Soil Survey Investigations Report No. 44

Supplement to

The Desert Project Soil Monograph

Volume II

Natural Resources Conservation Service
U.S. Department of Agriculture
National Soil Survey Center, Lincoln, NE

FOREWORD

Volume II of the Supplement to the Desert Project Soil Monograph is the second of a number of reports on soils in the Desert Project area. Volume II consists of two chapters, of which the first is a detailed study of a remnant of the Rincon surface and its soils. The Rincon surface is a remnant of one of the oldest basin landscapes in North America, and probably dates from late Pliocene time or earlier. The remnant consists of an ancient basin floor and an adjacent alluvial-fan piedmont, preserved in a bedrock-defended area 600 feet above the Rio Grande flood plain. Chapter 2 focuses on clay mineralogy of the Desert Project and the Rincon study area. It describes clay mineralogy as a function of age, parent material, and depth. It also compiles the narrative clay mineralogy information produced during the period from 1957 to 1972.

L. H. Gile and R. J. Ahrens, editors

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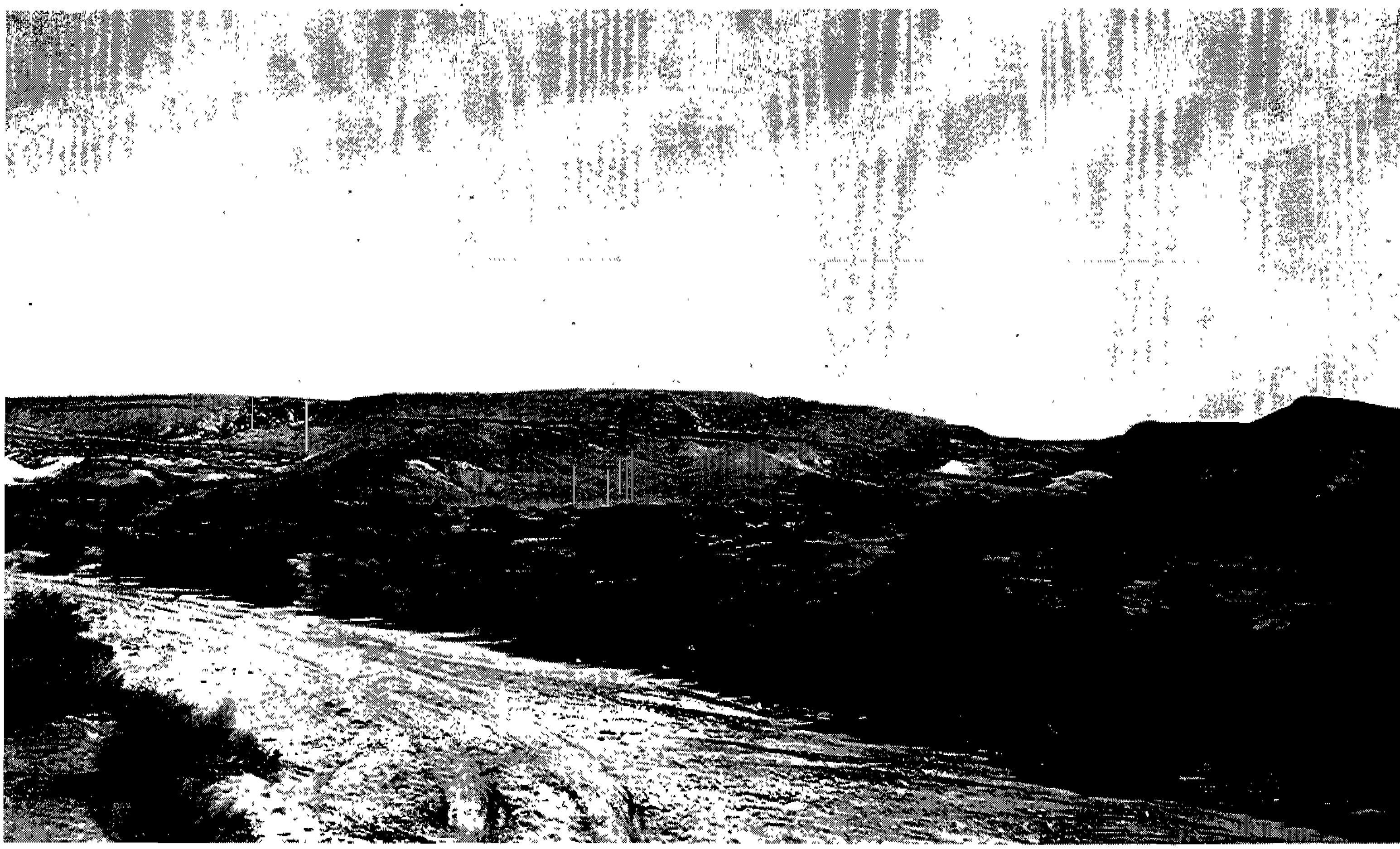
ANCIENT SOILS OF THE RINCON SURFACE, NORTHERN DONA ANA COUNTY



The Rincon surface (from the arroyo leading to it, looking east) occupies most of the skyline, from left to right of center.

Frontispiece -- Playa and vicinity at the Rincon surface study area, looking south. Lower slopes of the alluvial-fan piedmont are in the foreground. The trench across the playa (see text) was being dug when the photograph was taken. The Rincon Hills are on the skyline. Photographed September, 1969.

ANCIENT SOILS OF THE RINCON SURFACE, NORTHERN DONA ANA COUNTY

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1/ Capital letter in parentheses designates the map unit in the soil map (fig. 3).

2/ Pedon numbers used throughout this report (except for the appendix) are abbreviations of the full pedon numbers used in the appendix (e.g., 69-1 = 69NM-013-001). Pedons with 69(70) designation were sampled both in 1969 and 1970.

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SUPPLEMENT TO THE DESERT PROJECT SOIL MONOGRAPH

Soils and Landscapes of a Desert Region Astride the

Rio Grande Valley Near Las Cruces, New Mexico

L. H. Gile and R. J. Ahrens, editors

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ABSTRACT

A remnant of the Rincon surface, one of the oldest basin landscapes in North America, occurs on the edge of the Rio Grande Valley in southern New Mexico. Preserved by bedrock in fortuitous positions, the ancient landscape, which probably dates from the late Pliocene or earlier, contains an alluvial-fan piedmont, a basin floor, and a playa. The basin-floor portion of the remnant stands about 600 feet above the present flood plain of the Rio Grande. Soils of the basin floor formed primarily in fluvial sediments deposited by the ancestral Rio Grande; soils of the alluvial-fan piedmont formed in sediments derived primarily from limestone; and soils of the playa formed in sediments derived primarily from the alluvial-fan piedmont upslope. In addition, smaller amounts of eolian sediments derived from the Rio Grande Valley have probably contributed to parent materials of upper horizons of soils of the playa and the basin floor. The basin-floor sediments contain very little calcium, and calcium in the thick carbonate horizons must have been mostly derived from atmospheric additions.

Typic Petrocalcids with thick petrocalcic (Km) horizons are the dominant soils in the fan piedmont and the basin floor, but a few Petroargids and Argic Ustic Petrocalcids are preserved at stablest sites. Both stage V and VI horizons occur in most of the studied Km horizons. The stage VI carbonate has common 5YR and 2.5YR hues, pisoliths, and highest values of carbonate, bulk density and hardness. The pisoliths are mostly engulfed, separated, and cemented by carbonate. Microscopic features of the stage VI pisolitic zone include ooliths, silicate grains with prominent dissolution features, concentric clay bands, and biologically-induced structures. The stage V carbonate has pisoliths, is dominated by 7.5YR and 10YR hues, is not as hard or as dense as the stage VI carbonate, and commonly penetrates the stage VI horizon in places if one is present.

Prior development of a dense precursor horizon, such as a laminar horizon, is apparently required for development of both stage V and VI horizons. The precursor horizon may be viewed as a sort of <u>super-plugged</u> horizon; it is similar to the stage III <u>plugged</u> horizon in that it severely restricts vertical water movement in the soil, but to a greater degree.

Brecciation of pre-existing Km horizons appears to be involved in development of pisolitic zones in the study area. During pluvials, soil water can reach deep Km horizons much oftener than during interpluvial times, and cracks can be more readily penetrated by soil water, carbonate, clay and roots. Repetition of this penetration would force parts of the Km horizon away from it, eventually forming a continuous brecciated horizon above the Km horizon. With a change to drier climates, the wetting fronts would be lifted and the brecciated zone would be cemented by accumulation of carbonate between the brecciated fragments. In addition to change to drier climates, long-continued carbonate accumulation in a given zone would tend to cause shallower depths of wetting and carbonate accumulation over time because of the gradually increasing fineness, decreasing porosity, and increasing shallowness of the zone of carbonate accumulation itself. This would eventually result in Km horizons so shallow that soil water and roots could penetrate cracks in the Km horizons even during interpluvial times, and this is the typical situation at present in the extensive shallow Petrocalcids of the study area.

In the playa, long-continued carbonate accumulation has formed an extremely hard Km horizon, which is relatively shallow in one end and very deep in the other. Haplotorrerts and Haplocalcids, calcareous throughout, now dominate the latter end of the playa. Buried soils with argillic horizons occur beneath these soils. The change in the direction of soil development from buried soils with argillic horizons to soils without them at the present land surface is attributed to abundant carbonate in parent materials of the land surface soils. This carbonate must have been derived largely from eroded soils with shallow Km horizons that occur upslope of the playa.

A previous study concluded that the Rincon surface probably formed about 0.6-0.5 million years ago. In contrast, estimates of soil age based on amounts of pedogenic carbonate in a soil at the basin-floor scarp in the Rincon surface indicate that the soil is at least 3.1 million years old. This is a minimum figure because some pedogenic carbonate must have been eroded from this soil at the scarp. Dated volcanic ash, dated pumice, and paleomagnetic work on sediments associated with nearby lower La Mesa surface, known to be younger than the Rincon surface, also indicate that the Rincon surface is considerably older than 0.6-0.5 million years.

ACKNOWLEDGMENTS

We greatly appreciate the encouragement and support of the late Guy D. Smith throughout the course of this study. We thank the Burn Construction Company for their cooperation in transporting a backhoe to the study area, which is difficult to reach with machinery. Some soils could not be excavated by backhoe due to their extreme hardness; we gratefully acknowledge the assistance of the late John W. Clark, who provided exposures of these soils by dynamiting at three critical sites. Laboratory analyses were performed by the National Soil Survey Laboratory in Lincoln, Nebraska. Grateful acknowledgment is made to Ellis Knox and Carl Glocker for reviewing the manuscript. We thank Yvonne Flores for her careful work in typing the manuscript.

INTRODUCTION

A remnant of a basin landform that probably dates from the late Pliocene or earlier occurs near Rincon, New Mexico, and is termed the Rincon surface (figs. 1, 2; Hawley, 1965). The remnant is particularly significant because it contains both a relict basin floor and an adjoining alluvial-fan piedmont. In addition, a playa occurs in what appears to be the lower part of the fan piedmont (fig. 2). This is an unusual position for a playa as will be discussed later. No basin remnant of this kind and age is known to exist elsewhere in southern New Mexico. The remnant has quite stable areas, in which virtually no evidence of erosion can be seen, as well as less stable areas that have been eroded. These contrasting areas are helpful in a general assessment of effects of landscape stability on pedogenesis over a long period of time.

Geomorphology and geology of the Rincon surface have been discussed (Hawley, 1965; Seager and Hawley, 1973). The soils were studied and sampled for analyses during investigations at the nearby Desert Soil-Geomorphology Project (fig. 1; Hawley, 1975; Gile and Grossman, 1979; Gile et al., 1981). This report concerns the morphology, genesis, and classification of these ancient soils.

SETTING

The study area is in the Mexican Highland section of the Basin and Range physiographic province (Fenneman, 1931; Thornbury, 1965). Broad desert basins and discontinuous mountain ranges are typical of the area.

The basin remnant of the Rincon surface is preserved in an area that has been protected from erosion by bedrock that nearly surrounds it (fig. 2; cf Seager and Hawley, 1973, Sheet 1, in pocket). Much of the area adjacent to the remnant has been strongly dissected by entrenchment of the Rio Grande, which at Rincon is about 600 ft below the basin-floor portion of the remnant. Figure 2 shows contours and elevations of the study area.

The general slope of the fan piedmont (figs. 2 and 3, map unit D) to the southeast is interrupted by a playa (map unit A, fig. 3). The reversal in slope may be associated with nearby faulting (Seager and Hawley, 1973, Sheet 1, in pocket). Differential compaction of alluvium may also be a factor because the bedrock that can be seen to the southeast (fig. 3) may extend westward beneath the alluvium. Whatever the cause, the apparent displacement of part of the fan piedmont and subsequent playa formation clearly took place a very long time ago, as shown by the cycles of sedimentation and soil formation in the playa as discussed later.

Seager and Hawley (1973) present the geomorphic setting of the area. Valley-border geomorphic surfaces at the Desert Project (Gile et al., 1981) occur in the Rincon area as well, rising to extensive areas of the La Mesa surface, a relict basin floor of middle Pleistocene age. At 4620 ft, the ancient basin floor of the Rincon surface stands more than 200 ft above La Mesa south of Rincon (fig. 1). Kortemeier (1982) considers the Rincon surface to be from 0.6-0.5 million years old. This age is considered to be too young as discussed later.

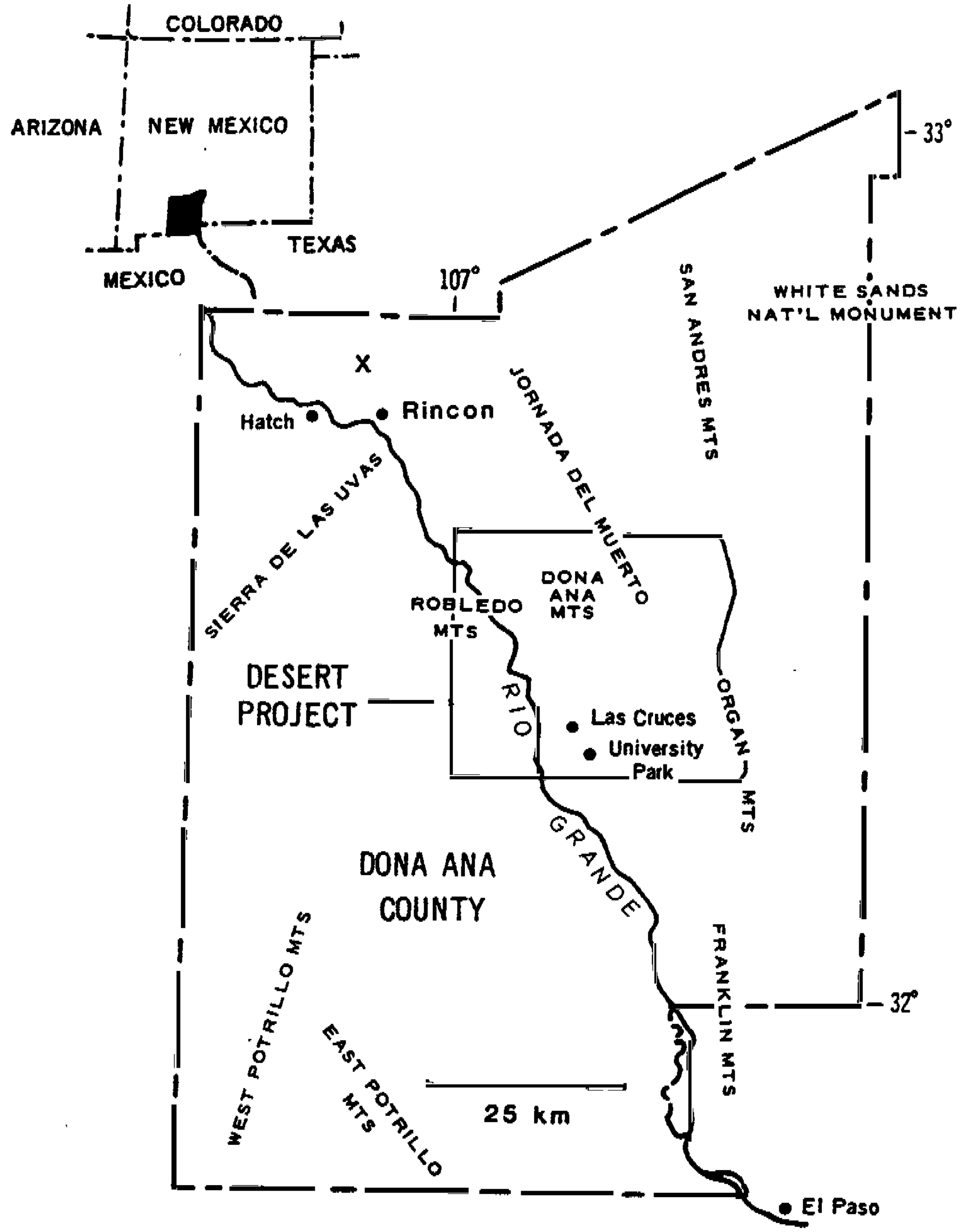

Fig. 1. Location of the study area (X) on the Rincon surface, north of Rincon in northwestern Dona Ana County, N.M.

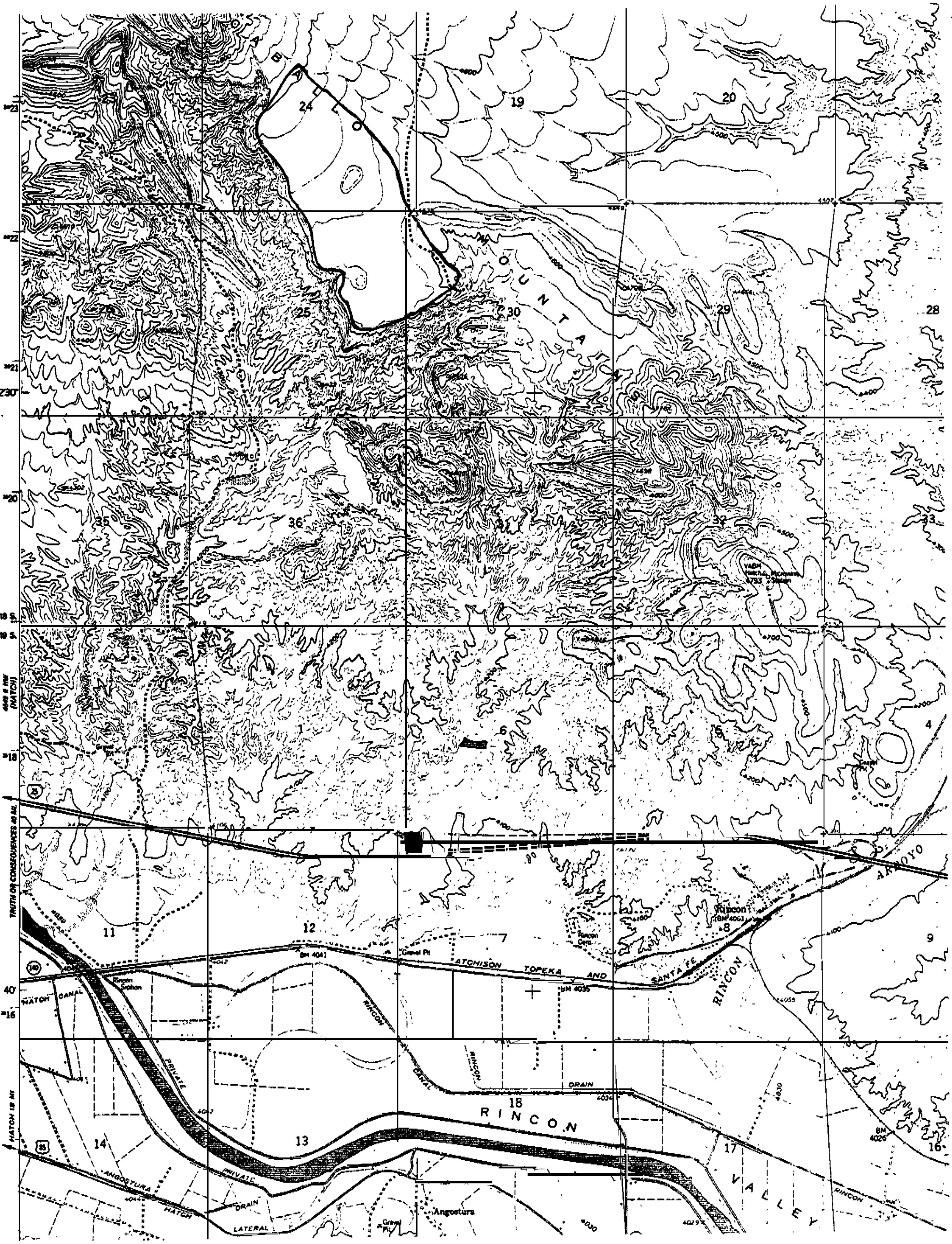

Fig. 2. Part of the Rincon Quadrangle topographic map, showing the study area (outlined) on the Rincon surface, the Rio Grande flood plain, and the dissected area between.

