. John W. Hawley and by the writings of other members of the Desert Project Staff, Soil Conservation Service, U.S. Department of Agriculture. Dr. Dwight W. Taylor, San Diego Natural History Museum, provided identification of certain snails. Funds for the radiocarbon date reported (1-3784) were provided by Research Grant 083-2782 (1968), The University of Texas at El Paso.

The basic late Cenozoic geologic and geomorphic features of the area have recently been described by Hawley and Kottlowski (1969) and Hawley et al. (1969). Several cycles of valley erosion separated by episodes of landscape stabilization with formation of geomorphic surfaces have occurred during late Quaternary time in the area (Gile, Peterson, and Grossman, 1965, 1966) . The surfaces mentioned below are mainly aggradational features formed on alluvial fans near mountains or on fluviatile sediments in valleys. Along scarps, they may exist as erosion surfaces cut into alluvium below the next higher surface. In many places, sediments underlying the geomorphic surfaces seem to consist of alluvium deposited in association with the geomorphic cycles that culminated in formation of the surfaces. Hence, they are morphostratigraphic units in the sense of Frye and Willman (1962:113), identified chiefly by means of the landform with which they are associated. The various surfaces treated herein and their associated alluviums have recently been formally designated as morphostratigraphic units by Hawley and Kottlowski (1969), whose terminology is employed herein. Some alluviums (or colluviums) contain fossil mollusks, which seem useful within limits, as paleoecological indicators. Quaternary terminology of the mid-continent region is employed.

The locality numbers noted in text are listed in the final section of the paper. Mentioned frequently is the "outer valley-rim scarp," a salient escarpment approximately 70-90 feet high, topping at 4,200-4,300 feet elevation. This escarpment was named by Hawley and Gile (1966:42) in the Las Cruces area. Kottlowski (1958:53) noted it west of Vinton Canyon as " . . . the only sharp break in alluvial surfaces. . . ." Generally, west of the Franklin Mountains, the scarp parallels, a short distance to the east, the El Paso Natural Gas Company pipeline road, a north-south road at 106° 33' 30" W Long. In El Paso, the scarp is excellently exposed in the northwest part of the city from the Lomas del Rey subdivision northwestward.

FILLMORE SURFACE AND FILLMORE ALLUVIUM

Contrary to usual practice, it seems judicious to consider younger deposits and surfaces first, since dating of these is more reliable. Recently, Haynes (1968) has made a coherent compilation of many reports, substantiated with radiocarbon dates, comprising latest Pleistocene and Holocene deposits from the western United States. Of the deposits discussed by Haynes, oldest fluvial sediments (depositional unit A) were dated at ca. 11,500-13,000 B.P. and occurred at the base of exposed sequences. These were overlain, with various intervening unconformities, by progressively younger units (B, C, D, and E).

In the Mesilla Valley, the youngest major geomorphic surface is the Fillmore Surface of the Fort Selden Surface complex (Rube, 1964:157; Hawley, 1965:194). Charcoal from Fillmore alluvium has yielded radiocarbon dates that range, in general, from 200-5,000 years B.P. Thus, they extend through part of the depositional units C, D, and E, of Haynes (1968:Fig. 3)—see Hawley and Kottlowski (1969: Fig. 4). From silts of the Fillmore alluvium exposed in arroyo banks laterally from the Rio Grande floodplain, seven species of terrestrial snails were collected (Table 1). However, in Fillmore alluvium along the Rio Grande at the base of the Robledo Mountains, a relatively rich fauna was found in a Rio Grande floodplain facies, some of which may have been accumulating up until the time of

TABLE 1. OCCURRENCES (X) OF (1) FOSSIL MOLLUSKS FROM LATE QUATERNARY ALLUVIUMS (=ALLUV.) IN MESILLA AND RINCON VALLEYS AND FROM CANYON FILL OF THE FRANKLIN MOUNTAINS AND (2) LIVING MOLLUSKS FROM THE RIO GRANDE (=R.G.) VALLEY IN THE SAME REGION AND FROM THE FRANKLIN AND ORGAN MOUNTAINS, FLANKING THE VALLEY.