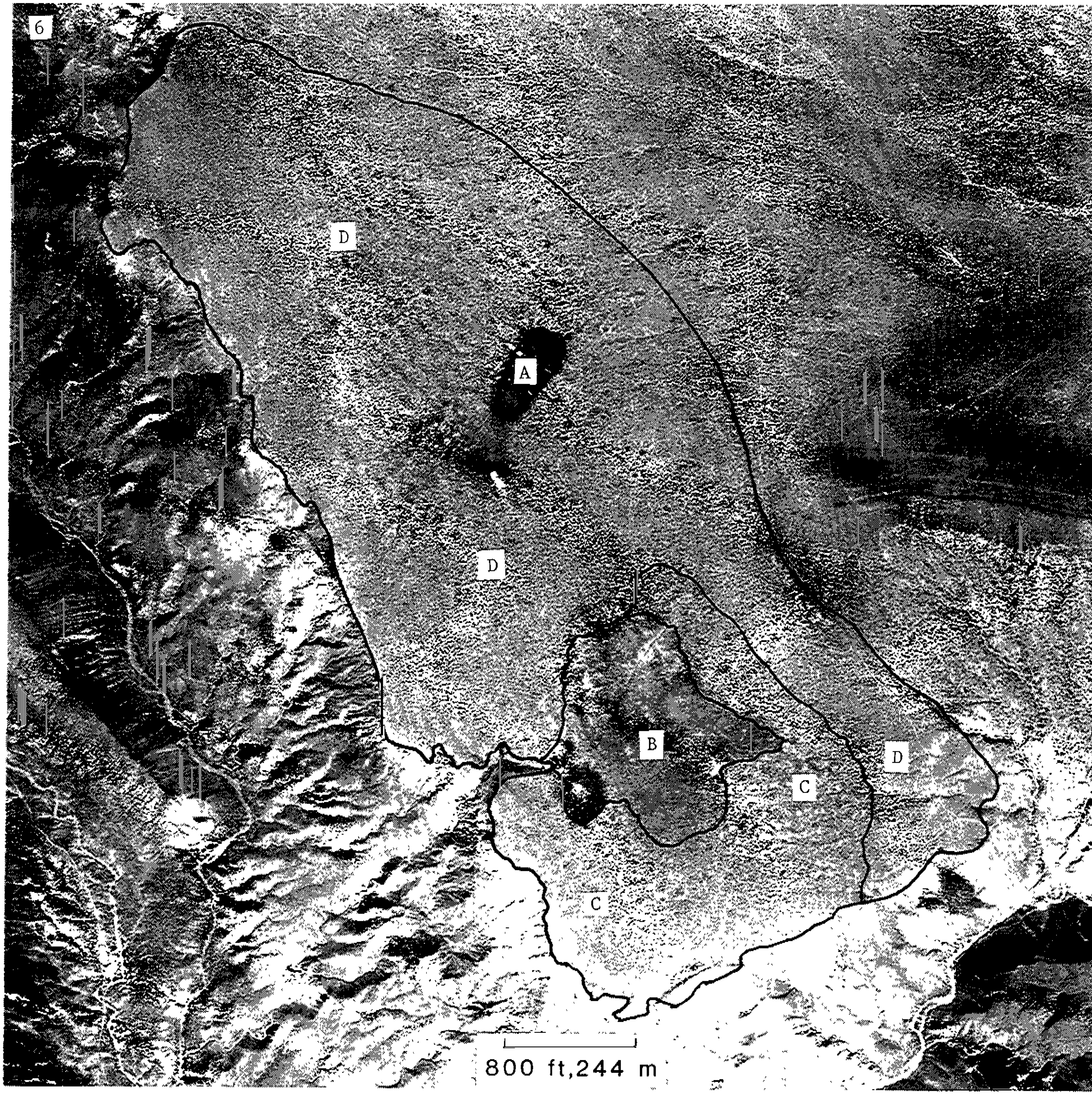

Fig. 3. Soil map of the study area. A=Dalby-Ratliff-Stellar complex; B=Tencee-Simona-Stellar complex; C=Tencee and Simona soils, 0 to 1% slopes; D=Tencee and Simona soils, 1½ to 6% slopes.

Soil parent materials in the alluvial-fan component of the remnant are mostly limestone-derived sediments from the Caballo Mountains upslope. The basin-floor deposits consist primarily of sand and gravelly sand of the Camp Rice Formation (Seager and Hawley, 1973). Soils of the playa formed in sediments derived primarily from the alluvial-fan piedmont upslope. In addition, smaller amounts of eolian sediments derived from the Rio Grande Valley have probably contributed to parent materials of upper horizons of soils of the basin floor and the playa. The basin-floor materials contain very little calcium, and calcium in the thick carbonate horizons must have been largely derived from atmospheric additions (Gile et al., 1981). The mean annual temperature at Hatch is about 60 F, and the mean annual precipitation is about 25 cm.

Vegetation observed in the study area consists of buckwheat (Eriogonum Wrightii), burrograss (Scleropogon brevifolius), bush muhly, (Muhlenbergia porteri), mammillaria cactus (Mammillaria sp.), creosotebush (Larrea tridentata), fluffgrass (Tridens pulchellus), mesquite (Prosopis juliflora), Mormon tea (Ephedra torreyana), ocotillo (Fouquieria splendens), prickly pear (Opuntia sp.), snakeweed (Gutierezzia sarothrae), sumac (Rhus microphylla), tarbush (Flourensia cernua), tobosa (Hilaria mutica), and yucca (Yucca baccata).

SOIL CLASSIFICATION, MAPPING, AND CONVENTIONS

Table 1 lists soils of the study area and their classification; table 2 gives the map unit names, location, and composition. Figure 3 is a soil map of the area. Aridisols occupy the whole remnant except for a small area of Vertisols in the northeastern part of the playa (fig. 3).

The soil map has 4 map units (table 2, fig. 3). Two of the units are soil complexes and two are undifferentiated groups. In soil complexes, major components cannot be mapped separately at a scale of about 1:24,000 (Soil Survey Division Staff, 1993). In undifferentiated groups, the major components are not consistently associated geographically and, therefore, do not always occur together in the same map delineation (Soil Survey Division Staff, 1993). Use and management are the same or very similar for common uses. In the two undifferentiated groups, substantial areas of two soils (Tencee and Simona) are known to occur but intricacy of the soil pattern has not been determined.

Clay mineralogy of soils of the Rincon surface is discussed elsewhere in this volume (Monger and Lynn, 1996).

Several terms used in this report are defined as follows.

Pisolith. Pisoliths are subangular to spherical bodies, ranging from 2 mm to more than 10 cm in diameter, that have concentric coatings of carbonate around a nucleus that commonly consists of fragments of massive and/or laminar carbonate. Pisoliths are generally separated by massive carbonate (see fig. 24 for illustration of pisoliths). Ooliths are also accretionary bodies but are less than 2 mm in diameter (see fig. 25 for illustration of ooliths). (Modified from Birkeland, 1984, p. 141.)

Table 1. Classification of soils discussed in this report. All soils are in the thermic soil temperature class and all series are established. The term variant has been discontinued (Soil Survey Staff, 1993), and is here replaced by analog for informal use. Conger, moderately deep analog has a petrocalcic horizon at a depth of 50 to 100 cm. Reagan, deep petrocalcic analog has a petrocalcic horizon at a depth of 100 to 150 cm. Stellar, deep petrocalcic analog has a petrocalcic horizon at a depth of 100 to 150 cm; in some pedons, a calcic horizon is present above the petrocalcic horizon. Simona, eroded has the petrocalcic horizon at or very near the surface. Hilken, fine analog is in the fine particle-size class.

Order	Suborder	Great group	Subgroup	Family	Series or analog, and illustrative pedon(s)
Aridisols	Argids	Petroargids	Ustic	Fine, mixed	Stellar, deep petrocalcic analog 69-6, 69-7
	Calcids	Petrocalcids	Argic Ustic	Fine, mixed	Hilken, fine analog 70-4
			Ustic	Loamy, mixed, shallow	Conger, 69(70)-5
				Fine-loamy, mixed	Conger, moderately deep analog
			Typic	Loamy-skeletal carbonatic, shallow	Tencee 69(70)-4,-5; 70-2; 70-3
				Loamy, mixed, shallow	Simona
					Simona eroded
		Haplocalcids	Ustic	Fine-loamy, mixed	Ratliff 69-2, 69-3
				Fine-silty, mixed	Reagan, deep petrocalcic analog
Vertisols	Torrerts	Haplotorrerts	Typic	Fine, montmorillonitic	Dalby 69-1

Table 2. Location and composition of map units (see fig. 3)

Map unit symbol and name	Physiographic position and slope	Components of map unit: Dominant soils	Components of map unit: Other soils
A. Dalby-Ratliff-Stellar complex	playa; level or nearly level	Ratliff Dalby Stellar phase	Conger phase Reagan phase Tencee Hilken analog
B. Tencee-Simona-Stellar-complex	Very slight, broad depression in basin floor; slopes range from level to 1%	Tencee Simona Stellar phase	Conger phase Hilken analog
C. Tencee and Simona soils, 0 to 1% slopes	Basin floor; slopes range from level to 1%	Tencee Simona	Simona, eroded
D. Tenc e and Simona soils, 1 1/2 to 6% slop s	Alluvial-fan piedmont and east border of basin-floor remnant; slopes range from 1 1/2 to 6%	Tencee Simona	Simona, eroded Stellar phase Hilken analog

<u>K-fabric</u>. In K-fabric, fine-grained authigenic carbonate occurs as an essentially continuous medium. Th carbonate coats or engulfs, and commonly separates and cements skeletal pebbles, sand, and silt grains. Interstices between skeletal grains are partly or completely filled with carbonate. (From Gile, Peterson, and Grossman, 1965.)

<u>Calcrete</u>. Calcrete is used to designate carbonate-cemented materials (e.g., calcrete fragments) and not to designate soil horizons. (Modified from Lamplugh, 1907).

<u>Pipe</u>. The term pipe refers to roughly funnel-shaped, downward extensions of B horizon material into horizons with more carbonate, commonly K horizons. In very old soils, such as soils of the Rincon surface, some pipes have been filled or nearly filled with illuvial carbonate. (For illustration and further discussion, see Gile et al., 1966, and Gile and Grossman, 1979).

Horizon designations follow the Soil Survey Division Staff (1993) except for the K horizon nomenclature (Gile et al., 1965) and the designations for buried soils, which are placed at the end of the designation to handle more than one buried soil. The K horizon continues to be used because, as noted by Birkeland (1984), "Most pedologists and geologists working in arid lands find it a very useful term". Stages I-IV of carbonate accumulation follow Gile et al. (1966). Bachman and Machette (1977) and Machette (1985) proposed adding stages V and VI to the four previously proposed. These additions should be useful because they recognize advanced evolutionary changes beyond formation of the stage IV laminar horizon. Machette (1985) proposed that stage IV be limited to laminae or laminar layers that are less than 1 cm thick and that stage V be distinguished by laminae or laminar layers thicker than 1 cm, and in some cases also by pisoliths. Birkeland (1984) and Birkeland et al. (1991) do not limit stage IV to laminar layers that are less than 1 cm thick, and require that pisoliths, as well as <u>lam</u>inae, be present for stage V. That usage is followed here. In stage VI horizons, the pisolitic zone has multiple generations of brecciation and recementation. As pointed out by Machette (1985, fig. 4) stage VI horizons have higher bulk densities and $CaCO_3$ contents than do stages IV and V.

SOILS OF THE PLAYA: DALBY-RATLIFF-STELLAR COMPLEX (A, FIG. 3)

Soils of the playa (map unit A, fig. 3) have a complex pattern in which Haplotorrerts (Dalby soils) and Haplocalcids (mostly Ratliff soils) dominate the northeast side and Petroargids (Stellar analog) and Petrocalcids (Hilken analog) dominate the southwest side. A trench was dug across the northeast side of the playa (fig. 4) to determine the character of its soils and their relation to soils adjacent to the playa (figs. 5, 6). The trench bottoms in an extremely hard petrocalcic horizon. Haplotorrerts in the central part of the playa grade through Haplocalcids in the outer parts of the playa to Petrocalcids that border the playa (fig. 6). The Petrocalcids at each end of the trench are in adjacent map unit D, but are discussed in this section to have all of the trench data in one place. The boundary of the playa (fig. 6) is taken as the boundary between the grassy vegetation that dominates the playa and the shrubby vegetation that dominates areas bordering the playa.

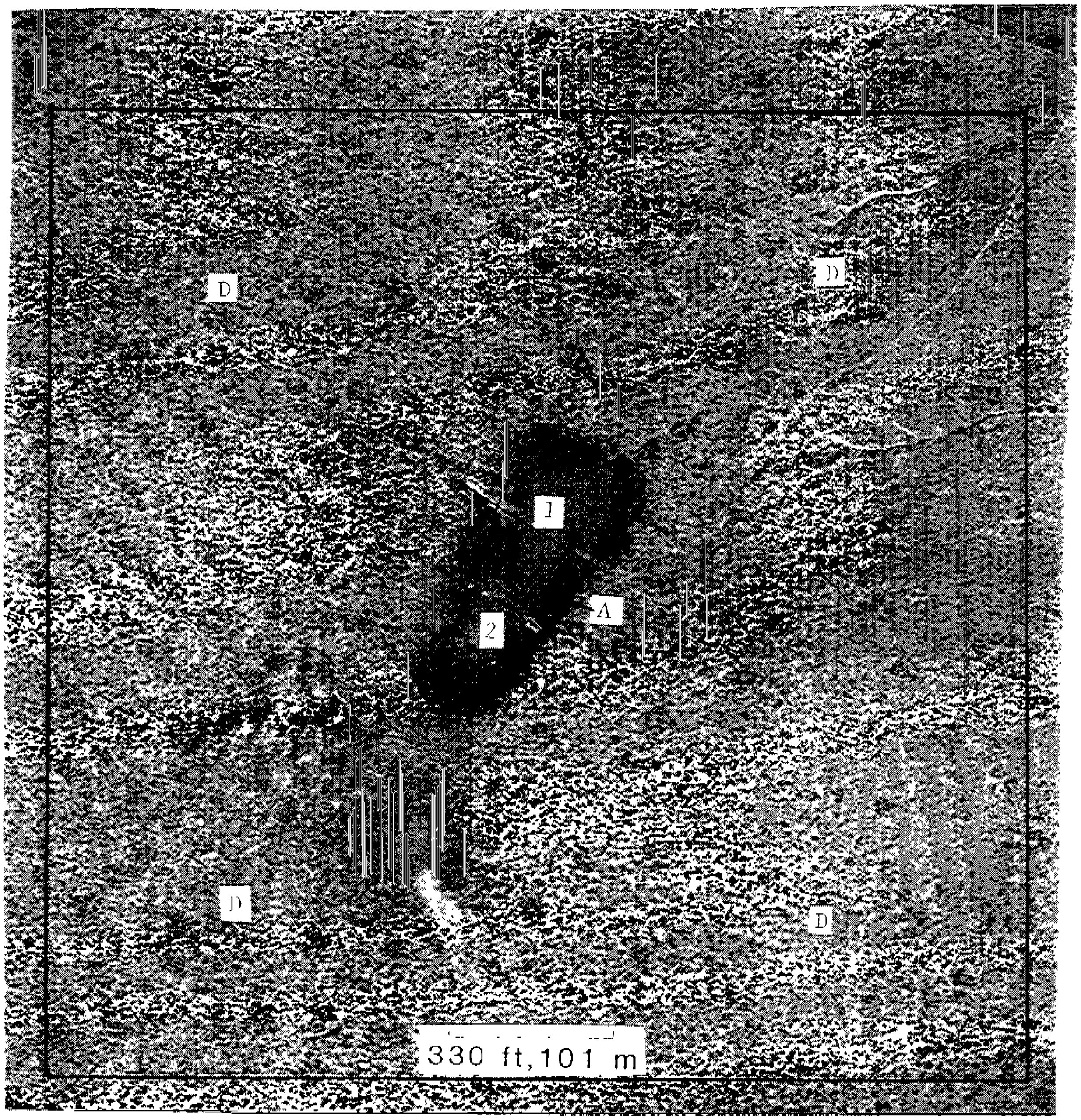

Fig. 4. Enlargement of part of the soil map (Fig. 3), locating the playa and study trenches. A-Dalby-Ratliff-Stellar complex; D-Tencee and Simona soils, 1½ to 5% slopes; 1-trench across playa (see figs. 5 and 6); 2-trench at Hilken analog 70-4. Dashed line encircles approximate area of Vertisols.

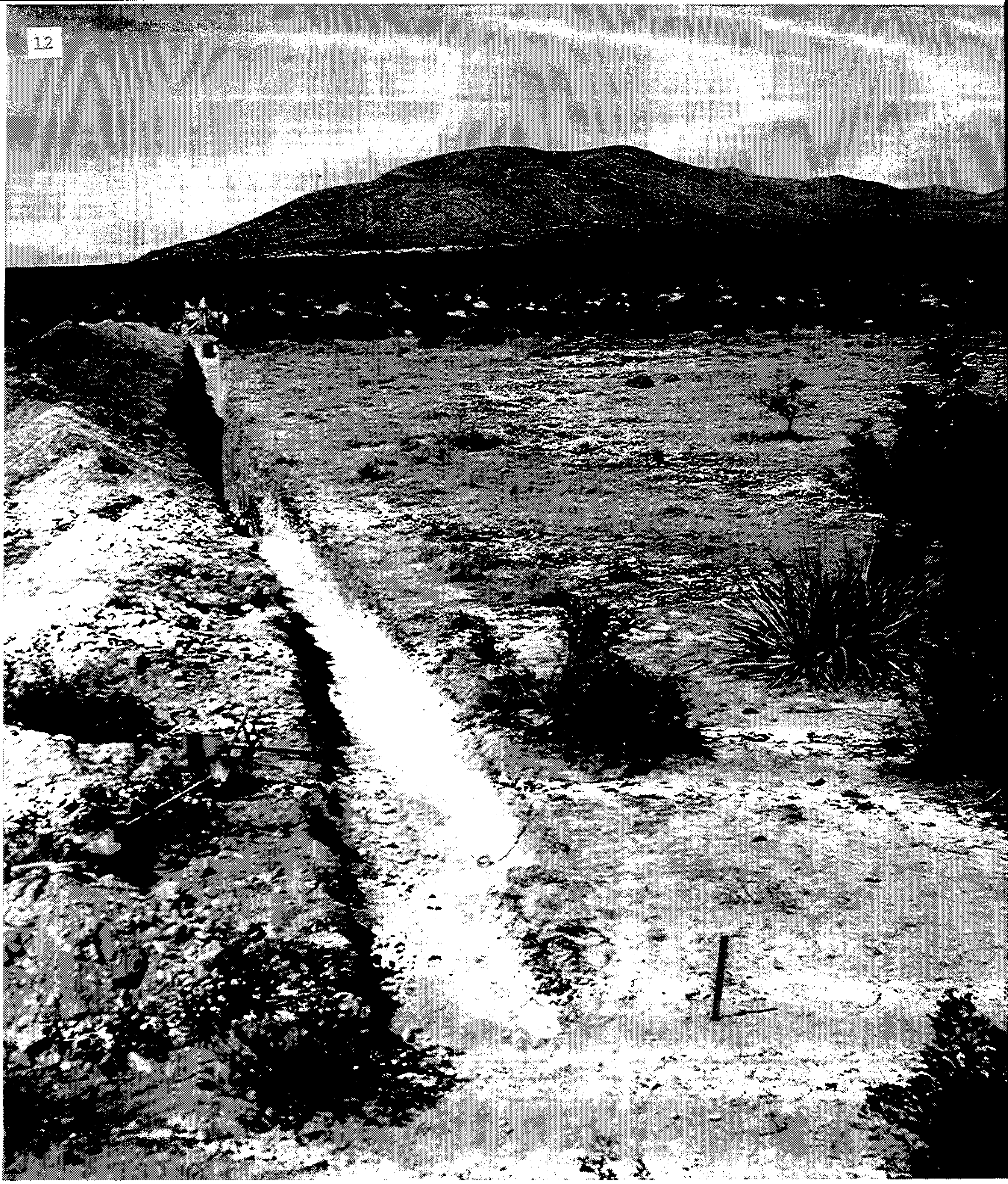

Fig. 5. Landscape of the study trench across the playa (cf fig. 4), looking north. Typic Petrocalcids are exposed in the foreground part of the trench, Typic Haplotorrerts in the central part, and Typic Petrocalcids in the far end of the trench, by the backhoe. The Caballo Mountains are on the skyline. Photographed October, 1969.