SPECIES	TORTUGAS ALLUV.	CANYON FILL	PICACHO ALLUV.	B-2 ALLUV.	FILLMORE ALLUV.	LIVING, R.G. VALLEY	LIVING, FRANKLIN MTS.	LIVING, ORGAN MTS.
Pisidium casertanum			X					
Stagnicola bulimoides			X		X	X		
Fossaria parva			X		X	X		
Fossaria obrussa			X		X			
Ferrissia fragilis					X	X		
Gyraulus circumstriatus			X		X			
Gyraulus parvus			X		X			
Planorbella tenuis			X		X	X		
Biomphalaria sp.			X		X			
Physa virgata			X	X	X	X		X
Cionella lubrica	X	X		X				X
Gastrocopta pilsbryana	X	X	X					X
Gastrocopta ashmuni							X	X
Gastrocopta procera				X	X			
Gastrocopta cristata	X		X	X	X	X		
Gastrocopta pellucida	X		X	X	X	X	X	X
Gastrocopta armifera	X			X				
Gastrocopta holzingeri	X							
Pupoides albilabris	X		X	X	X	X	X	
Pupoides hordaceus	X		X		X			
Pupilla sonorana		X			X			X
Pupilla blandi	X	X	X					
Pupilla syngenes	X							
Vertigo ovata	X		X		X			
Vertigo cf. *berryi*			X					
Vertigo gouldi								X
Vallonia cyclophorella	X	X	X					
Vallonia perspectiva	X	X		X			X	X
Vallonia gracilicosta	X	X	X	X				
Succineids, sp. indet.	X	X	X	X	X	X	X	
Oxyloma sp.					X			
Bulimulus dealbatus	X							
Bulimulus pasonis							X	
Holospira roemeri		X					X	
Discus cronkhitei	X		X					
Helicodiscus eigenmanni			X	X				X
Helicodiscus singleyanus	X	X	X	X	X	X	X	
Retinella indentata		X		X			X	X
Hawaiia minuscula	X	X	X	X	X	X	X	X
Euconulus fulvus		X						X
Zonitoides arboreus	X		X	X				
Striatura meridionalis								X
Vitrina alaskana		X						
Deroceras laeve						X	X	
Ashmunella sp.	X							
Ashmunella organensis								X
Ashmunella kochi								X
Ashmunella pasonis		X					X	
Oreohelix ferrissi		X						
Oreohelix cf. *metcalfei*		X						
Thysanophora horni							X	X
Sonorella hachitana								X
Sonorella sp.		X					X	
Total:	21	18	25	15	20	12	14	17

European man's modifications of the Rio Grande Valley. Charcoal from the upper part of this alluvium yielded a date of "less than 195 years" (1-2226). The fauna from these floodplain silts consisted chiefly of aquatic species or of species that typically inhabit the vegetated margins of marshes and pools.

The disparity between faunas of the "tributary arroyo" and the "ancient floodplain" facies of the Fillmore alluvium suggests that in the past 5,000 years up until perhaps a century ago, aquatic and semi-aquatic species were able to linger on in a narrow strip of marshland along the Rio Grande, whereas the terrestrial fauna, laterally from the river, was approaching the depauperate condition seen in those areas today. Probably the few species found in the tributary alluvium continued to live along arroyos until the latest episode of arroyo entrenchment in the past 100 years.

B-2 ALLUVIUM

Previously, radiocarbon dates obtained from charcoal in alluviums in the Mesilla, Rincon, and Palomas valleys have not exceeded ca. 5,000 B.P. in age. Recently a date of 9,360 ± 150 B.P. was obtained (I-3784) from alluvium exposed in a scarp, located on the west edge of a narrow strip of the Rio Grande floodplain, approximately 1.5 miles WSW of Garfield, Dona Ana County, New Mexico (E1/2 SW1/4 SW1/4 SETA Sec. 7, T. 18 S, R. 4 W). The unit from which the charcoal was obtained is eight feet thick, with charcoal occurring three feet from bottom of the exposure. Lying disconformably above the unit, is eleven feet of Fillmore alluvium, topped by the Fillmore Surface. The unit from which charcoal was obtained seems equivalent to the Leasburg alluvium of Hawley (1966:194) and Hawley and Kottlowski (1969) . However, since an absolute date is available, it is referred to herein as B-2 alluvium, following the classification of Haynes (1968) . Within Unit B-2, Haynes (Table 2) reported deposits ranging in age from 7,110 ± 270 to 10,850 ± 550 B.P.; the date listed above falls near the center of this time span. Since several feet of sediment occur both below and above the charcoal horizon, a major part of the B-2 time span may be represented in the exposure. The disconformity between B-2 alluvium and the overlying Fillmore allumium may represent a hiatus in deposition (altithermal?) occurring between 5,000 and 7,000 B.P.

Shells of 14 species of terrestrial snails and of one aquatic snail were found associated with the dated charcoal horizon. As late, then, as ca. 9,300 B.P., the snails *Cionella lubrica,* Gastrocopta armifera, Vallonia perspectiva, V. gracilicosta, Helicodiscus eigenmanni, Retinella indentata, and Zonitoides arboreus, now found in the region in mountains above 6,500 feet, were still able to inhabit the Rio Grande floodplain. Their presence suggests continued existence of an extensive riparian deciduous forest. None of these species were found in the younger floodplain alluvium discussed above. Seeds of hackberry were recovered with the snails. Celtis does not occur along the Rio Grande in this area today, but is common along its tributary arroyos above 5,000 feet.

PICACHO SURFACE AND PICACHO ALLUVIUM

Dunham (1935:179) recognized and named the Picacho Surface in the northern Mesilla Valley, with type locality around the eastern base of Picacho Mountain. Ruhe (1964: Table 3) and Hawley (1965:192) correlated the Gold Hill Surface, named by Kottlowski (1958:53) in the city of El Paso, with the Picacho Surface. The Picacho is the next major surface above the Fillmore Surface. Surface and underlying alluvium terminate in scarps, 70-90 feet high, marginal to the Rio Grande floodplain (Locs. 6, 8, 12) . At terminal scarps, the Picacho alluvium comprises mainly fluviatile silts, sands, and mixed, rounded gravels of the ancestral Rio Grande. Laterally, angular gravels derived from the Franklin Mountains predominate in the alluvium and the Picacho Surface occurs as an arroyo-flanking terrace.

Metcalf (1967:16-18) reported a molluscan fauna from Picacho alluvium in Mesilla, Rincon, and Palomas valleys. Ten of sixteen terrestrial species reported now seem to occur only in montane forests in southern New Mexico, suggesting that the fauna lived during a pluvial time. Approximately one-third of the mollusks were aquatic species occurring in silts interbedded with fluvial sands and gravels. Probably these silts formed in quiet pools along the floodplain. That these may have been temporary pools, perhaps resulting from seasonal overflow is suggested by the large number of immature specimens present. In the southern Mesilla Valley, large concentrations of juvenile Biompha*laria* sp. occurred, suggesting that pools dried up before snails had time to reach maturity. This snail was erroneously reported (Metcalf, 1967:39, Table 1) as Promenetus umbilicatellus

Ruhe (1967:Table 6) suggested that age of the Picacho Surface was "Late Wisconsin (more than 9,550 years)." Metcalf (1967:Table II) suggested genesis during a mid-Wisconsinan interglaciation equivalent of the Farmdalian Substage. Dates reported above from B-2 and Fillmore alluviums ranged from ca. 9,360 to 200 B.P. Thus, alluviation seems to have reoccurred a number of times since the last glacial maximum (Woodfordian) . Major downcutting, which cut over 150 feet below the Picacho Surface (Hawley and Kottlowski, 1969) before deposition of the B-2 and Fillmore alluviums seems most likely to have occurred during the waxing time of the Woodfordian Substage, as in the model of Frye (1961:600), who visualized ". . . early glacial erosion. . . ." Alternatively, one might envision a Farmdalian Substage in which soil formation on stable surfaces occurred concomitantly with downcutting.