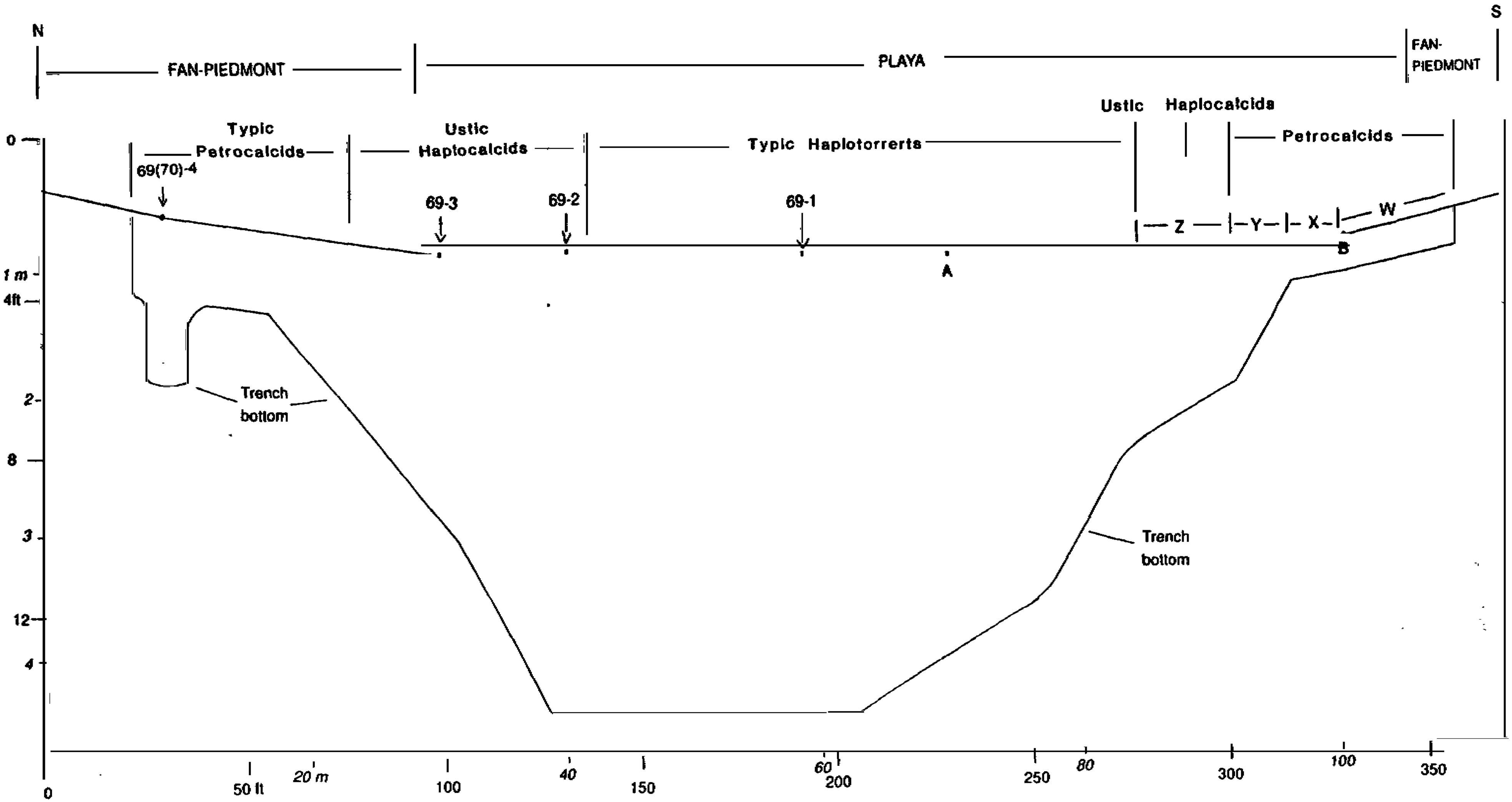

Fig. 6. Trench across the playa (at #1, fig. 4). Sampled pedons are located on north side of trench; described sections W-Z are located on the south side. The trench bottoms in an extremely hard Km horizon that could not be excavated by backhoe. The deepened zone at left was dynamited. See figs. 7-14 for illustrations of the four analyzed pedons, located above by arrows and an abbreviation of the sample number (e.g., 69-1=S69NM-013-001).

An elevational survey with a dumpy level and rod showed these relative elevations along the trench, assigning a value of 100 ft to the lowest point (A in Fig. 6): pedon 69-1, 100.16; pedon 69-2, 100.29; pedon 69-3, 100.24; pedon 69-4, 101.24; point A, 100.00; point B, 100.46. Thus, the playa (Fig. 6) is very nearly level, and the adjacent fan piedmont slopes into it.

Northeast side of playa, northwest part

Four pedons were sampled in the central and northwestern part of the trench (fig. 6). Table 3 presents selected laboratory data for the four pedons; complete data and pedon descriptions are in the appendix. The pedons are discussed in their numerical order of sampling, from the center of the playa towards the fan piedmont (fig. 6).

The Typic Haplotorrert, Dalby 69-1

Figure 7 shows the landscape and upper profile of the Typic Haplotorrert Dalby 69-1. The soil surface is marked by gilgai microrelief (small depressions and holes, fig. 7; see also pedon description). Small holes, a few cm in diameter and of irregular shape, descend from some of the small depressions deeper into the soil. This microrelief is attributed to movement of surficial water and fine earth into deep cracks that form during dry periods. Most of the area is occupied by grass, mainly burrograss, with scattered clumps of tobosa. Barren areas between the grass clumps generally range from about 5 to 20 cm wide, but some are considerably larger.

As is characteristic of Vertisols, clay content changes little with depth (table 3) due to repetitive cycles of shrinking and swelling when the soil is dried and wetted. The morphological evidence of this shrinking and swelling (wedges, slickensides, and similar clay content with depth) occur in a zone from about 31 to 159 cm depth (see Soil Survey Staff, 1975, page 375, for a discussion of origin of wedges and slickensides). There has been little of this profound mixing below about 159 cm depth as indicated by the absence of wedges and slickensides, and by the presence of such pedogenic features as carbonate filaments; black manganese oxide filaments and coatings; gypsum filaments and coatings; Bt material with oriented clay; calcareous and noncalcareous zones; and blocky structure.

Lithologic discontinuities and soil morphology (appendix) indicate buried soils at about 194 and 325 cm depth. Most parts of the Btkb2 horizon in the lowest buried soil are still noncalcareous. The Btkb2 and K2mb2 horizons could be traced continuously 12 m to the north, where the Bt horizon was still noncalcareous in part.

This lowermost buried soil in Dalby 69-1 was eventually buried by a layer with abundant gravel consisting of rounded calcrete fragments derived from Km horizons of the alluvial-fan piedmont upslope. This gravelly layer, which occurs at a depth of 306 to 325 cm (69-1 data, appendix), thickens upslope and in places is as much as 30 cm thick. Deposition of the gravelly layer was followed by a deposit of mostly fine earth (appendix), in which another Bt horizon (the Btk1b horizon, Table 3) formed, with its top at about 194 cm depth. This Btk1b horizon, which could also be traced about 12 m to the north, was eventually buried by clayey sediments in which the Haplotorrert

TABLE 3. Characteristics of soils in and adjacent to the playa.

Depth	Horizon	Particle-size distribution, mm [1/]: Sand 2-.05	Silt .05-.002	Clay < .002	Clay < .0002	Sand fractions: VCS 2-1	CS 1-.5	MS .5-.25	FS .25-.10	VFS .10-.05	Silt fractions: C .05-.02	F .02-.002	Organic C	Carbonate < 2 mm	Carbonate < .002 mm	pH 1:1 H2O	Extractable Na	Extractable K	Bulk density, oven dry	COLE
cm		%															me/100g		g/cc	
Typic Haplotorrert, Dalby 69-1																				
A	0-3	25	49	26	3	0	0	1	7	16	20	29	2.05	9	4	8.1	0.1	3.7		
Bw1	3-16	17	38	44	8	0	1	1	6	10	14	25	0.90	14	8	7.7	0.2	2.7		
Bw2	16-31	17	36	47	12	0	0	1	6	10	13	24	0.63	15	10	7.9	0.3	1.9	1.70	.075
Bw3	31-72	16	36	48	13	0	0	1	5	9	13	23	0.51	14	10	8.1	0.5	1.7	1.83	.091
Bw4	72-110	14	37	49	15	0	0	1	4	9	13	24	0.45	15	10	8.0	1.4	1.5	1.75	.085
BC	110-159	14	40	46	13	0	0	1	4	9	14	25	0.20	16	10	7.9	2.2	1.3	1.70	.072
BCky	159-194	17	38	45		0	1	1	5	10	14	24	0.19	15	9	7.6	2.3	1.1	1.68	.036
Btk1b	194-235	16	38	45		1	1	1	4	10	14	24	0.11	13	7	7.6	2.4	1.0		
Btk2b	235-278	25	34	40		1	2	3	8	12	12	23	0.07	5	TR	7.9	1.9	1.1	1.72	.047
Btk3b	278-306	48	21	31		3	4	7	20	15	10	12	0.03	7	TR	8.1	1.3	0.8		
Btk4b	306-325	53	21	27		20	11	6	10	7	6	14	0.05	64	3	8.0	1.1	0.6		
Btkb2	325-337	50	16	34		3	4	6	21	17	8	8	0.04	16	0	7.7	1.7	0.9		
K2mb2	337-351												0.08	66						
Ustic Haplocalcid, Ratliff 69-2																				
A	0-4	18	54	28	3	0	0	1	5	12	20	34	4.23	10	2	7.8	0.1	3.3	1.56	.029
Bw1	4-15	37	41	22	3	1	1	2	14	20	19	22	1.06	6	4	7.9	0.1	2.4	1.55	.037
Bw2	15-38	38	34	29	7	1	1	3	16	18	17	16	0.75	12	7	7.9	0.1	1.7	1.63	.028
Bw3	38-60	41	31	28	8	1	1	3	18	19	16	15	0.54	13	7	8.1	0.1	1.4	1.66	.039
Bw4	60-88	38	34	28		0	1	3	15	19	16	18	0.43	12	6	8.2	0.1	1.6		
Bk1	88-122	28	36	36		0	1	2	11	14	11	25	0.31	28	13	8.1	0.2	1.5		
Bk2	122-168	25	37	39		0	1	2	10	12	9	28	0.18	32	14	8.0	0.2	1.3		
Bk3	168-224	24	37	39		0	1	2	9	12	9	28	0.11	28	11	8.1	0.2	1.2		
Btk1b	224-268	49	28	24		1	2	5	18	23	13	14	0.04	7	2	8.1	0.4	1.1		
Btk2b	268-289	58	20	23		1	4	9	26	19	9	10	0.04	19	2	8.2	0.4	0.9		
Btk1b2	289-305	57	22	21		3	4	9	26	16	8	14	0.04	33	2	8.2	0.5	0.7		
Btk2b2	305-318	59	16	24		1	4	9	29	16	6	10	0.04	20	1	8.2	0.6	0.8		
K1b2	318-336												0.08	71						
K1b2	318-356	(sampled laterally - see description)											0.08	81						
Ustic Haplocalcid, Ratliff 69-3																				
A	0-5	18	56	26		0	1	1	5	12	19	36	4.06	12	4	7.8	0.2	2.6	1.51	.022
BA	5-15	44	35	21		1	1	3	18	21	16	19	1.24	12	4	7.9	0.2	1.2	1.48	.016
Bw1	15-38	44	33	23		1	1	3	19	20	16	17	0.62	15	7	8.1	0.2	1.0	1.44	.011
Bw2	38-61	46	31	24		2	2	4	20	19	14	17	0.46	21	10	7.9	0.2	0.8		
K1	61-72	37	32	31		1	2	3	16	15	11	22	0.43	38	18	8.1	0.2	0.5	1.48	.016
K2	72-105	31	38	31		1	2	3	13	12	8	29	0.31	48	20	8.2	0.2	0.5		
K3	105-144	36	33	31		1	1	4	17	13	8	26	0.16	40	17	8.0	0.2	0.5		
Bkb	144-157	40	30	30		2	2	4	18	14	8	22	0.11	31	13	8.0	0.2	0.5		
Btkb	157-173	36	34	30		2	3	4	14	14	11	23	0.11	32	8	8.0	0.2	0.7		
Kb	173-183	35	37	28		3	2	4	13	14	11	26	0.19	59	11	8.1	0.2	0.6		
K2mb	183-197												0.12	84						
Typic Petrocalcid, Tencee 69(70)-4																				
A	0-5	65	25	10		1	2	5	27	30	16	8	0.51	10	3	8.4	0.2	0.9		
K11	5-18	55	29	16		1	2	4	23	26	18	11	0.85	18	5	8.1	0.2	1.0		
K12	18-37												0.27	72		8.0	0.2	0.5		
K21m	37-44												0.43	85		8.2	0.2	0.2		
K22	44-64												0.23	85		8.1	1.6	0.2		
K23m	64-84												0.19	70		8.2	1.5	0.1		
K24m	84-97												0.23	85		8.4	1.2	0.1		
K25m	97-131												0.15	85		8.3	1.8	0.1		
Argic Ustic Petrocalcid, Hilken analog 70-4																				
E	0-7	22	52	26	3	0	0	1	5	16	16	36	1.83	4		7.8	0.2	4.1		
BAt	7-16	19	47	34	6	0	0	1	5	14	15	32	0.63	TR		7.9	0.2	3.6	1.48	.048
Bt1	16-25	18	45	37	10	0	0	1	4	13	14	31	0.92	0		7.7	0.2	2.9		
Bt2	25-46	18	41	40	16	0	0	1	5	12	14	27	0.84	3		7.9	0.2	2.2	1.63	.058
Bt3	46-71	17	43	41	14	0	0	1	5	11	16	27	0.64	5		7.9	0.2	2.0	1.70	.056
Btk	71-93	21	44	35	13	0	0	1	6	12	20	24	0.44	6		7.9	0.2	1.6		
K21mb	93-117	not analyzed (see text).																		
Btk [2/]	93-117	17	39	43		0	0	1	5	10	19	20	0.44	8		8.0	0.2	1.6		

1/ Regular basis.
2/ Offset sample 1.5 m to the south, where the K2mb (petrocalcic) horizon is deeper. Because the K2mb is at 100 to 150 cm depth, the soil is a Petroargid (Soil Survey Staff, 1994; Stellar, deep petrocalcic analog; table 1).

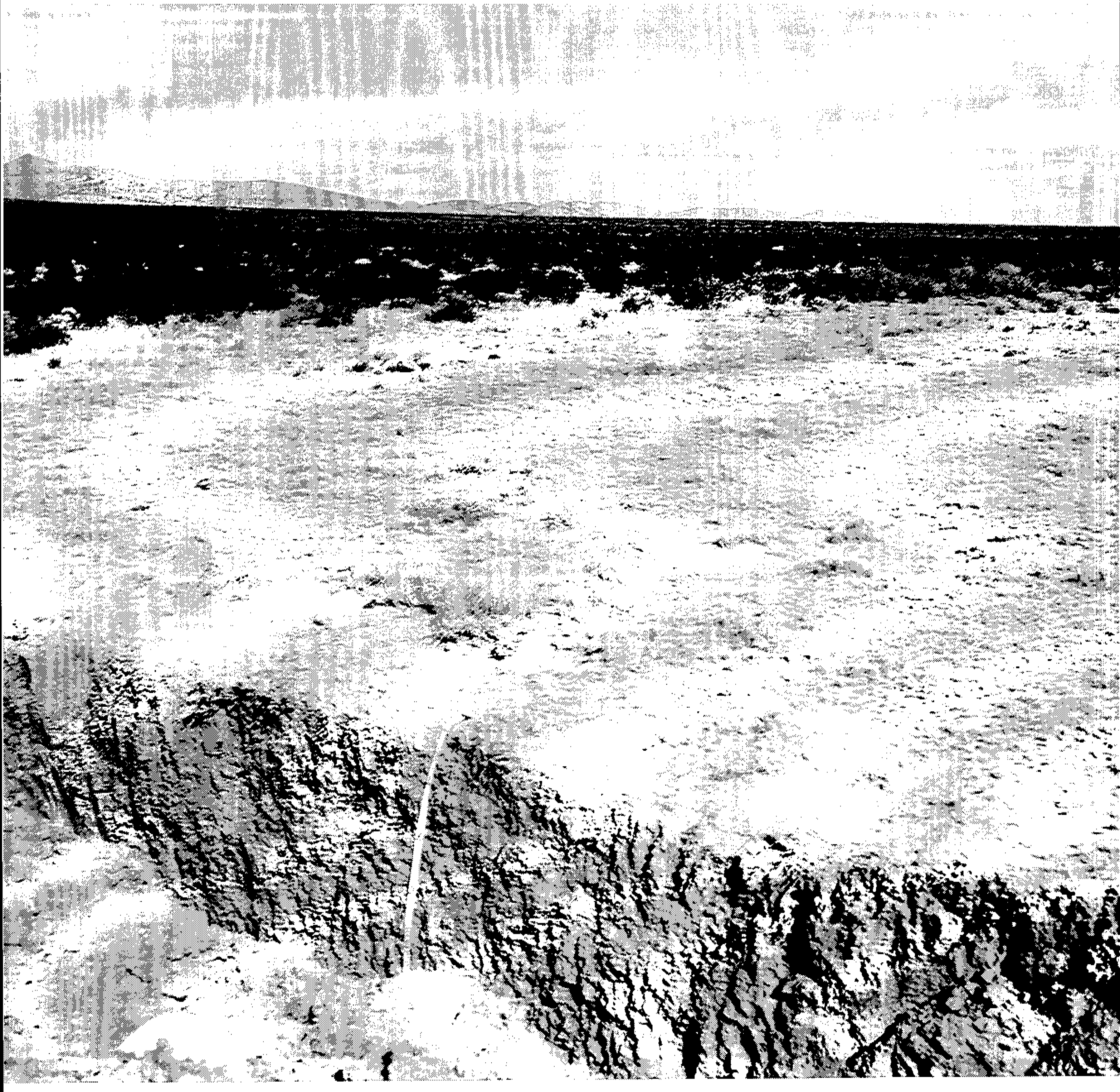

Fig. 7. Landscape and upper horizons of the Typic Haplotorrert Dalby 69-1. Note the common barren areas and gilgai relief. The dark boundary of shrubs marks the edge of the playa. The Caballo Mountains are on the skyline at left and center. Photographed November, 1969.

formed. These clayey sediments are generally gravel-free (appendix), perhaps reflecting the gentler slopes that resulted as sediments continued to accumulate in the playa. Continued mixing in the Vertisol would obliterate any evidence of a discontinuity in these fine-textured materials.