Radiocarbon dates reported (Ruhe, 1967; Hawley and Gile, 1966:Table 4) from soil carbonates of the Picacho Surface, have ranged from ca. 14,000 to ca. 27,900 B.P. Paired organic carbon dates indicate the inorganic dates may be 4,000-10,000 years too old (Hawley, personal coinmunication) . Granting this margin of error, however, the older dates still suggest that the Picacho Surface had already formed and that the associated upper Picacho alluvium had been impregnated with some soil carbonate by 18,000-24,000 B.P. Thus, it seems most likely that the Picacho alluvium was deposited during Altonian (early Wisconsinan) time, with final stages of valley aggradation possibly extending into Farmdalian time. Evidence summarized by Morrison and Frye (1965:39) indicated that the early Wisconsinan Bull Lake (or Tahoe) Glaciation of the West was much longer than the late Wisconsinan (Pinedale) Glaciation. Thus, the former, despite its greater age, might be expected to have left more evidence of its existence, even in extra-glacial regions.

At Localities one and eight, silts of the Picacho alluvium grade upward into aeolian sands, in the lower part of which are several horizons of weak carbonate accumulation in the form of nodules and inter-grain fillings. Probably these sands accumulated in more than one episode of deposition (marked by aridity?) from late Picacho time up into a time or times in the Holocene.

The caprock of the Picacho Surface in its type area is characteristically no more than two feet thick. However, in many places along arroyos east of the Rio Grande in the southern Mesilla Valley the surface overlies angular gravels, which may be cemented to as much as five or more feet (Locs. 6 and 12) . Explanation for presence of these cemented gravels may comprise one or more of the following: (1) They are partly a tributary alluvium facies of the Picacho alluvium, in which an abundance of calcareous gravels has led to a relatively rapid and thick calichification. Gile, Peterson, and Grossman (1966), in discussing the genesis of carbonate horizons in soils, noted that attainment of a given stage of morphologic development was more rapid in gravelly than in non-gravelly soils. (2) Some of these gravels might conceivably have been deposited in earliest Altonian time and subsequently indurated during a time of stability earlier than the Farmdalian Substage. Kempton and Hackett (1968:33, Fig. 5) reported evidence for such a time of deglaciation (Plano Silt) within the Altonian in its type region of northern Illinois. (3) The thickest and most highly cemented of the gravels probably pertain to the Tortugas or upper Santa Fe Group alluviums, which have been dissected in the Picacho cycle and, thus, may underlie the Picacho Surface.

TORTUGAS (KERN PLACE) SURFACE AND ALLUVIUM

The term "Kern Place Terrace" was introduced by Kottlowski (1958:53) and was applied to a surface in the city of El Paso that is well exhibited along Rim Road for approximately one mile. Subsequently, Ruhe (1964:Table 3) and Hawley (1965:Table 1) correlated the Kern Place Surface with the Tortugas Surface, named by Ruhe (1962: 165) with type locality in the Las Cruces area.

The Tortugas Surface is underlain by a caliche caprock, 4-10 feet thick, which tops prominent scarps. This caprock consists chiefly of cemented, angular gravels derived from the Franklin Mountains, as is the underlying alluvium in most places. Fluviatile deposits are rare in Tortugas alluvium of the southern Mesilla Valley, although mixed, rounded gravels and limonitic sands are exposed at Locality 9 and in the first cut on Interstate Highway 10 north of the Border Steel Rolling Mills plant in Westgate.