The bulk of the sediments in pedon 69-1 and north of it must have been derived from upslope on the fan piedmont. This is because the deposits (as traced along the trench) slope down into the playa, and because the number of calcrete pebbles in the deposits increases towards the fan piedmont upslope.

The Ustic Haplocalcid, Ratliff 69-2

Figure 8 shows the landscape and upper horizons of the Ustic Haplocalcid, Ratliff 69-2, which is 18.3 m north of Dalby 69-1 (fig. 6). The small depressions and holes that typify the surface of the Haplotorrert are absent here. The morphological change between the Haplocalcids and the Haplotorrerts coincides with the change in the soil surface, the Haplocalcids occurring where the small depressions and holes disappear. Vegetation is mostly burrograss and tobosa, with a few snakeweed. There are scattered barren areas ranging from 5 to 30 cm wide.

Morphology of this Haplocalcid (appendix) differs greatly from the Haplotorrert, which has its north boundary about 2.5 m south. In the Haplocalcid, prisms in the B horizon (4 to 88 cm) have blocky structure instead of wedges and plates (Dalby 69-1, 31 to 110 cm). The soil has a nodular stage II carbonate horizon with its top at 88 cm. There is more sand and less clay in the Haplocalcid than in the Haplotorrert (table 3).

The two buried soils in Ratliff 69-2 are the same age as those at Dalby 69-1 since they could be continuously traced between the two pedons. The K1b2 horizon (318 to 336 cm), which was sampled laterally to illustrate a harder zone nearby, has more carbonate than the 318-356 cm horizon (table 3). This harder zone consists of closely fitted blocks of calcrete about 5 to 6 cm thick and about 5 to 15 cm wide. The blocks are firmly packed and set in fine earth which occupies cracks between the blocks, but they can be readily removed with the hammer, and the material is not continuously indurated. This K1 is underlain by material that is much more easily removed and that consists of small calcrete fragments and some reddish Bt material. Carbonate in this material appears to be weathering out, possibly the result of long-continued water movement down the cracks and along the top of the continuously carbonate-cemented material beneath.

Prisms in the Bk3 horizon are oriented 10 to 20 degrees to the north instead of vertical. This may be caused by swelling of the clay in the Vertisol to the south, and/or by moisture movement along the top of the Km horizon just north.

The Ustic Haplocalcid, Ratliff 69-3

Figures 9 and 10 show the landscape and profile of the Ustic Haplocalcid Ratliff 69-3, which is 9.8 m north of Ratliff 69-2. Vegetation is mostly burrograss, with scattered tobosa and snakeweed. There are a few barren areas 10 to 30 cm wide.

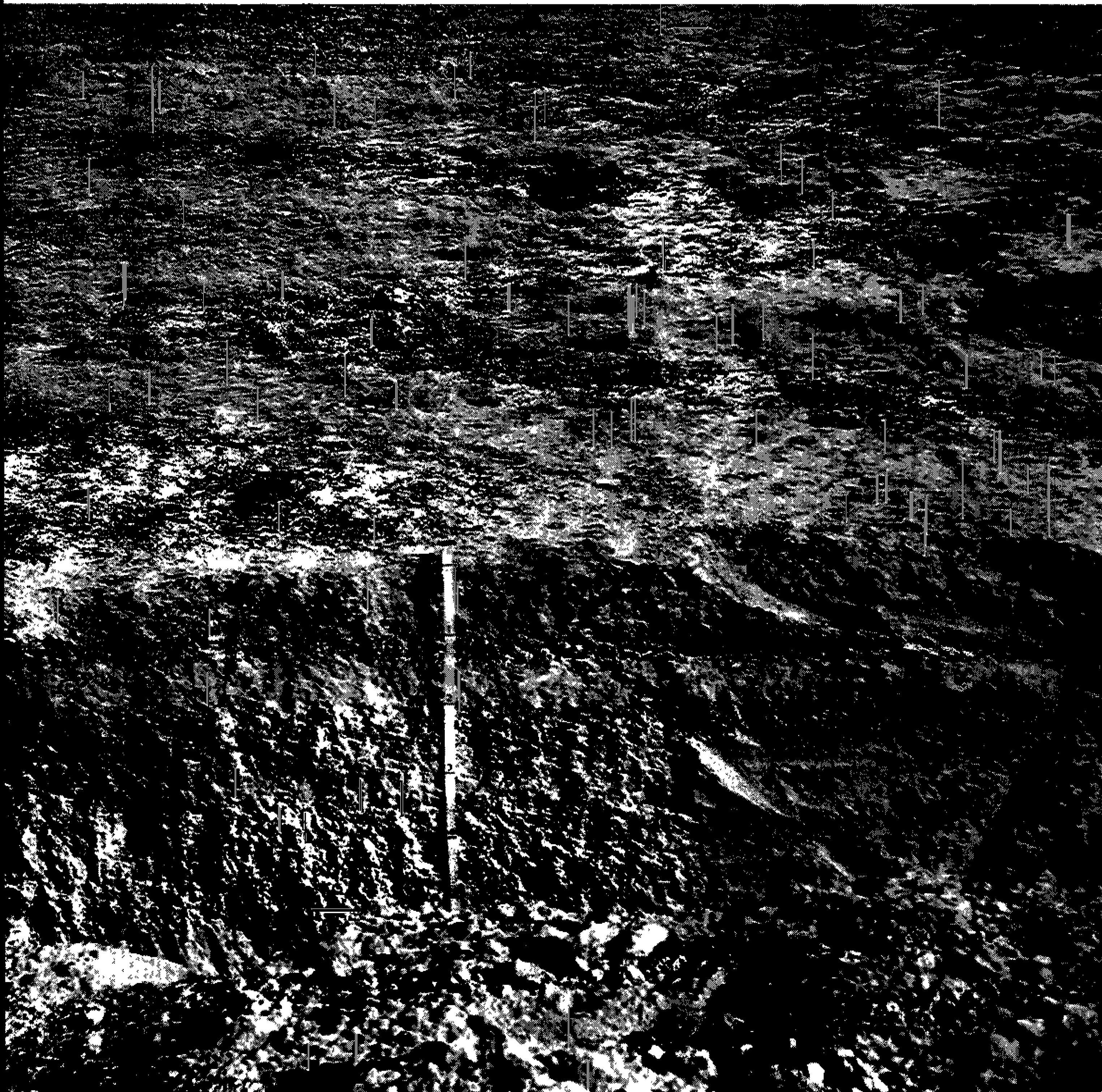

Fig. 8. Playa landscape and upper horizons of the Ustic Haplocalcid Ratliff 69-2. Note gilgai beyond the trench at right. The edge of the gilgai coincides perfectly with the morphological boundary between the Vertisols at extreme right and the Haplocalcids which occupy the rest of the exposure. Scale is in feet. Photographed November, 1969.

Fig. 9. Landscape of the Ustic Haplocalcid Ratliff 69-3. The line of shrubs beyond the tape marks the edge of the playa. Slightly darker tongues descending across the face in places along the exposure represent fine earth washed down from the surface after a heavy rain. The Caballo Mountains are on the skyline. Photographed November, 1969.

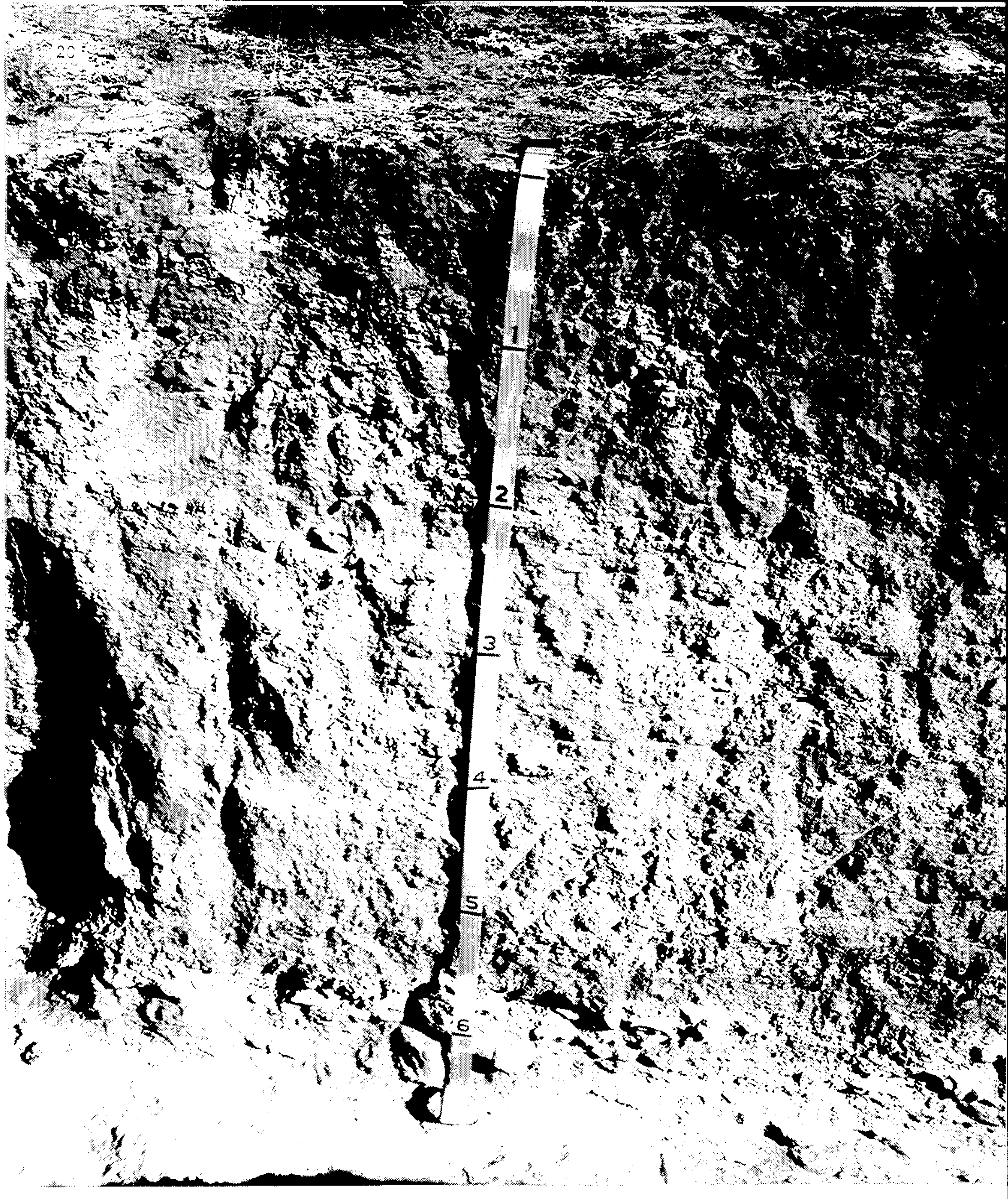

Fig. 10. Profile of the Ustic Haplocalcid Ratliff 69-3. Note the very gravelly horizon at a depth of about 6 ft. The gravel consists of calcrete fragments that rest on top of the petrocalcic horizon at the base of the trench. Scale is in feet. Photographed November, 1969.

Ratliff 69-3 has less clay, more sand and more calcrete pebbles than Ratliff 69-2 (table 3; appendix). The pebbles are subrounded to subangular calcrete fragments. Ocurrence of th se pebbles throughout the deposit strongly suggests that most of them must have been derived from carbonate horizons upslope.

The trench is considerably shallower at Ratliff 69-3 than at pedons 69-1 and 69-2 (fig. 6), and only the upper buried soil in those two pedons could be traced to Ratliff 69-3. Occasional reddish, noncalcareous spots in the Btkb horizon indicate that it was once largely or wholly noncalcareous, and that the former Bt material has now been largely engulfed by carbonate associated with formation of the overlying K horizon. Partial obliteration of former Bt horizons by carbonate was found to be a very common feature at the Desert Project (Gile et al., 1981, p. 74, 75). Carbonate-free clay data (indicated as buffered, second tier of first data sheet, appendix) show a distinct increase in silicate clay for the Btkb horizon, supporting the interpretation of a Bt horizon.

Above the buried soil, Ratliff 69-3 has a stage III K horizon and more carbonate than the land-surface soil at Ratliff 69-2. The K horizon is attributed to lesser depth of wetting on the margin of the playa. No carbonate nodules or filaments occur in the Bw horizon, suggesting that carbonate accumulation at the present time is largely in the K1 horizon.

In contrast to soils at the playa surface in this transect, the buried soils have Bt horizons, illustrating a change in the direction of soil development during evolution of the playa. This change is attributed to a change in parent materials; the soils at the playa surface apparently formed in parent materials that contained more carbonate than did the buried soils. This increased carbonate may have been caused by long-continued soil truncation upslope, which would bring high-carbonate horizons closer to the surface, where they would be more readily available for sediment movement downslope.

The Typic Petrocalcid, Tencee 69(70)-4

Fig. 11 shows Typic Petrocalcids at the north end of the trench dug in the 1969 excavation, which penetrated only to 64 cm. The tape locates Tencee 69(70)-4. In 1970 the trench was deepened by blasting and cleaned out by backhoe (fig. 12). The soil surface has a desert pavement of extremely hard calcrete fragments, mostly ranging from about 1/2 to 3 cm in diameter. Shallowness of the K horizon (at only 5 cm depth, table 3) is typical in these ancient soils, and suggests long-term erosion, in which the more friable and easily erodible A and B horizon materials that once must have been at the surface have now been eroded away. Vegetation consists of creosotebush, tarbush, prickly pear, mammillaria cactus and small clumps of bush muhly around some of the creosotebush.

The K1 horizon contains calcrete fragments derived more or less in place from upper subhorizons of a formerly continuous Km horizon. With erosion of surficial horizons, roots and moisture can more readily penetrate cracks in a

Fig. 11. Landscape of the Typic Petrocalcid Tencee 69(70)-4 (at the tape), in the alluvial-fan piedmont. This is the north end of the trench that crosses the playa (see fig. 5). The tape, darkened by ink, is about 2 feet long and locates the site deepened in 1970 (see figs. 12-14). The Caballo Mountains are on the skyline. Photographed November, 1969.

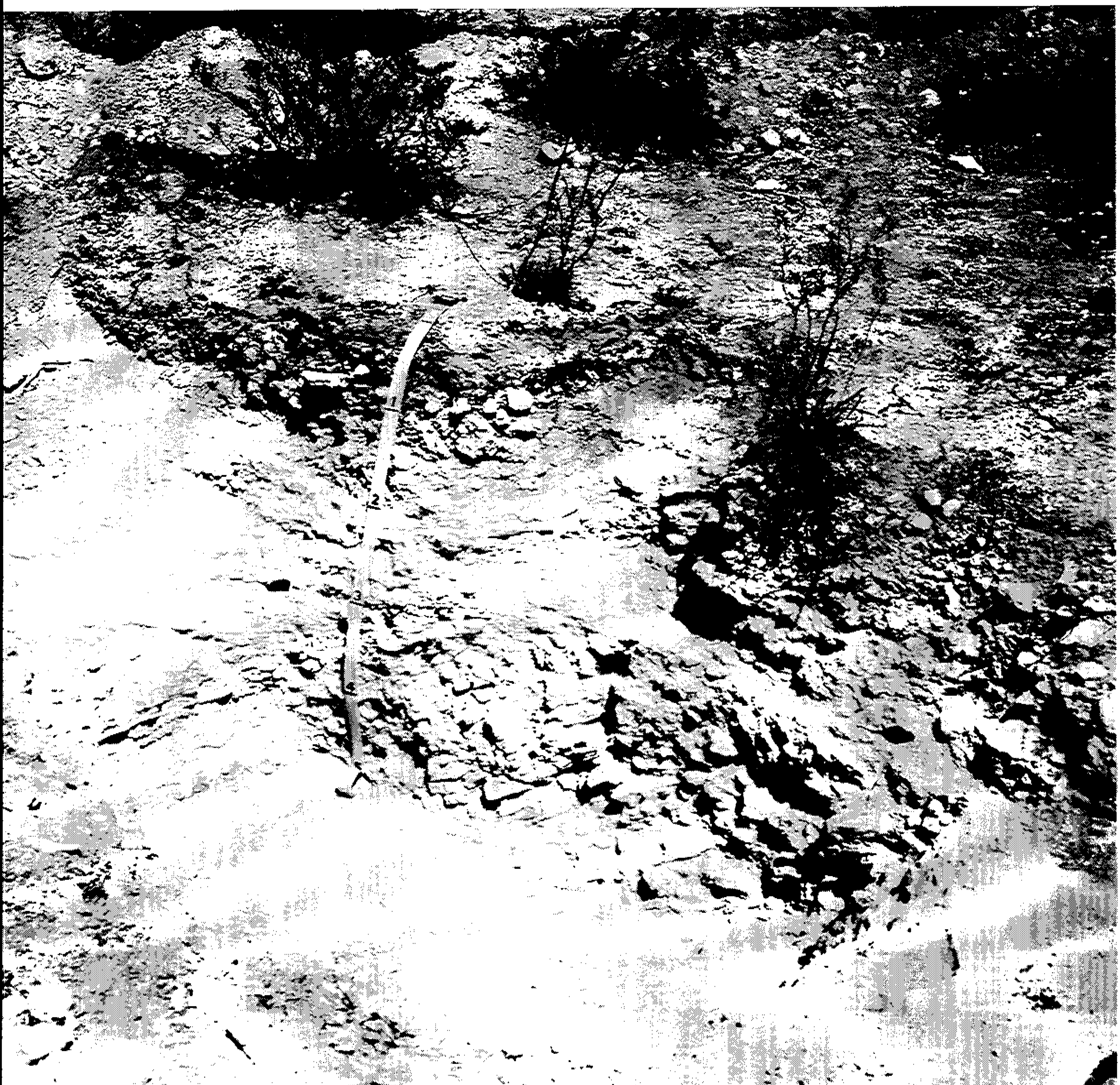

Fig. 12. The Typic Petrocalcid 69(70)-4 at right of tape; 1970 excavation after dynamiting the section. Steeply dipping laminae (fig. 14) occur at right of tape; stage VI pisoliths are exposed at left of tape. Scale is in feet. Photographed April, 1970.

petrocalcic horizon, eventually fracturing it. The same phenomenon is widespread in dissected landscapes in the Desert Project (Gile et al., 1981, p. 110).

The K12 horizon consists primarily of calcrete fragments of gravel size. The surface of many calcrete fragments are partly rounded and smooth, probably by the action of soil water and roots. Such rounding probably happens most rapidly during a pluvial episode, when there would be more available water.

Carbonate in the Km horizon at the sampled pedon (at the right of the tape, fig. 12) can be divided into two general kinds that differ in morphology and age. The uppermost part of the Km horizon has laminar and massive carbonate that commonly has 10YR or 7.5YR hue. This carbonate is younger because it overlies the older type (which has pisoliths, steep laminae, and some 5YR hues), penetrates it as crack fillings, and occurs as the outer most laminae of laminar coatings on calcrete fragments. In addition to differences in form and color, the younger carbonate seemed less dense and is not as hard as the older type. Both the K24m and K25m horizons have strongly sloping laminar horizons (figs. 12, 14; description, appendix). Sloping laminar horizons also occur just northwest, in the north end of the deepened part of the trench (fig. 13). Sloping laminar horizons commonly line pipes in soils of upper La Mesa at the Desert Project (Gile et al., 1981, p. 121, 124). The sloping laminar horizons and overlying thick K-fabric (fig. 14) in Tencee 69(70)-4 suggests a former pipe now filled with carbonate. This may have chronological significance, as suggested by a comparison of pipes of lower and upper La Mesa surfaces, both of which are younger than the Rincon surface. Lower La Mesa pipes contain relatively little carbonate whereas the older pipes of upper La Mesa contain considerably more (Gile and Grossman, 1979, pp. 418-421). However, the pipes of upper La Mesa are not filled or even nearly filled with carbonate. Thus, pipes that are filled or nearly filled with carbonate might be expected in soils of the Rincon surface, because it is known to be older than upper La Mesa.

At the end of the trench (left of tape, fig. 12, 13) morphology of the Km horizon differs considerably from that of the sampled pedon. A prominent pisolitic zone is shown at left center in figure 13. The redder colors of the pisolitic zone suggest a different regime of soil formation than now exists. Redder colors are features of Bt horizons on the Rincon surface (see also discussions at pedons 70-4 and 69(70)-5). These redder colors of the pisolitic zone may reflect a time of Bt horizon development early in the history of this soil. The younger, yellower carbonate above would have accumulated later, after the Bt horizon was obliterated by soil truncation, engulfment by carbonate and/or biotic mixing (Gile et al., 1981, p. 74, 75). A laminar zone sloping from left to right above the pisolitic zone (fig. 13) probably is a part of the pipe discussed in the nearby sampled pedon (fig. 12). A thick laminar zone occurs beneath the pisolitic zone and appears to be its precursor (fig. 13; see also discussion at pedon 69(70)-5).

Northeast side of playa, southeast part

Vegetation of the area just outside the playa consists of tarbush, creosotebush, *Yucca baccata*, a few Mormon tea, cactus, cholla, and one large

Fig. 13. Carbonate forms exposed in the north end of the Tencee 69(70)-4 study trench (cf fig. 12). A laminar horizon slopes from left to right (above the quarter in the center), and is interpreted as the west wall of an ancient, former pipe that has now been filled with carbonate. The large subangular blocky unit below the quarter contains pisoliths. Note the thick laminar zone below this unit (see text discussion). Quarter gives scale.

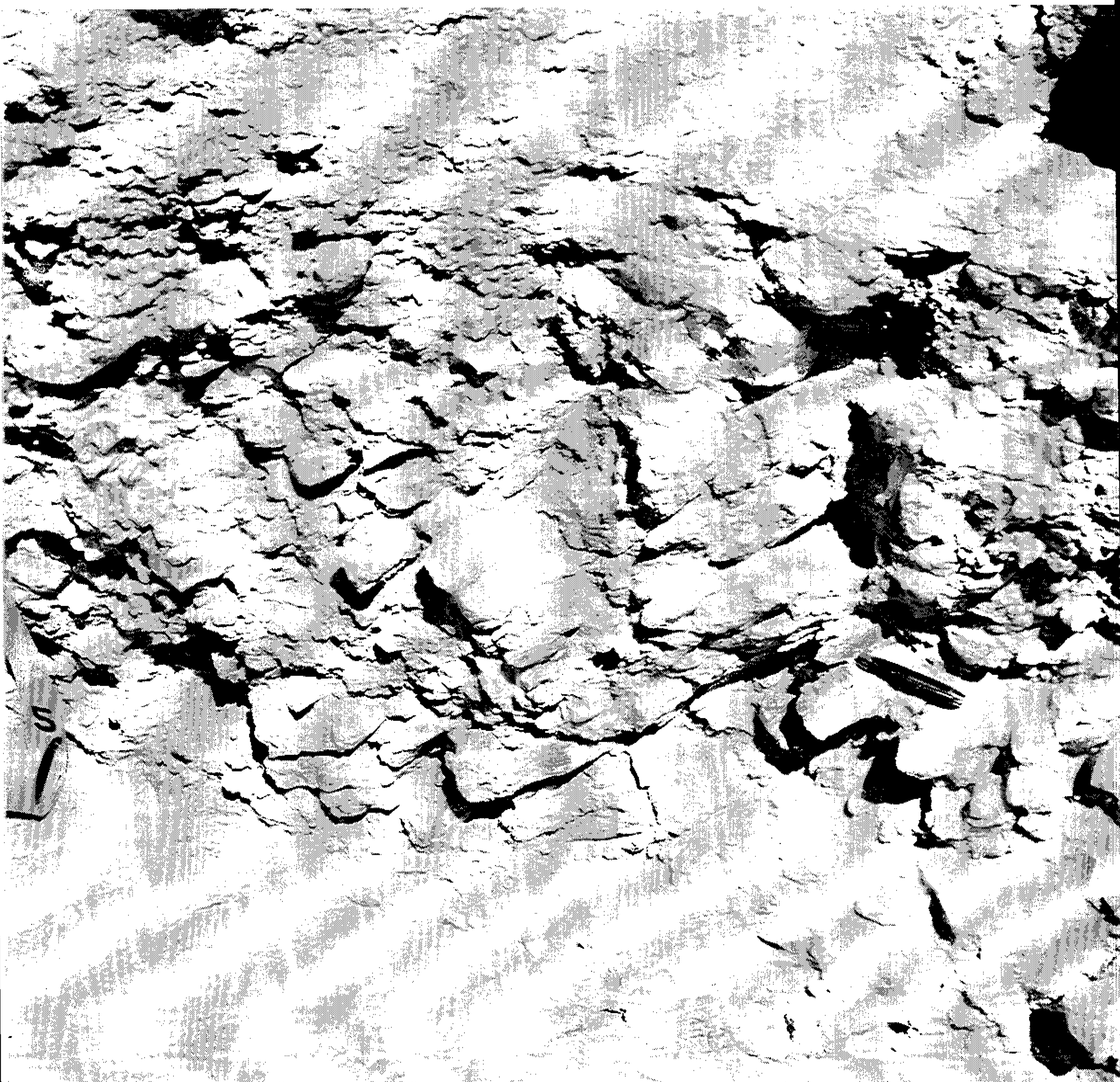

Fig. 14. Closeup of steeply dipping laminae (jacknife) at right of tape in fig. 12. The laminae are thought to represent the margin of a former pipe. Laminae at bottom center slope less steeply. Jacknife and tape (far left) give scale. Photographed April, 1970.

sumac bush east of the trench, along the edge of the playa. All these shrubs look very thrifty and are larger than the same kinds of shrubs where they occur away from the playa. Grass does not occur except at the playa edge, and grass (mainly burrograss and tobosa) is the dominant vegetation in the playa itself. Few shrubs, mostly mesquite, occur in the playa; there are a few scattered snakeweed around the inner margin of the playa and on the west side.

Soil color darkens in the transition from the shrubby vegetation to the grassy vegetation of the playa, but colors are not quite dark enough for a mollic epipedon. No laboratory analyses were made for soils on the southeast side of the trench (fig. 6). Following are comments and partial descriptions for some of these soils, presented in order from the end of the trench towards its center (W-Z, fig. 6).

The Typic Petrocalcids. Simona and Tencee, in zone W (fig. 6)

At the south end of the trench, the A and B horizons of Simona soils extend from 0 to 15 cm and are a light and medium loam respectively; they are nearly gravel-free, having only a few small calcrete fragments. The K1 horizon extends from 15 to 30 cm; the K-fabric occurs as calcrete fragments. The Km horizon occurs at a depth of 30 cm.

For the rest of zone W, the Km horizon is mostly about 25 to 30 cm from the surface. A low-gravel (about 10% calcrete fragments) loam occurs from about 0 to 10 cm; a very gravelly (calcrete fragments) heavy loam occurs from about 10 to 30 cm. In places the 0 to 30 cm zone averages more than 35% by volume of calcrete fragments and these are the Tencee soils.

In the northern 2.1 m of zone W, the A and B horizons are darker because of grass influence, but not quite dark enough for a mollic epipedon. The A horizon (0 to 5 cm) is 10YR 6/1, dry, 10YR 4/2, moist. The B horizon is commonly 7.5YR 5.5/2, dry, 7.5YR 4/2, moist. The grass roots are much finer and more numerous than the shrub roots. The grass roots extend to the top of the Km where they are concentrated in a mat on its top. The roots are remarkably adaptable in penetrating very fine cracks in the Km, even though it is extremely hard and rock-like. This is transitional to the Ustic Petrocalcid discussed in the next section.

The Ustic Petrocalcid. Conger, in zone X (fig. 6)

The low-gravel horizon thickens northward and the K1 merges into a Bk horizon with less than 50% of K-fabric. The Km horizon deepens slightly to the north, ranging from about 30 to 40 cm from the surface. At 1.2 m south of the boundary to unit Y (fig. 6) are these horizons.

A, 0 to 5 cm: 10YR 5.5/2, dry, 10YR 3.5/2, moist; light loam.
B, 5 to 28 cm: 7.5YR 5.5/2, dry, 7.5YR 4/2, moist; medium loam.
K1, 28 to 36 cm: 7.5 6/2, dry, 7.5YR 4/2, moist; very gravelly loam.
K2m, 36 cm.

<u>The Ustic Petrocalcid, Conger, moderately deep petrocalcic analog (50 to 100 cm to Km), in zone Y (fig. 6).</u>

In zone Y there is the usual thin A horizon and the Bk horizon, which extends from about 5 to 38 cm. Below the Bk horizon there is a light-colored K11 horizon with K-fabric occurring as nodular and massive carbonate that occupies nearly all of the horizon. Carbonate in the K11 horizon (which is extensive in this part of the trench) probably was largely emplaced in the late Pleistocene. Below the K11 horizon, which has little or no calcrete gravel, is a very gravelly K12 horizon, a distinctive zone of quite loose, rounded calcrete fragments. This horizon of rounded gravel occurs continuously along the top of the Km horizon. These rounded fragments, which range from about 2 mm to 5 cm in diameter, appear to have been rounded in place, apparently by action of roots and moisture. Roots extend down into this zone in places.

The following description illustrates the soil 1.5 m south of the boundary to zone Z (fig. 6).

A 0 to 8 cm. Light brownish gray (10YR 6/2, dry) or dark grayish brown (10YR 4/2, moist) loam; weak medium and coarse platy; slightly hard; effervesces strongly; roots common; clear smooth boundary.

B 8 to 23 cm. Light brownish gray (10YR 6/2 dry) or brown to dark brown (7.5YR 4/2, moist) clay loam; few fine tubular pores; weak coarse prismatic parting to weak medium subangular blocky; few roots; effervesces strongly; clear wavy boundary.

Bk1 23 to 38 cm. Light brownish gray (10YR 6/2, dry) or dark brown (10YR 4/3, moist) clay loam; weak coarse prismatic parting to weak medium and coarse subangular blocky; few roots; few very fine tubular pores; scattered fine (1 mm diameter) carbonate nodules, appear to have formed in place; effervesces strongly; clear wavy boundary.

Bk2 38 to 50 cm. Very pale brown (10YR 7/3, dry) or dark brown (10YR 4/3, moist) clay loam; weak medium subangular blocky; slightly hard and hard; more fine carbonate nodules than above, and increased carbonate diffused throughout; about 5% by volume of calcrete fragments scattered throughout, up to 4 cm diameter; few fine tubular pores; effervesces strongly.

K11 50 to 71 cm. Pink (7.5YR 8/4, dry) or light brown (7.5YR 6/4, moist) silty clay loam; massive; slightly hard; a few carbonate nodules (2-10 mm diameter), that are 7.5YR 7/4, moist; few fine tubular pores; effervesces strongly; occasional rounded calcrete fragments throughout, up to 5 cm diameter, occupy about 10 percent by volume; abrupt wavy boundary.

K12 71 to 84 cm. Light brown (7.5YR 6.5/4, dry) or brown (7.5YR 5/4, moist) very gravelly clay loam; weak very fine granular; loose mass of granules between calcrete fragments; many rounded calcrete fragments 2 mm to 15 cm diameter; roots are quite common in the K12 horizon, more so than in B horizon.

Scattered small calcrete fragments occur in the Bk1 position along the trench, but generally not above the Bk1. Larger fragments are scattered throughout horizons below this.

The Ustic Haplocalcid, Reagan, deep petrocalcic analog (100 to 150 cm to Km) in zone Z (fig. 6).

This soil has a calcic (K11) horizon at about 50 cm depth. The B and K11 horizons are a silty clay loam. The pedon is fine-silty in the 25-100 cm control section. The Km horizon is fairly regular in its occurrence and depth, deepening gradually to the north.

The distinctive zone of rounded calcrete pebbles continues from zone Y. Most range from about 2 to 5 cm in diameter. Some pebbles are discontinuously stained reddish brown, suggesting accumulation of silicate clay. Many pebbles have thick, continuous laminar coatings.

Vegetation consists of burrograss, scattered clumps of tobosa, and a few snakeweed. Grass clumps occupy most of the surface, with about 20% smooth and barren between clumps, and about 20% cover of horse and cow dung. The soil surface is weakly cracked into polygons. Most of the roots are in the A horizon with a few descending between prisms of the B horizon; almost all of the roots are above depth of 60 cm.

The following description illustrates the soil 3.6 m south of the north boundary of zone Z (figs. 6, 15, 15a).

A 0 to 8 cm. Light brownish gray (10YR 6/2, dry) or dark brown (10YR 3.5/3, moist) clay loam; weak medium platy and weak medium subangular blocky, with platy areas occurring between clumps of grass roots and blocky areas in and near grass roots; hard; few fine pores; roots common; effervesces strongly; clear smooth boundary.

Bw 8 to 23 cm. Brown (7.5YR 5.5/2, dry) or brown to dark brown (7.5YR 4/2, moist) silty clay loam; weak medium and coarse prismatic, parting to weak medium subangular blocky; hard; few fine tubular pores, few roots; effervesces strongly; clear wavy boundary.

Bk1 23 to 36 cm. Brown (7.5YR 5.5/2 dry) or brown to dark brown (7.5YR 4/2 moist) weak medium and coarse prismatic, parting to weak medium subangular blocky; few roots; few fine (1 to 2 mm) carbonate nodules; few fine tubular pores; effervesces strongly; clear smooth boundary.

Bk2 36 to 61 cm. (Light gray (10YR 7/2, dry) or brown (10YR 5/3, moist) heavy clay loam; very weak coarse prismatic parting to very weak coarse subangular blocky; few roots; common fine carbonate nodules, 1 to 3 mm diameter; few rounded calcrete fragments, 1 to 10 mm diameter, scattered throughout; few fine tubular pores; effervesces strongly; clear smooth boundary.

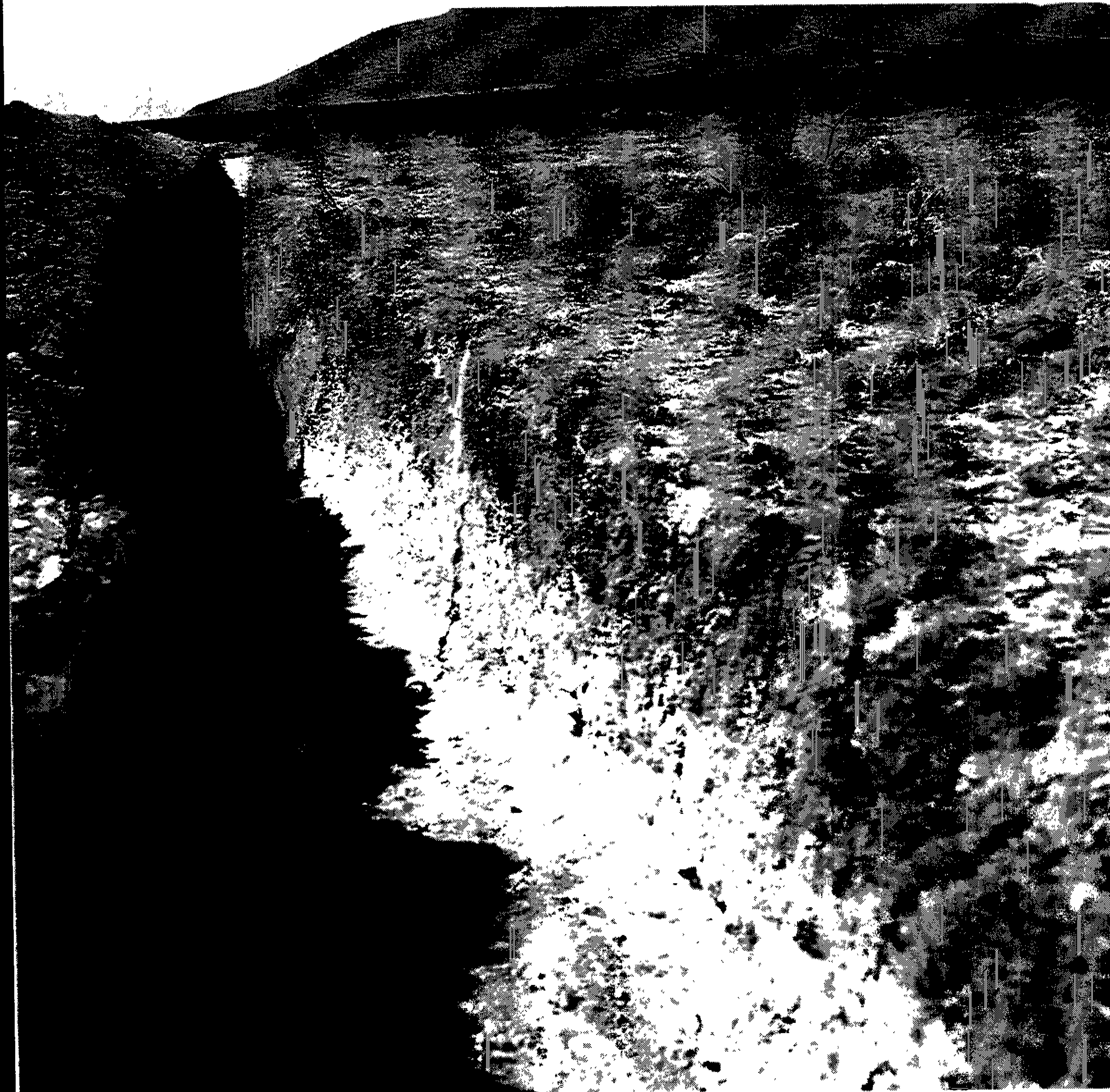

Fig. 15. Landscape of the Ustic Haplocalcid Reagan, deep petrocalcic analog (see fig. 6). The base of the trench is the top of the petrocalcic horizon, which slopes steeply beyond the tape, marking the approximate boundary to the Vertisols in the lowest part of the playa. The Caballo Mountains are on the skyline. Photographed September, 1969.