Fossiliferous deposits have not been found in the Tortugas alluvium in the southern Mesilla Valley. However, fossil mollusks were found (Metcalf, 1967:18) at the foot of the Robledo Mountains in the northern Mesilla Valley and along the east side of Palomas Valley between Salem and Derry (Table 1). All mollusks collected were terrestrial. Presumably, more medial sediments nearer the ancestral Rio Grande, which probably contained aquatic mollusks, have been removed by erosion. However, more species of terrestrial gastropods have been found in the Tortugas alluvium than in any of the other alluviums reported herein (Table 1). Many of the species are characteristic of deciduous woodlands, suggesting presence of an extensive riparian forest on the Rio Grande floodplain during what was probably a pluvial time. The diversity of the fauna and the presence of such montane groups as the genus *Ashmunella* suggest that this was an interval even more favorable for molluscan life on the floodplain than Picacho alluvium time. Approximately 75 percent of the species are no longer found as far south as southern New Mexico or are restricted there to elevations above 7,000 feet.

Early in the Tortugas cycle there appears to have been significant downcutting below the next highest (Jornada) surface in the southern Mesilla Valley, resulting in a landscape with considerable relief. In part, this downcutting was surely associated with entrenchment of the Rio Grande, although other (climatic?) factors might also have been involved. On this undulating surface, Tortugas alluvium was deposited, thinned laterally and thickened towards the ancestral Rio Grande. Subsequently the Tortugas Surface formed, with the following components, on a landscape still exhibiting considerable relief:

1. On *hillslopes* and on beveled surfaces cut into the *Santa Fe Group below the Jornada Surface.* Such occurrences seem to account for a surface in northwestern El Paso supposedly intermediate in position between the Picacho and Tortugas surfaces (Kottlowski, 1958:53). Here, a highly cemented slope-wash, colluvial mantle has formed on steep slopes that were cut into the massive gravels of the upper Santa Fe Group that occur below the Jornada Surface. On canyon walls above and below Argonaut Drive (Loc. 14), this colluvium contains boulders as large as 15 x 5 feet that were clearly derived upslope from the Santa Fe sediments. Downcutting in tributary drainage systems subsequent to entrenchment of the Rio Grande is reflected. This relict slope surface seems to grade downward to remnants of the "Kern Place Surface" recognized by Kottlowski (1958:53) in this area. The term "High Tortugas" has been used by Hawley and Gile (1966: Fig. 4) for a surface in Selden Canyon and the Palomas Valley,

which they correlated with the "Intermediate Surface" of El Paso.

2. On the undulating plain that extended river-ward from the outer *valley-rim* scarp. Below the scarp, remnants of this surface extend outward in a manner aptly described by Rube (1967:35) as ". . . noses along interfluve axes. . . ." Large expanses of graded surface extend valley-ward in much of the area west of the Franklin Mountains, terminating in many places in the vicinity of Interstate Highway 10. However, along what must have been former low hills and shallow valleys, the surface dips and rises. This seems especially to have been the case as the surface neared the ancestral Rio Grande floodplain. The Tortugas Surface seems to have graded more steeply river-ward than did the inset Picacho Surface. This relationship can be observed approximately one mile to the south when viewed from the intersection of Pipeline and Vinton Canyon roads, east of Westgate. Here, the Tortugas Surface seems to grade below the Picacho Surface near Interstate Highway 10.

3. Probably the Tortugas Surface formed on fill in mountain canyons, as described in the next section.

If the Picacho alluvium is actually Altonian-Farmdalian in age, as suggested above, and if some sediments below the older Jornada and La Mesa surfaces are actually Kansan in age (Hawley et al., 1969), then a general Illinoian/Sangamonian time assignment seems applicable to the Tortugas cycle. The marked period of downcutting, mentioned above, that involved canyons on both sides of the Franklin Mountains before deposition of the Tortugas alluvium may be correlative to the major interval of Pleistocene canyon cutting in the Rocky Mountain Region, which Richmond (1965:217, 220, Table 2) believes to have occurred between equivalents of the Kansan and Illinoian glacial maxima. Possibly such a regionally widespread episode of downcutting might also have been related to initial ingress by headward cutting of a lower Rio Grande tributary into the Hueco and Mesilla bolsons and to its early entrenchment in the bolsons. Deposition of the Tortugas alluvium may, then, have occurred in late Illinoian time (Metcalf, 1967:Table II) and genesis of the strong soil of the Tortugas Surface during the Sangamonian Stage. The Sangamonian soil has been widely reported in the central United States and Rocky Mountain region as an especially strong and salient feature compared to later Pleistocene soils (Frye and Leonard, 1965:203; Richmond, 1962:96, Table 11 and 1965:220).

CANYON FILL

As mentioned above, on both the east and west side of the Franklin Mountains an interval of canyon cutting occurred at a time in the Pleistocene, followed by a time or times of filling. Alluvial sediments filled canyons to depths of 80 or more feet in places and interdigitated laterally with a thick hillslope colluvium at the upper ends of canyons (amphitheaters). Subsequently, strong carbonate horizons developed in the sediments and, still later, erosion cut into the sediments. In the amphitheaters and in narrow benches along canyon walls (Locs. 2, 5, 10, 15, 16), remnants of the fill are still preserved, especially below cliffs, where it seems to consist both of talus and of slope-wash mantle (terminology of Richmond, 1962:19).

The nature of this unsorted, heterogeneous fill, with few recognizable unconformities, does not lend itself well to division into sub-units. However, three phases of deposition within the fill may be suggested. (1) Early *Phase.* This consists of highly cemented deposits, which are well exposed at Localities 10 and 16. This material seemingly was the first major unit deposited after the time of canyon cutting described above. Hence, it may be equivalent to the Tortugas alluvium. (2) *Middle* Phase. Usually occurring above early phase sediments are less consolidated deposits, which are, nevertheless, carbonate impregnated. Upward these sediments become more friable and secondary carbonate is less prominent. A laminar soil K horizon occurs in the top of these sediments in many places (Locs. 15 and 16). In degree of development, the K horizon atop this middle unit suggests the Picacho Surface of the valley-border. Furthermore, in some places, this horizon seems to grade to arroyo-flanking terraces, seemingly topped by the Picacho Surface (Locs. 5 and 10).

Shells of gastropods occur in the hillslope colluvium of "middle phase" deposits. Fossiliferous localities (such as Locs. 2 and 16) are at an elevation of about 5,000 feet. The fauna contains, however, a large proportion of species now characteristically found in montane forests at elevations above 7,000 feet (Table 1). Ten of the eighteen species found in this colluvium seemingly do not occur in the Franklin Mountains today. This suggests deposition at a time of increased rainfall and/or cooler temperatures. The coarser materials of the colluvium may have been produced by increased mechanical weathering caused by frost action during a cooler, pluvial time. Slopes were probably forested, perhaps mainly with Gambel oak, as are steep slopes in the Organ Mountains today at higher elevations, where several of the species extinct in the Franklin Mountains still persist. Stands of trees might have contributed to initial stability of the talus/slope-wash mantle that was accumulating. As for the Picacho alluvium, discussed above, an Altonian age seems most probable for the "middle phase" sediments.

(3). Late Phase. Uppermost deposits of the canyon fill are in most places unconsolidated slope-wash and talus, much of which is probably Holocene in age. However, on steep slopes around North Franklin Mountain (Loc. 4), elongate mounds of rhyolite talus up to one-half mile long overlie cemented canyon fill in places. Possibly much of this talus formed during Woodfordian time in response to increased frost action.