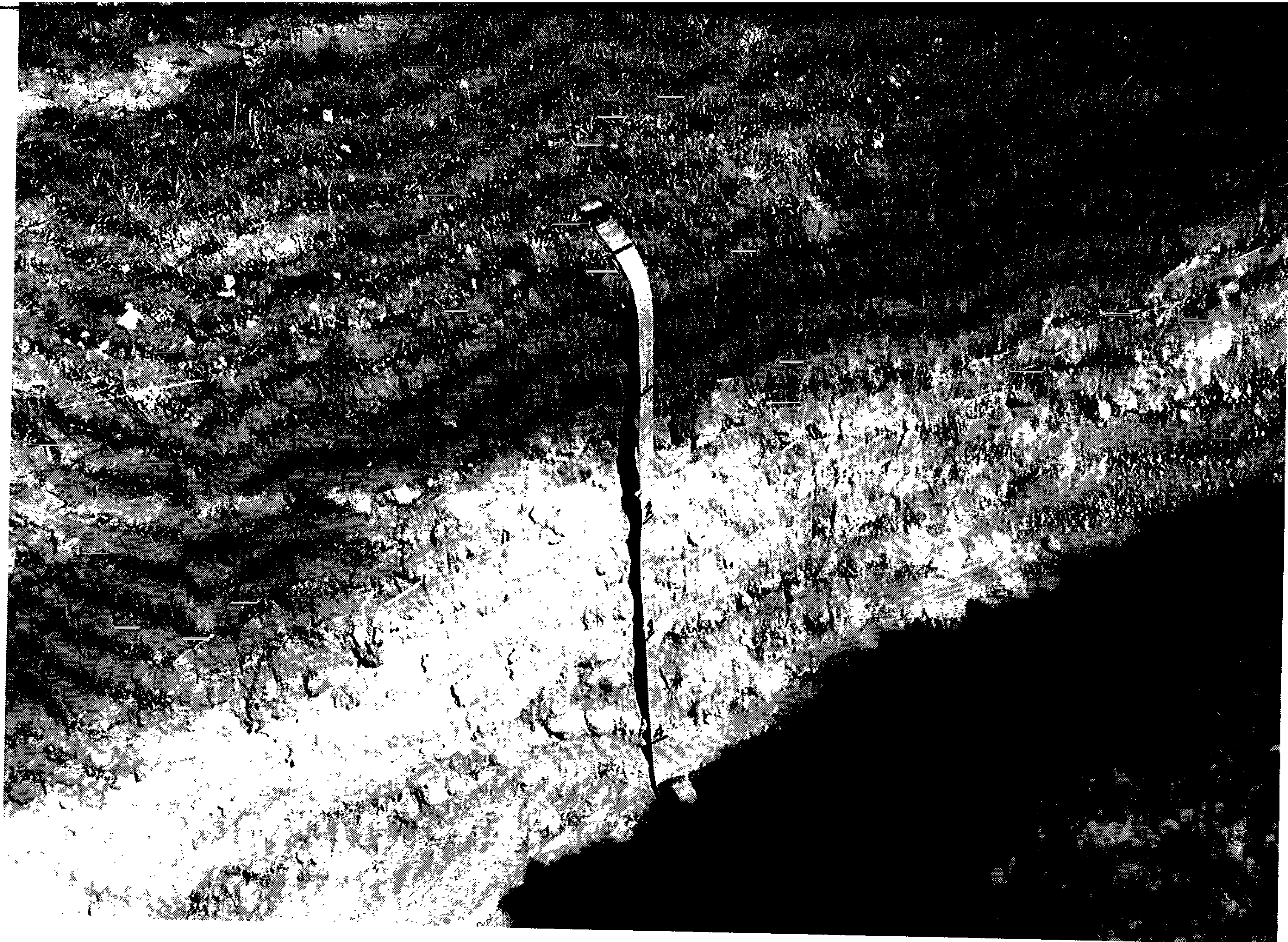

Fig. 15a. Profile of the Ustic Haplocalcid, Reagan, deep petrocalcic analog. Note the very gravelly horizon just above a depth of 4 ft; the gravel consists of calcrete fragments that rest on the petrocalcic horizon. Scale is in feet. Photographed November, 1969.

K11 61 to 102 cm. Dominantly pink (7.5YR 8/4, dry) or light brown (7.5YR 6/4 moist) few carbonate nodules, colored pink (7.5YR 9/4, dry) or pink (7.5YR 7/4, moist); silty clay loam; massive; slightly hard; very few fine roots; few very fine tubular pores; fine-grained carbonate occurs throughout, enough carbonate for a calcic horizon; effervesces strongly; abrupt wavy boundary.

K12 102 to 122 cm. Dominantly pink (7.5YR 7/4, dry) or brown (7.5YR 5/4, moist) very gravelly (calcrete fragments) clay loam; there are a few concentrations of fine roots; in places the calcrete fragments are very tightly fitted together and nearly qualify as a continuous petrocalcic horizon; scattered soft carbonate nodules represent in-place carbonate accumulation and are much younger.

The softer kind of carbonate accumulation (e.g., soft carbonate nodules in the K12 horizon) could have accumulated in the late Pleistocene, judging from the morphology. In contrast, the rounded, extremely hard calcrete fragments (which form a continuous layer along the top of the Km horizon) have a complex origin and chronology. The rounding is not attributed to sedimentary transport, because the slope is short, nearly level (fig. 6), and the same rounding occurs elsewhere in level areas of the Rincon surface. The pebbles have distinct laminar coatings. The internal morphology of these calcrete pebbles includes massive, laminar, and cemented-nodular, indicating variable origin before rounding and exterior lamination. The reddish concentric laminae were not seen, however. The extremely hard K2m horizon at 122 cm depth is the base of trench.

At the north boundary of zone Z (fig. 6) the soils change abruptly from Haplocalcids to Haplotorrerts. This soil boundary also coincides with a surface boundary, because it is here that the small holes begin to occur in the surface. At the same location, slope of the Km horizon and the bottom of the trench increase markedly (fig. 6). The K-fabric in the K11 horizon, which here starts at a depth of about 60 cm, grades into clay with slickensides, and the friable carbonate disappears. This is a good illustration of the effect of clay texture and churning on the development of horizons. Large fracture zones about 50 cm wide are apparent, and extend to a depth of about 70 cm.

Southwest side of playa

The Argic Ustic Petrocalcid, Hilken analog 70-4

In contrast to the northeast side of the playa, soils of the southwest side (fig. 4) are relatively uniform. They are dominated by Argic Ustic Petrocalcids with a petrocalcic horizon at depths <1 m, and by Petroargids in which depth to the petrocalcic horizon is 1 m or more, generally ranging from about 1 to 1 1/2 m. Hilken analog 70-4 illustrates the Argic Ustic Petrocalcids (fig. 16, table 3). Vegetation is mostly burrograss, with a few snakeweed and clumps of tobosa. There are scattered barren areas from 20 to 30 cm wide.

Over the trench as a whole, the E horizon is distinct, consistently present, and ranges up to about 10 cm thick. The E horizon is usually calcareous. The Bt horizon is noncalcareous to as much as 25 cm depth in its

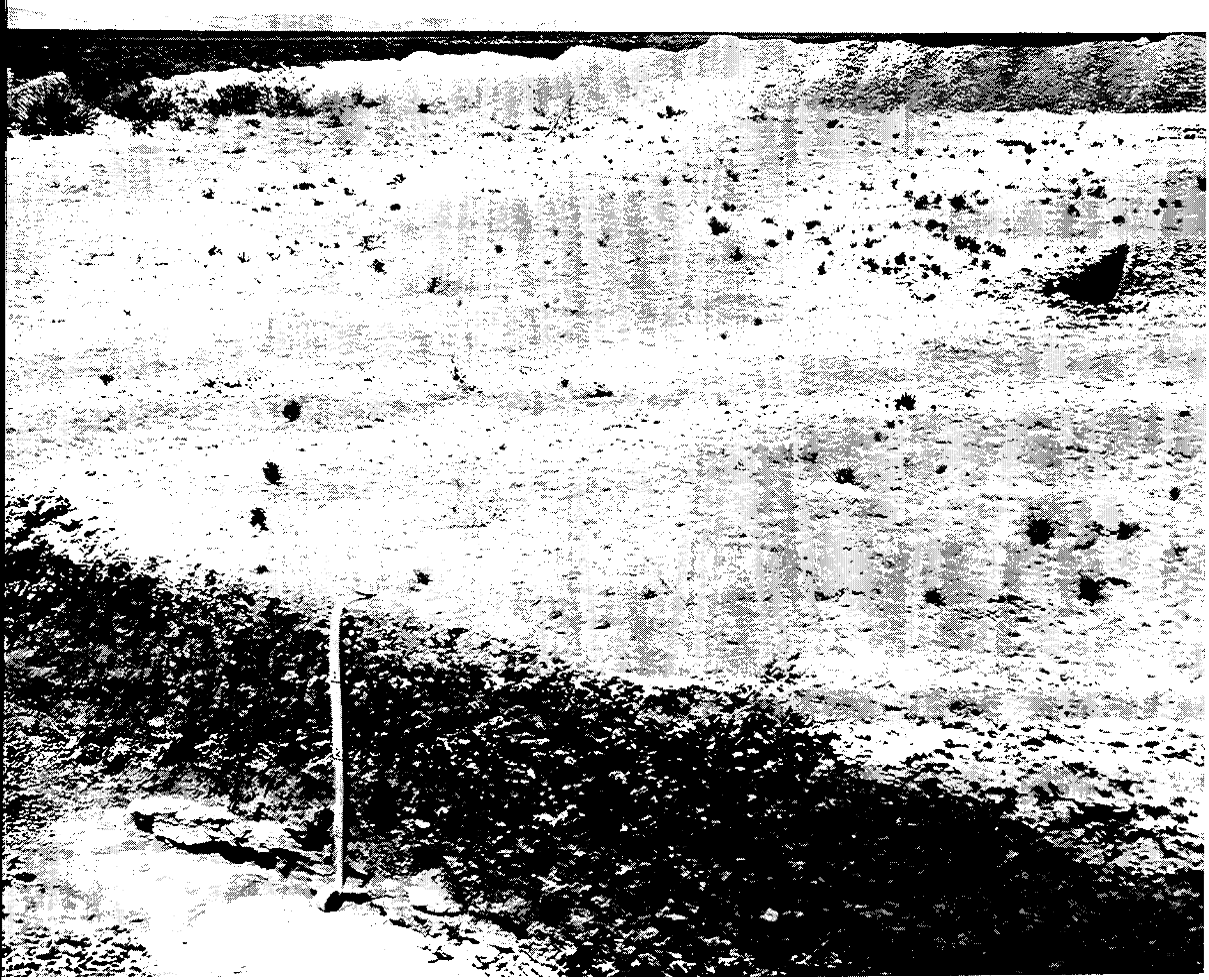

Fig. 16. Landscape and upper horizons of the Argic Ustic Petrocalcid, Hilken analog 70-4, in the western part of the playa, looking northeast. Fill for the main trench across the playa is at center and right in the middle ground. Scale is in feet. Photographed April, 1970.

upper part. The soils are calcareous throughout around edges of the playa, reflecting calcareous run-in from upslope.

The Bt horizon of pedon 70-4 is mostly fine-textured (table 3). The K2mb horizon is at 93 cm depth, and is about at that depth over most of the trench except for the offset sample (table 3) and for an area on the south end of the trench, where depth is about 1.2 m.

Carbonate in the Btk horizon is filamentary and, as for similar situations in the Desert Project (Gile and Grossman, 1979), is thought to have accumulated primarily or wholly in the Holocene. The Bt horizon was probably noncalcareous throughout during the full-glacial pluvial in the late Pleistocene, when clay illuviation may have occurred in the lower part of the Bt horizon and atop the K21mb horizon as discussed later.

The K21mb horizon is thought to be buried although evidence of alluviation and soil burial is not apparent on the southwest side, where slopes above the playa are gentler. Soils such as pedon 70-4 may represent long-term, quite stable sites on the Rincon surface, with additions of sediment being so slight that any evidence of them has been obliterated by pedogenic mixing. The thick argillic horizon is thought to have formed in eolian sediments derived from the Rio Grande Valley to the west, because eolian deposits with argillic horizons have been found east of the Rio Grande Valley south of the Rincon surface study area (Gile, 1994). This would explain the presence of thick argillic horizons just below a fan piedmont with abundant carbonate in the parent materials (high-carbonate parent materials can preclude development of the argillic horizons, Gile et al., 1981). Relatively shallow stage III carbonate in the playa, and the virtual absence of Holocene sedimentation in the Rincon study area, suggest that such an eolian deposit would have been emplaced primarily in the late Pleistocene.

The red (2.5YR 5/6, dry) laminae along the top of the Km horizon (description, appendix) are common in these soils with a Bt horizon resting directly on the Km horizon. The red laminae reflect illuviation of silicate clay, along with carbonate, from the overlying Bt horizon. In contrast to the red laminae, materials below them are dominated by 10YR hues (description, appendix). As noted in the discussion of pedon 69(70)-4, the 10YR hues and horizon stratigraphy indicate that illuviation of carbonate alone (with virtually no silicate clay) was the major genetic process involved in soil formation at the time the 10YR carbonate accumulated. For pedon 70-4, the 10YR hues and horizon stratigraphy discussed above could also indicate that the dominant genetic process before the deposition of eolian sediments was the illuviation of carbonate but virtually no silicate clay.

In places, the top of the K21mb horizon of pedon 70-4 is stained with black material. In the High Plains of southeastern New Mexico, Bretz and Horberg (1949) found similar black accumulations to be manganese oxide. Both the red laminae and the black coatings on top of the Km would appear to be relatively recent features, and may have been deposited from soil water associated with pluvials such as the full-glacial of the late Pleistocene.

The K21mb horizon has stage V pisoliths. Microscopic examination showed that the K21mb horizon also has ooliths and concentric clay laminae (see Tencee 69(70)-5, discussed later, for illustration of these features).

At the time the study trench was dug, the K21mb (but not the K22mb) horizon could be removed by the backhoe. Because the stage VI pisolitic zone at other sites (e.g., 69(70)-4) could not be removed by the backhoe, the K22mb horizon at pedon 70-4 could contain a stage VI pisolitic zone.

Between the east and west trenches

Two small trenches were dug between pedon 70-4 and the long trench across the playa (fig. 4). A trench 7 m east differed in showing a K1 horizon from 77 to 116 cm. A zone with indurated nodules occurred from 116-123 cm depth and was underlain by the Km horizon. This soil is Stellar, deep petrocalcic analog.

A second trench, about 7 m long and 22 m east of 70-4, showed similar horizons over most of the exposure. But only the western 1 m of the trench showed the upper part (7-14 cm) of the Bt horizon to be noncalcareous; the remainder of the exposure was calcareous throughout. In the eastern end of the trench, the Bt, K1 and Km horizons disappeared and the soil changed abruptly from Stellar analog to a Haplotorrert. The boundary of the Haplotorrert coincides with the westernmost occurrence of small depressions and holes in the soil surface, and marks the western edge of the Haplotorrerts in the playa.

Presence of the K1 horizon and stage III carbonate in these two pits is a marked change from pedon 70-4 just west. The change is attributed to the effect of depressions and holes on soil moisture. Loss of surficial water down the holes would reduce depth of penetration of wetting fronts and near the Haplotorrerts would result in the formation of stage III carbonate at shallower depths than for Argic Ustic Petrocalcids such as pedon 70-4.

SOILS OF THE RELICT BASIN FLOOR

Soils of slight depressions and intervening areas: Tencee-Simona-Stellar complex (B, fig. 3).

Several small, roughly circular depressions occur between the playa of unit A and the rim to the south (figs. 3, 17). The depressions are dominated by Ustic Petroargids (Stellar, deep petrocalcic analog), in which depth to the Km horizon is commonly between 1 and 1.5 m, and by Argic Ustic Petrocalcids (Hilken analog), in which depth to the Km horizon is < 1 m. Between these soils in the depressions are slightly higher areas of Typic Petrocalcids (dominantly Tencee and Simona soils), in which the Km horizon is mostly shallow (<50 cm depth).

Pedons 69-6 and 69-7, and another pedon, described but not analyzed in the laboratory, illustrate the Ustic Petroargid Stellar, deep petrocalcic analog. As for pedon 70-4 discussed previously, the Kmb horizon of these soils is thought to have been buried by very gradual accumulations of eolian

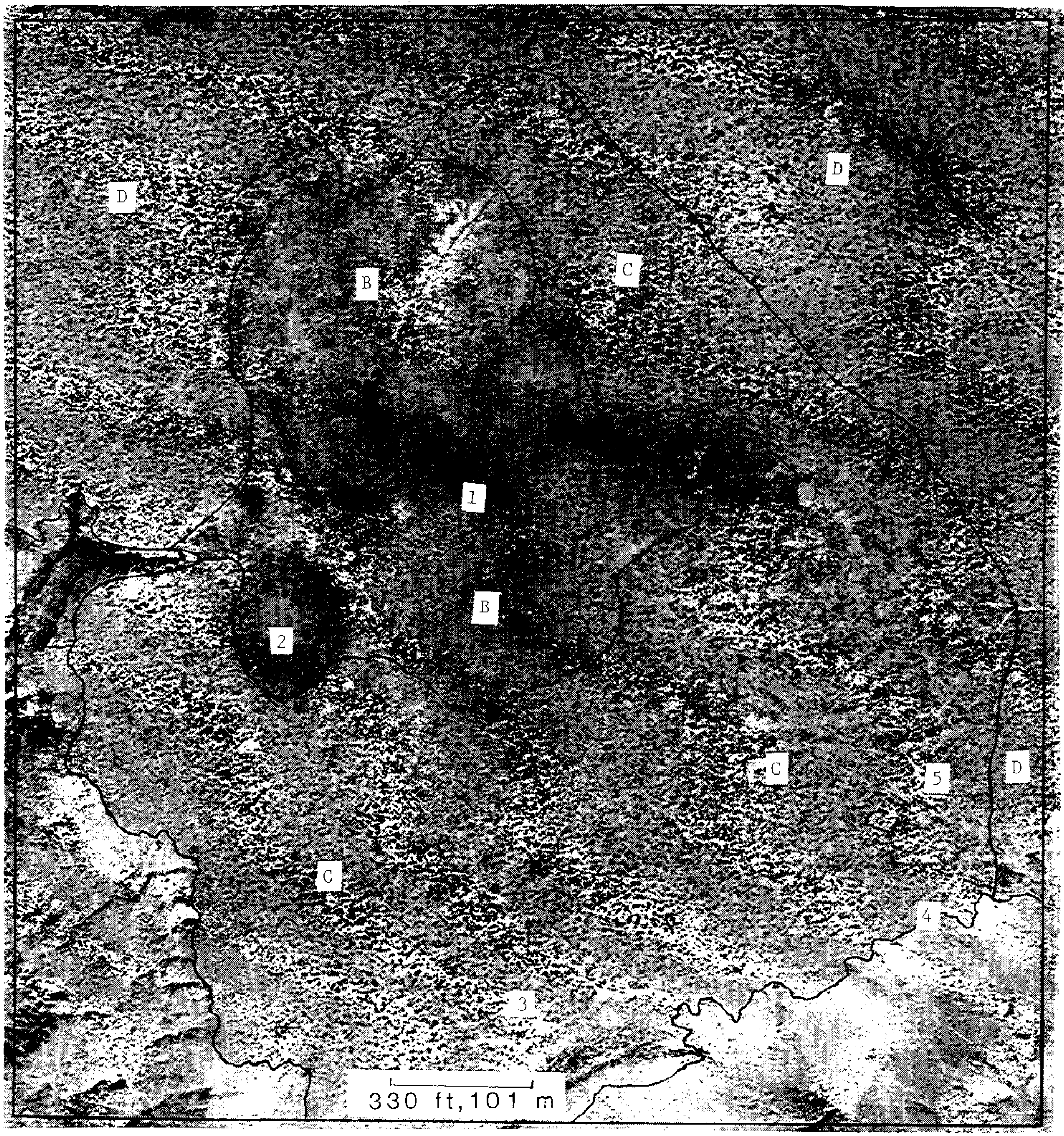

Fig. 17. Enlargement of part of the soil map (fig. 3), locating study trenches. B=Tencee-Simona-Stellar complex; C=Tencee and Simona soils, 0 to 1% slopes; D=Tencee and Simona soils, 1 1/2 to 6% slopes; 1=pedons 69-6,7; 2=pedon described but not analyzed (see figs. 20, 21); 3= pedon 69(70)-5; 4=pedon 70-2; 5=pedon 70-3.

sediments derived from the Rio Grande Valley to the west. Any evidence of a discontinuity would have been obliterated by pedogenic mixing.

The Ustic Petroargid Stellar analog 69-6

Stellar analog 69-6 (fig. 17 and 18, table 4) has a thin E horizon, a Bt horizon with clay and silty clay texture, and a Km horizon at a depth of 130 cm. Vegetation is mainly burrograss, with a few clumps of tobosa, a few mammillaria cactus, and a very few small creosotebush and tarbush. Bush muhly occurs at the base of some of the shrubs. The soil surface is about 50% occupied by grass clumps. The surface is smooth and barren between the grass clumps, and is cracked into polygons ranging from about 3 to 8 cm in diameter.

Stage I filamentary carbonate occurs in the Bt horizon, and analyses (table 4) show a slight carbonate maximum in the Bt2 and Bt3 horizons, well abov the Km horizon. Judging from horizon position and dated soils in the Desert Project, the stage I carbonate could be of late or middle Holocene age. In pluvials, particularly the full-glacial pluvial, the Bt horizon was likely noncalcareous throughout because the greater effective moisture of pluvials would have moved carbonates deeper than now.

This area may have been very stable for a very long period of time, and an area that was little affected, if at all, by erosion cycles of the late and middle Holocene that gave rise to the Organ and Fillmore deposits at the Desert Project. Sedimentation in the late and middle Holocene, and possibly earlier, may have been confined largely to very gradual movement of small amounts of sediment from the adjacent slight highs into the depressions.

The Ustic Petroargid Stellar analog 69-7

Pedon 69-7 is near pedon 69-6, occurring on the south end of the trench (fig. 19). Upper horizons are similar except that the upper subhorizon of the Bt horizon is calcareous and not as red as for pedon 69-6. Analyses (table 4) show that both horizons are very similar except that the calcareous horizon contains 2% carbonate. The subhorizon overlying the Km horizon also differs. Pedon 69-7 has a very gravelly K1b horizon in which the pebbles are extremely hard, rounded calcrete fragments (fig. 19). These are thought to have formed as a result of weathering in place over a very long period of time. Presence of the rounded fragments on this level surface supports the interpretation that the rounding occurred in place and not by sedimentary transport. Some of the rounded fragments are coated with clay, some are coated with carbonate, and some have black coatings.

The K1b horizon is about 75 cm wide at the sample site and laterally changes to a K1b horizon consisting of closely fitting calcrete blocks 10 to 20 cm in diameter. These closely fitted blocks must once have been part of the continuously cemented Km horizon, and apparently represent an early stage in the brecciation process.

A third pedon of Stellar analog

The most visually prominent small depression in the aerial photograph (fig. 17) occurs in the western part of unit B. The surface is level.

TABLE 4. Characteristics of soils in a slight depression and along and near the rim of the relict basin floor.

Horizon	Depth	Particle-size distribution, mm [1/] Sand 2-.05	Silt .05-.002	Clay < .002	Clay < .0002	> 2	Sand fractions VCS 2-1	CS 1-.5	MS .5-.25	FS .25-.10	VFS .10-.05	Silt fractions C .05-.02	F .02-.002	Organic C	Carbonate < 2 mm	< .002 mm	pH 1:1 H2O	Extractable Na	K	Bulk density, oven dry	COLE
	cm	%																me/100g		g/cc	
Ustic Petroargid, Stellar analog 69-6																					
E	0-5	29	44	28	4		0	1	2	10	16	15	28	1.18	0		8.2	0.2	2.8		
Bt1	5-14	20	37	43	11		TR	1	2	7	11	12	24	0.76	TR		8.1	0.2	2.4		
Bt2	14-36	17	35	48	24		0	0	1	6	10	12	24	0.71	3		8.0	0.7	1.7	1.34	1.63
Bt3	36-57	15	39	46	20		TR	0	1	4	9	13	26	0.59	3		7.9	1.3	1.7		
Btk	57-86	12	43	45			TR	0	1	4	8	12	30	0.35	2		8.0	1.7	1.6		
Bt	86-106	14	41	45			TR	0	1	5	8	13	28	0.24	1		8.0	2.0	1.6		
K1b	106-130	28	25	47			1	1	3	11	13	10	15	0.15	11		8.4	1.8	1.0		
Ustic Petroargid, Stellar analog 69-7																					
E	0-6	31	42	28	4	37	0	1	2	10	17	16	26	1.14	1		7.9	0.3	3.2		
Bt1	6-15	19	35	46	17		0	1	1	6	11	11	24	0.83	2		7.9	0.3	2.6		
K1b	104-127	21	25	54	19		1	1	2	8	10	10	15	0.24	14		7.9	2.1	1.7		
Typic Petrocalcid, Tencee 69(70)-5																					
A	0-5	48	37	15		12	1	2	3	18	25	18	19	0.72	13	3	8.3	0.2	1.1		
Bk	5-25	42	38	20		20	1	1	3	15	23	19	19	0.78	23	3	8.2	0.2	0.6		
K1	25-46					53								1.13	46		8.1	0.3	0.3		
K21m	46-61													0.21	85		8.5	0.2	0.1		
A+Bk	0-25	46	37	18		25	1	2	3	16	24	19	18	0.86	19	5					
K22m	61-101													0.15	83		8.7	0.6	0.1	2.57	
K23m	101-148													0.15	83		8.3	0.4	0.1		
K24m	148-162													0.08	72		8.5	0.9	0.1		
Typic Petrocalcid, Tencee 70-2																					
K21m	7-20													0.15	85						
K22m	20-50													0.23	88						
K23y	50-90													0.15	82						
K24m	90-170													0.11	75						
K31	170-250													0.08	62						
K32m	250-330													0.08	51						
Rk	330-370													0.08	64						
R1	370-490													0.04	63						
R2	490-540													0.04	77						
R3	540-610													0.04	20						
Typic Petrocalcid, Tencee 70-3																					
A	0-4	53	34	13		19	1	2	3	20	27	20	15	0.66	22	3	8.2	0.2	1.0		
Bk	4-10	41	34	26		26	1	1	3	16	20	15	19	1.19	29	5	8.0	0.2	0.9		
K11	10-28	38	36	26		40	1	2	3	13	20	18	18	1.16	51	9	7.8	0.3	0.4		
K12	28-42					62								0.62	79		7.9	0.2	0.2		
K21m	42-102													0.11	67		8.0	0.7	0.1		
K22m	102-156													0.15	63		8.0	1.2	0.1		
K23	156-206													0.11	63		7.9	1.5	0.1		
COMP	0-18	47	34	19		21	1	2	3	18	24	17	17	0.86	31	4	8.1				

1/ Regular basis.

Fig. 18. Landscape of the Ustic Petroargids Stellar analog 69-6 (left side trench) and 69-7 (right side of trench, by the tape) looking east. Parts of the Rincon Hills are on the skyline. Photographed November, 1969.

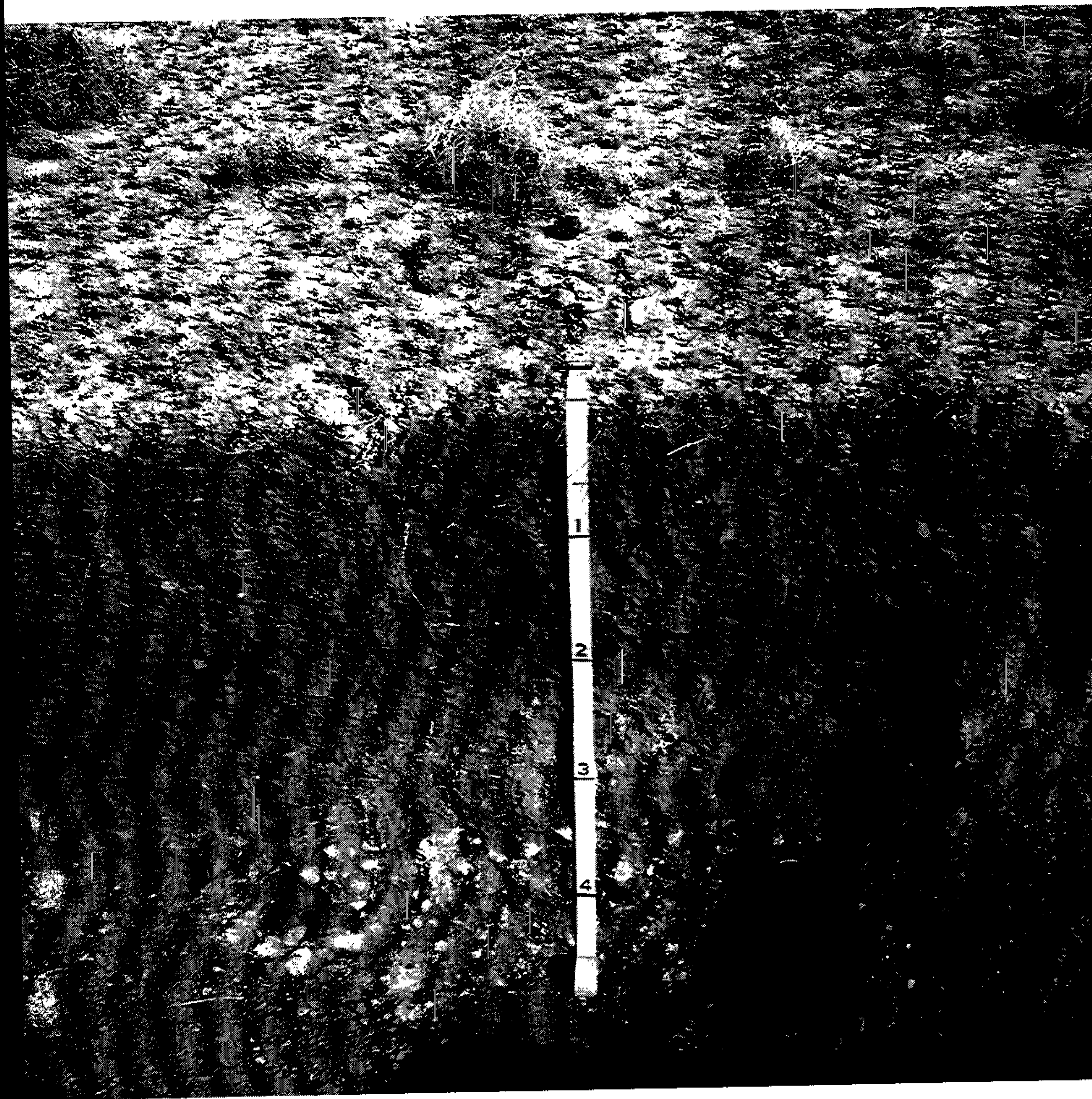

Fig. 19. Closeup of Stellar analog 69-6. Pebbles in the very gravelly layer from 3½ to 4½ ft consist of calcrete fragments, some of which are rounded. Scale is in feet. Photographed November, 1969.

Vegetation over most of the depression consists mostly of burrograss and tobosa, with a very few tarbush. Around the playa margin, which would get somewhat more runoff than the center, there are many more shrubs--tarbush, creosotebush, cholla, prickly pear, and a few sumac. However, the area around the depression slopes only very slightly into it; any runoff would be slight and very slow.

A trench dug about in the center of the depression (figs. 20, 21) showed a soil similar to pedons 69-6 and 69-7. A description follows.

A 0 to 8 cm. Pinkish gray (7.5YR 6/2, dry) or dark brown (7.5YR 4/2, moist) silty clay loam; weak medium and coarse platy; slightly hard to hard; few roots; effervesces strongly; clear smooth boundary.

BA 8 to 20 cm. Brown (7.5YR 5/2, dry) or dark brown (7.5YR 4/2, moist) heavy silty clay loam; weak medium and coarse subangular blocky; hard; roots common; effervesces strongly; clear wavy boundary.

Bt1 20 to 43 cm. Pinkish gray (7.5YR 5.5/2, dry) or brown (7.5YR 4.5/2, moist) clay; a definite clay pickup, which coincides with strongest expression of structure; moderate medium and coarse prismatic parting to weak medium subangular blocky; very hard; very few roots; a few carbonate filaments apparent in places but do not form a continuous horizon; effervesces strongly; clear wavy boundary.

Bt2 43 to 69 cm. Pinkish gray (7.5YR 5.5/2, dry) or dark brown (7.5YR 4/2, moist) clay; weak medium and coarse prismatic parting to weak medium subangular blocky; very hard; very few roots; very few small carbonate filaments; effervesces strongly; clear wavy boundary.

Bt3 69 to 86 cm. Pinkish gray (7.5YR 5.5/2, dry) or dark brown (7.5YR 4/2, moist) clay; very weak coarse prismatic parting to weak medium and coarse subangular blocky; very hard; no roots; very few carbonate filaments along old root channels; effervesces strongly; clear wavy boundary.

Btk1 86 to 107 cm. This is the first distinct horizon of carbonate accumulation. Light brown (7.5YR 5.5/3, dry) or dark brown (7.5YR 4/3, moist) silty clay loam; weak medium and coarse subangular blocky; hard; very few roots; few carbonate filaments on ped surfaces and also some within peds; effervesces strongly; clear wavy boundary.

Btk2 107 to 142 cm. Reddish brown (5YR 5/3, dry) or dark reddish brown (5YR 3.5/3, moist) clay; moderate very fine and fine angular and subangular blocky; hard and very hard; few roots; few carbonate filaments; effervesces strongly; abrupt wavy boundary.

K2mb 142 cm. The upper part of the K2m is rounded and cracked; clay commonly penetrates the cracks and has stained the top of the K2m. In places some of the fragments may be removed and are not strongly cemented to the underlying Km and these form a thin K1 horizon, several inches thick. These fragments range mainly from 1 to 5 cm diameter.

Fig. 20. Landscape of a small depression where Stellar analog occurs. The Caballo Mountains are on the skyline. Photographed October, 1969.

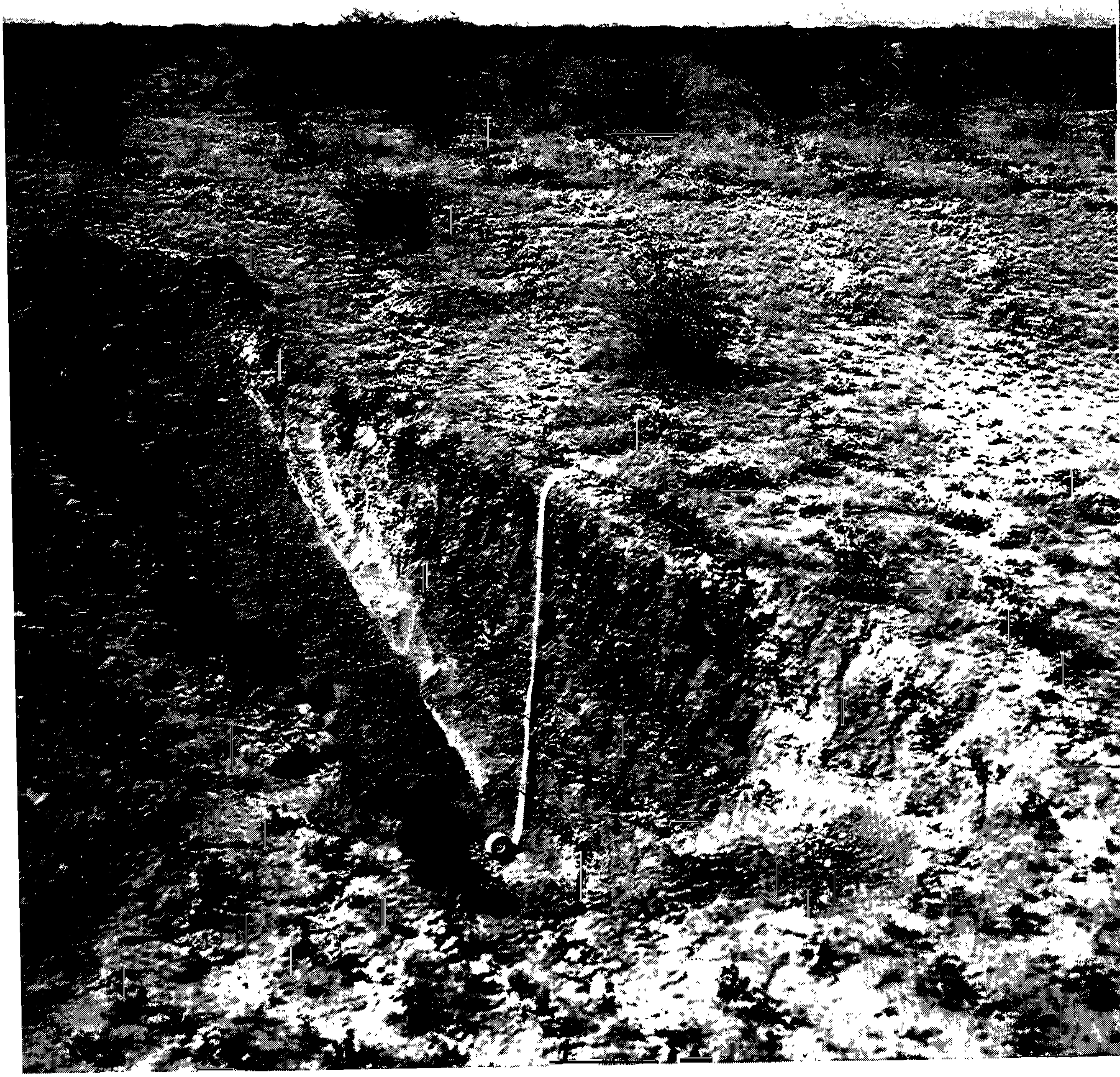

Fig. 21. Profile of the Ustic Petroargid, Stellar analog. Scale is in feet. Photographed October, 1969.

The soil is calcareous throughout and is virtually gravel-free; one calcrete pebble, about 2 cm in diameter, was found at a depth of 92 cm. Although a few scattered carbonate filaments occur in places in the upper part of the Bt horizon (description), the Btk horizon represents the first horizon with regular occurrence of carbonate filaments. This stage I filamentary carbonate extends to the bottom of the pit at a depth of 142 cm.

Soils along and near the scarp: Tencee and Simona soils, 0 to 1% slopes (C, fig. 3)

This area borders the steep scarp cut in the thick Km horizon of the basin-floor soils. Tencee and Simona soils are dominant. Occurrence of the Tencee (skeletal) and Simona (nonskeletal) soils, both Typic Petrocalcids, is dependent upon the volume of rock fragments (>2 mm material) in the control section. In these soils the control section extends either from the soil surface to the petrocalcic horizon, if it is within 36 cm of the soil surface, or, if it is not, from a depth of 25 cm to the top of the petrocalcic horizon. The rock fragments consist mostly of broken-up fragments from the top of the petrocalcic horizon. Pedons 69(70)-5, 70-2, and 70-3 illustrate the Tencee soils. The sample site at pedon 69(70)-5 (figs. 22, 23) shows both Tencee and Simona soils. Although the control section of the sampled pedon (at the tape, figs. 22, 23) contains barely enough rock fragments (35% by volume) for the Tencee soils, at the left of the tape the soils are easily skeletal (Tencee soils), and at the right of the tape the soils are easily nonskeletal (Simona soils).

The Typic Petrocalcid Tencee 69(70)-5

Tencee 69(70)-5 (figs. 17, 22, 23) has a thin A horizon, a Bk horizon with a few carbonate filaments and coatings on ped faces, a K1 horizon with common calcrete fragments, and a very thick Km horizon with subhorizons of both pisolitic and nonpisolitic carbonate. Vegetation consists of creosotebush, a few buckwheat, and scattered mammillaria cactus. The soil surface is about 20% covered with calcrete fragments ranging mostly from about 1/2 to 3 cm in diameter, with some smaller than 1/2 cm. About 30% of the fine-earth surface has rounded, black algal-topped plates with an amplitude of about 1 cm. The level, apparently stable basin floor landscape should reflect maximum expression of pedogenesis on the Rincon surface.