JORNADA SURFACE AND UPPER SANTA FE GROUP

The highest widespread surface in the area between the Franklin Mountains and the Rio Grande seems equivalent to the Jornada Surface. This surface extends generally from the top of the outer valley-rim scarp eastward to the base of the mountains. The Jornada Surface was mapped by Rube (1967:Pl. 2) as widespread in the northern part of Mesilla Valley west of the Organ Mountains. In the Las Cruces area, Ruhe earlier (1962:162) discerned a "Jornada-La Mesa Surface," which he later (1964:147-149) separated into Jornada and Las Mesa components. Kottlowski (1958: 53) applied the term "La Mesa pediment" to this surface in the southern Mesilla Valley.

Rube (1964:147-149; 1967:25,29), Hawley and Gile (1966:6,12), and Hawley and Kottlowski (1969) indicated that the following differences exist between the two surfaces and their associated alluviums. The Jornada Surface typically is associated with broad piedmont slopes adjacent to mountain fronts, where it occurs on alluvial fans and coalescent alluvial fan piedmonts. Only small areas of the Jornada Surface occur in a basin-floor position. The La Mesa Surface, on the other hand, is a " . . . relict basin-floor plain . . ." (Hawley and Gile, 1966:6). Thus, gradients are high on the Jornada Surface as it descends from mountain fronts towards basin floors, whereas the La Mesa possesses little relief except where affected by faulting. Reflecting their local, montane provenance, sediments below the Jornada Surface are predominantly thick-bedded, angular fan gravels. However, the La Mesa Surface, as described by Hawley and Gile (1966:11) " . . . is underlain by a carbonate-cemented veneer of pebbly sand to loam which in turn grades into an areally widespread unit of sand and rounded gravel of mixed composition. . . ." These sands and gravels comprise the uppermost part of the "fluvial facies" of the upper Santa Fe Group (Hawley, *et* al., 1969) and correlate with the upper part of the Camp Rice Formation of Strain (1966:19-21). The Jornada Surface locally overlaps the La Mesa Surface, hence is slightly younger, although underlying sediments associated with both surfaces are of the upper Santa Fe Group (Hawley, et *al.*, 1969) and are, in part, contemporaneous.

Alluvial fan gravels beneath the Jornada Surface are especially well displayed in northwest El Paso (Locs. 13, 14). In a road cut (Loc. 11), an area transitional between ancient alluvial fan and basinal deposits of the upper Santa Fe Group can be observed. Here fan gravels overlie a pinkish silt, which, in turn, overlies fluviatile gravels of the Camp Rice Formation.

In some places, as at Locality 7, the outer valley-rim scarp is vaguely expressed or lacking and the Jornada Surface seems to grade river-ward to elevations of 3,900-4,000 feet. Probably uppermost sediments of the Santa Fe Group have been removed by erosion at such low elevations, although downcutting has been halted by some especially resistant, cemented stratum within the Camp Rice Formation. Such a stratum caps the group of hills centered 11/2 miles east of the north part of Canutillo, Texas. These hills are separated from the outer valley-rim scarp by a salient inset area of the Tortugas Surface.

Gile and Hawley (1968:709-710) have recently separated the Jornada Surface complex into Jornada I and Jornada II components in the Jornada del Muerto. The Jornada I Surface comprises remnants of an ancient pied mont slope landscape that stabilized before initiation of Rio Grande Valley entrenchment and conforms to the concept of Jornada used in this paper. The Jornada II Surface includes younger piedmont slopes of mid to late Pleistocene age in basin areas still not integrated with the Rio Grande drainage system. The canyon fill discussed above may be, in part, correlative of the Jornada II alluvium.

In several places along the west side of the Franklin Mountains, ancient alluvial fans abutting against the mountains, and usually rock-defended towards the valley, may be equivalent to the Dona Ana Surface of Ruhe (1964:149) or they may only reflect differences in elevation in the individual fans that contributed to the Jornada Surface.

LIST OF LOCALITIES

1. 31° 59' 50-59" N Lat; 106° 34' 55-58" W Long. Cut along Int. Hwy. 10 in Picacho alluvium. Dune sand at top. Highly cemented gravels under Picacho Surface along arroyo to the northeast.

2. 31° 58' 0-5" N Lat; 106° 30' 25-29" W Long. Canyon fill along both walls and in amphitheater of Vinton Canyon.

3. 31° 55' 0-10" N Lat; 106° 32' 50" to 33' 5" W Long. Jornada, Tortugas, and Picacho surfaces displayed on hillslopes north of unsurfaced road leading to Tom Mays Park, .5 mi. E of its intersection with "Pipeline Rd." Can be viewed from where road crosses major arroyo.

4. 31° 54' 50-55" N Lat; 106° 30' 0-15" W Long. Unconsolidated rhyolite talus (Woodfordian?) and older canyon fill along and to south of footpath leading from Tom Mays Park to Cottonwood Spring.

5. 31° 54' 48-52" N Lat; 106° 30' 45-55" W Long. Picacho Surface on canyon fill along arroyo that crosses road 150 feet north of Memorial Marker in south part of Tom Mays Park. Canyon fill inset below cemented, angular gravels of upper Santa Fe Group.

6. 31° 54' 20-25" N Lat; 106° 34' 48-55" W Long. Exposures of Picacho fluviatile alluvium and older, problematic, highly cemented alluvium along first arroyo north of bridge on Trans-Mountain Hwy. over Int. Hwy. 10. Area may soon be modified if interchange is constructed here.

7. 31° 53' 30-50" N Lat; 106° 33' 20" to 34' 10" W Long. Graded surface (in area where outer valley-rim scarp has not developed) that has been beveled on resistant angular gravels of the upper Santa Fe Group.

8. 31° 52' 45-50" N Lat; 106° 35' 15-25" W Long. Exposures of Picacho alluvium, in terminal scarp along and south of Montoya Conn. Rd., showing lenses of rhyolitic gravels at two horizons. Picacho Surface capped by dune sand.

9. 31° 52' 20-25" N Lat; 106° 34' 40-45" W Long. Cut in fluvial facies of Tortugas alluvium along Int. Hwy. 10, .1-.2 mi. S of terminus of Montoya Lane in dumping area.

10. 31° 51' 30-50" N Lat; 106° 30' 15" to 33' 30" W Long. Area along arroyo from where it passes south of prominent knob-shaped hills eastward to the Franklin Mountains. Picacho Surface occurs as terraces along arroyo most of its distance; Tortugas Surface is a salient feature

between the knob-shaped hills and the outer valley-rim scarp; canyon fill of the three kinds discussed in canyons at head of arroyo.

11. 31° 50' 50" N Lat; 106° 33' 32"W Long. Cut in upper Santa Fe Group sediments, one mi. N Mesa Ave. on Pipeline Rd.

12. 31° 50' 35-40" N Lat; 106° 33' 35-55" W Long. Picacho alluvium and Surface exposed in cut on east side of frontage road immediately north of Mesa Ave. interchange on Int. Hwy. 10 and continuing upstream along arroyo for .3 mi.; exhibiting both fluvial and tributary facies of alluvium.

13. 31° 50' 0-30" N Lat; 106° 31' 0-30" W Long. Exposures in several cuts of massive, cemented, angular gravels of upper Santa Fe Group below Jornada Surface, as opposite Western Hills School on Thunderbird Drive.

14. 31° 48' 30-45" N Lat; 106° 30' 15-35" W Long. Lomas del Rey subdivision of El Paso. Cemented colluvium of "Intermediate Surface" on northwest canyon wall above and below Argonaut Drive and massive gravels of upper Santa Fe Group beneath Jornada Surface on southeast canyon wall.

15. 31° 48' 15-30" N Lat; 106° 29' 40-59" W Long. Canyon fill, alluvial and colluvial, displayed for 1/2 mi. along NE-SW trending canyon debouching immediately north of Temple Mt. Sinai and skirting north side of Crazycat Mountain.

16. 31° 50' 30-40" N Lat; 106° 29' 15-30" W Long. Canyon fill (all phases) at upper end of McKelligon Canyon Park, along arroyos radiating from main recreational area.

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