The 1969 sampling included only the upper subhorizon of the Km horizon. The pit was deepened by blasting in 1970 (fig. 23) and three additional horizons were sampled: the lower part of the pisolitic zone; the underlying non-pisolitic horizon; and the less hard, though still indurated material at the base of the pit.

Tencee 69(70)-5 has one of the thickest observed pisolitic zones; even the K1 horizon contains broken-up pisoliths. The total thickness of the pisolitic zone (the total of the K1, K21m and K22m horizons) is 76 cm.

The close relation of younger carbonate forms to the character of the overlying B horizon, discussed for pedons 69(70)-4 and 70-4 holds here as well. Most of the K21m horizon has the reddish, pisolitic morphology. The relations discussed at unit B strongly suggest that these reddish zones would

Fig. 22. Landscape of the Typic Petrocalcid Tencee 69(70)-5, looking north. The Caballo Mountains are on the skyline at center and left. White fragments on the soil surface are calcrete fragments. Scale is in feet. Photographed April 1970.

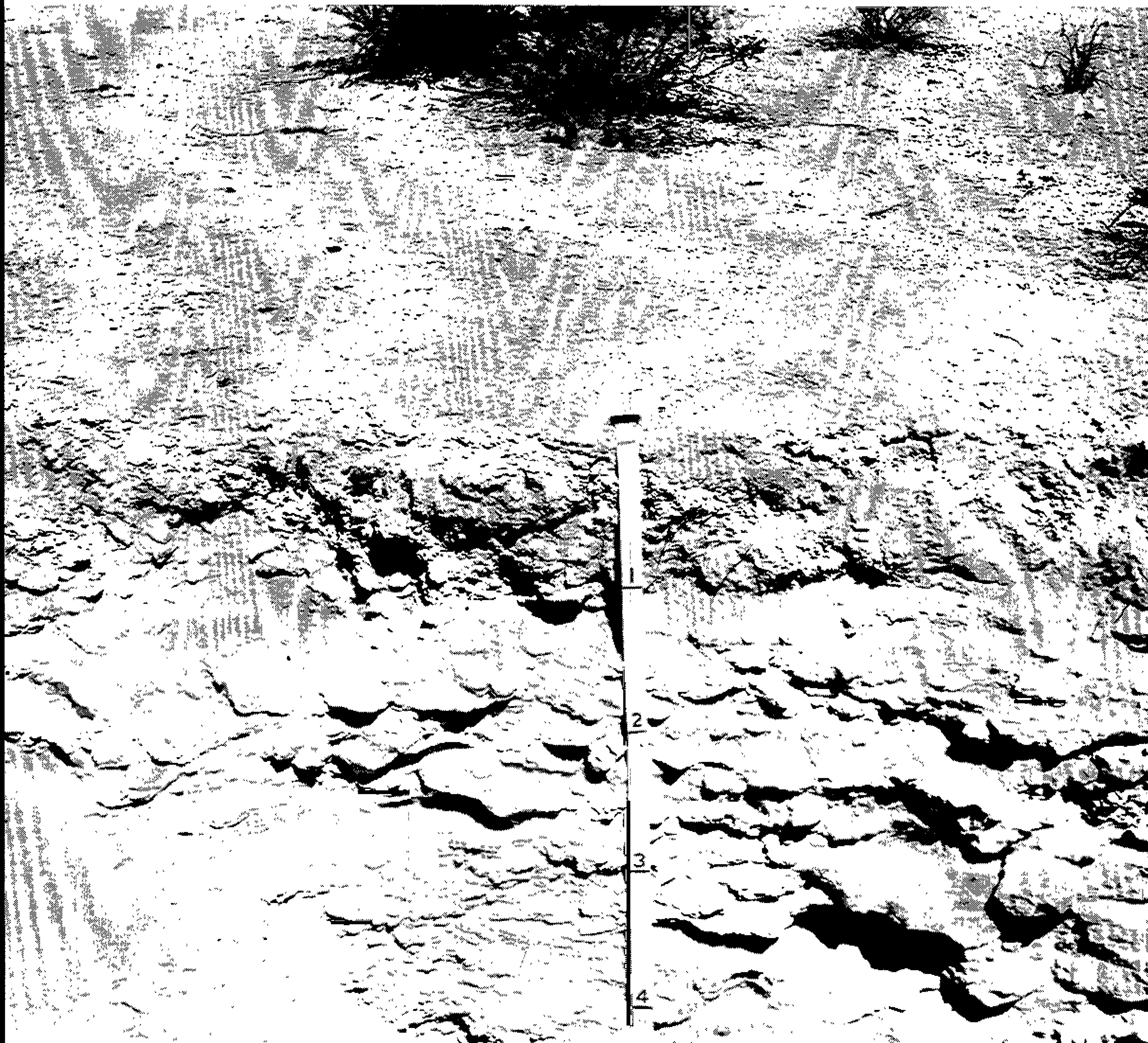

Fig. 23. Profile of the Typic Petrocalcid Tencee 69(70)-5. Scale is in feet. Photographed April 1970.

have largely formed during an earli r time of soil development, when a Bt horizon was present in the soil. But as carbonate continued to accumulate and be deposited at lesser depths due to carbonate-plugging and laminar horizon formation, horizons above the Km horizon became much thinner, opening the way for the disruptive action of roots and water on the Km horizon. The effects of this are well shown in the K1 horizon of Tencee 69(70)-5 (description, appendix).

Although the bulk of the K21m horizon consists of stage VI pisoliths and matrix material, younger carbonate is evident as a surficial, continuous laminar horizon usually ranging from about 1 mm to 1 cm in thickness, with dry colors dominantly 10YR 8/3, 10YR 8/4 and 10YR 7/3. This yellower, younger carbonate is interpreted as having accumulated largely since clay illuviation apparently ceased or greatly slowed, and the argillic horizon was obliterated.

In places the younger carbonate above the stage VI pisolitic zone thickens to platy units ranging from about 3 to 8 cm thick. These plates have stage V pisoliths, demonstrating that the stage VI pisolitic zone can serve as a plugged horizon for the formation of stage V pisoliths.

The K22m horizon is dominated by stage VI pisolitic carbonate (description, appendix). The K23m horizon lacks pisoliths and consists of alternating subhorizons of laminar and massive carbonate. The laminar horizon appears to have been the precursor of the overlying pisolitic zone. The pisolitic zone in pedon 69(70)-4 shown in figure 13, was also underlain by a thick laminar horizon. This coincidence strongly suggests that prior development of a fairly thick, dense horizon is required for formation of an overlying pisolitic zone, with its very high bulk density and carbonate content, and its very low porosity and permeability. This precursor may be viewed as a sort of super-plugged horizon, analogous to the plugged horizon that forms before development of the stage IV laminar horizon (Gile et al., 1966).

Thus the K23m horizon is not only morphologically but chronologically distinct from the overlying pisolitic zone: the K23m horizon is an older horizon virtually _in toto_, and must have formed before the pisolitic zone developed.

The K24m horizon consists of massively cemented and weak blocky carbonate that lacks a laminar horizon. The K24m horizon appears to have been the initial stage III plugged horizon that led to formation of the thick laminar zone in the overlying K23m horizon.

Micromorphology of the pisolitic zone

Figure 24 shows a cross section of the K22m horizon of Tencee 69(70)-5. Pisoliths, laminae, and ooliths (accretionary bodies less than 2 mm) are common features. Pisoliths and laminae can be seen with the unaided eye; however, ooliths are best viewed with the microscope (fig. 25). The concentric laminae of the large oolith in figure 25 record at least eleven episodes of calcite deposition. The latest deposition is the sparry calcite that fills voids between the ooliths. Ooliths are common in the whiter,

Fig. 24. Polished section from the pisolitic zone in Tencee 69(70)-5. Letters A-D locate zones discussed in text. Bar length = 10 cm.

Fig. 25. Ooliths from vicinity of zone A in fig. 24. Crossed polarizers. Bar length = 3 mm.

sparry zones that border micritic laminae (zone A, fig. 24). These areas are generally the most porous zones of the calcrete.

Indurated horizons with stage VI morphology can show 400 to 700 percent expansion relative to the original detrital framework (Machette, 1985). Such expansion can exert pressure on framework grains causing pressure solution (Maliva and Siever, 1988). In the K22m horizon of Tencee 69(70)-5, framework grains with dissolution features are common (fig. 26). These grains can be found throughout all zones in figure 24.

Concentric silicate clay laminae are micromorphic features of the Rincon calcrete that were not found in stage IV or V morphologies of the upper and lower La Mesa geomorphic surfaces in the Desert Project (Gile et al., 1995). Figure 27 shows silicate clay laminae surrounding a detrital quartz grain. Neoformation of clay minerals, such as palygorskite and sepiolite, has been observed in calcretes of the Ogallala Formation in eastern New Mexico (Frye et al., 1974) and soils of the lower La Mesa surface (Monger, 1990). In the stage VI pisolitic zone of the Rincon calcrete, laminae of concentric clay may result from clay neoformation as Si, Al, and other ions are released from silicate grains undergoing pressure solution.

Clay laminae also occur in the stage VI pisolitic zone (fig. 27). These clay laminae are commonly parallel to carbonate laminae that coat pisoliths, such as zone B in figure 24. Whether the clay is authigenic or translocated, the laminae may record the flow paths of percolating solutions.

The most visible laminae without magnification are the red ones (fig. 28, zone C in fig. 24). Red laminae are the result of iron oxide staining, probably hematite. The degree of redness is proportional to the density of the hematite stain.

Biologically-induced structures make up a minor part of the stage VI horizon. Figure 29 shows these structures in longitudinal orientation. They have also been recognized in the lower La Mesa calcrete (Chitale, 1986; Monger, 1990). Klappa (1978) interpreted these structures to be the calcified remains of mycorrhizae and used the name "Microcodium" even though he reports that the genus Microcodium was proposed for hypothetical marine algae. Chitale (1986) attributed their origin to calcified root hairs based on similarity of size. Figure 29 reveals black material within the "Microcodium" structures which may be organic remains of biological tissue.

Black material lines spar-filled zones and laminae (zone D, fig. 24). In thin section, the black material is opaque and is commonly filamentous and branching (fig. 30). The black material is probably manganese because it effervesces with 30% H_2O_2 and gives a green color when fused with $KHSO_4$ (Smith, 1953).

Micromorphology supports field observations and laboratory analyses that the various colors of laminae result from the presence of silicate clay, iron, manganese, and organic matter in the soil solution. The varied abundance of these constituents apparently reflects their supply to percolating solutions which, in turn, reflect soil morphology and climatic conditions.

Fig. 26. Plagioclase grain with dissolution features (serrated edges and large embayments). The grain is embedded in a micrite matrix. Crossed polarizers. Bar length = 0.15 mm.

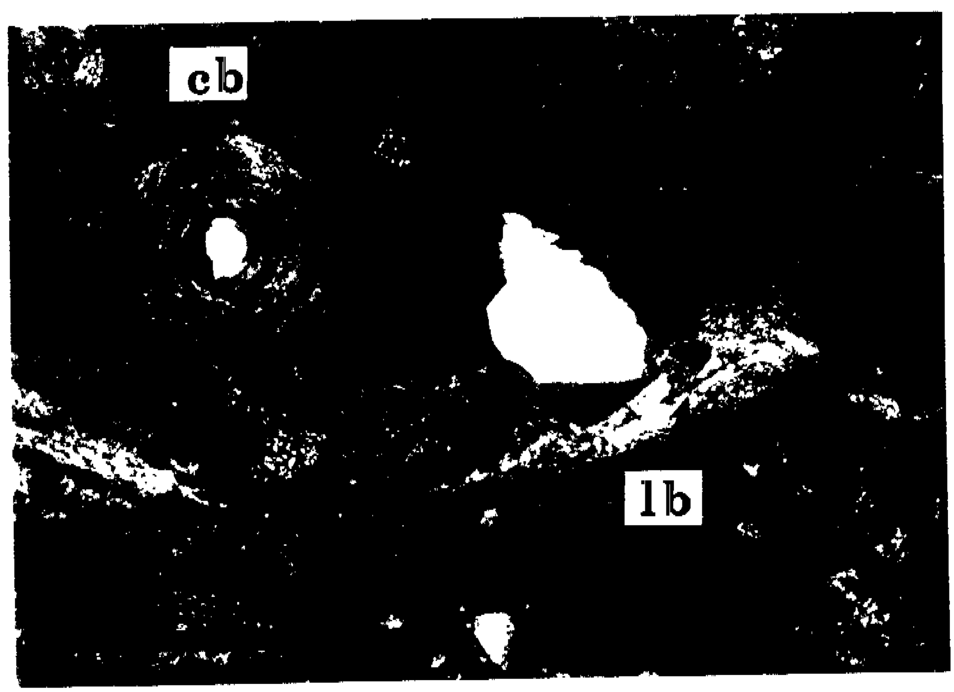

Fig. 27. Silicate clay bands occur as concentric layers around a quartz grain (cb) and as linear layers within the micrite matrix (lb). Crossed polarizers. Bar length = 0.3 mm.

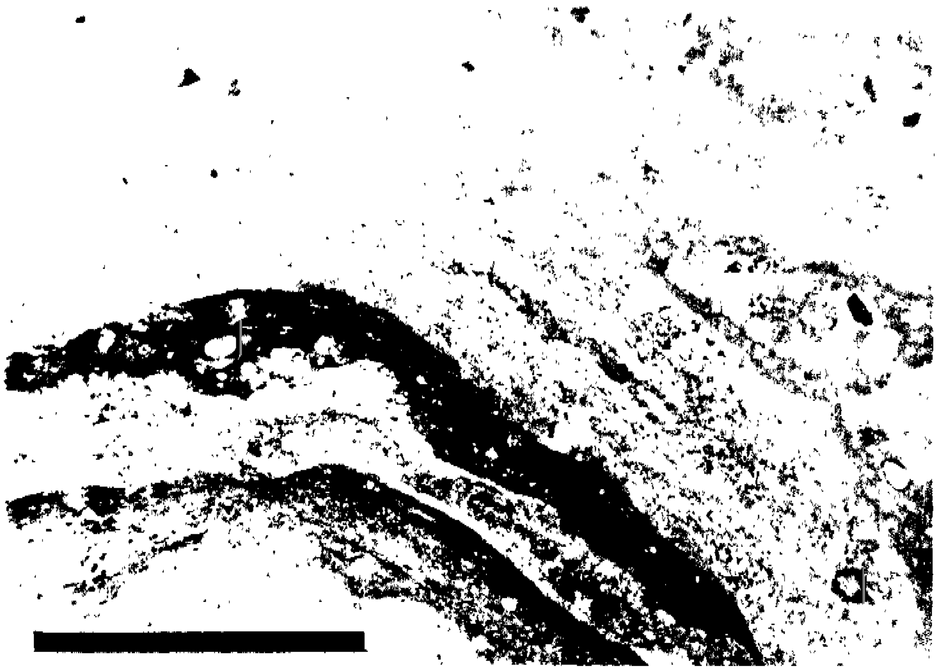

Fig. 28. Carbonate laminae stained red by iron oxide. From zone C of fig. 24. Crossed polarizers. Bar scale = 0.75 mm.

Fig. 29. "Microcodium" structures in longitudinal orientation. Note dark interiors, which may be organic carbon. Crossed polarizers. Bar length = 0.15 mm.

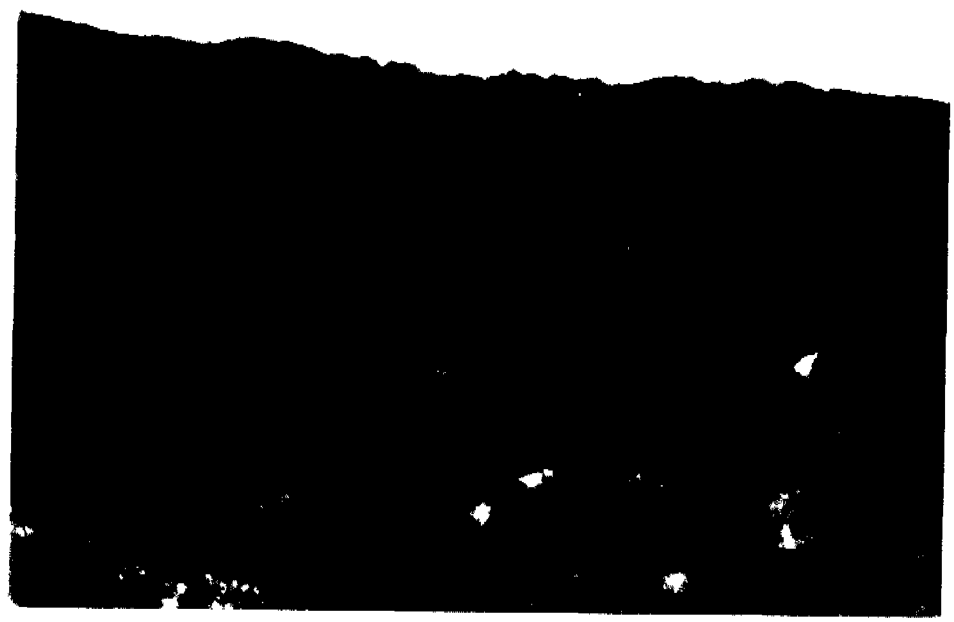

Fig. 30. The dark bands of zone D, along the edge of the pisolitic sample shown in fig. 24. Plane-polarized light. Bar scale = 0.3 mm.

Th Typic Petrocalcid. Tencee 70-3

Tencee 70-3 (figs. 17 and 31) has thin A horiz n, a gravelly Bk horizon in which the pebbles consist of calcrete fragments, a very gravelly K1 horizon with abundant calcrete fragments, and a Km horizon that lacks the stage VI pisolitic zone. Vegetation consists of creosotebush, mammillaria cactus, a few small poor-looking tarbush, buckwheat, and clumps of fluffgrass. The soil surface is about 40% covered with angular to subangular calcrete fragments that commonly appear etched and pitted. Most fragments are about 1/2 to 3 cm in diameter, with a few up to 10 cm diameter.

This area has a slight slope to the east, thus differs from the level positi n of Tencee 69(70)-5. This may be a reason for the absence of pisoliths; the slope, which increases to the east, may mark the margin of a surface that is younger than Rincon. Tencee 70-3 also differs in that the trench in it could be dug by backhoe; blasting was not required because the stage VI pisolitic zone (with its high bulk density and hardness) was absent. Further, pedon 70-3 had very few roots in lower horizons in contrast to no roots in pedon 69(70)-5.

As with many other Petrocalcids of the area, carbonate-cemented blocks and plates are common in the K1 horizon. The upper 1 to 2 cm of many of these fragments consist of laminar carbonate, clear evidence of a former continuously cemented laminar horizon that has broken up as a result of long-continued erosion as discussed at pedons 69(70)-4 and 69(70)-5. But in contrast to the prominent stage VI horizons of those pedons, the thick Km horizon of pedon 70-3 has only stage V morphology, in which there has been recementation of brecciated fragments, but with only incipient development of concentric laminae around the fragments. The Km horizon of Tencee 70-3 also has less carbonate (table 4), lower bulk density, and is not as hard. Lack of reddish colors indicates a very long period dominated by carbonate accumulation, with little or no illuviation of silicate clay.

Polished and thin sections of the K21m horizon (figs. 32, 33) illustrate th stage V morphology of the K21m horizon. A polished section of the lower zone of the K21m horizon (fig. 32) illustrates the cementation of older calcrete fragments by matrix carbonate. Although less prominent than stage VI horizons of pedons 69(70)-4 and 69(70)-5, this stage V sample also contains clay laminae concentrically oriented around voids, and encased in a dense micrite matrix (fig. 33).

The Typic Petrocalcid. Tencee 70-2

Tencee 70-2 (figs. 17, 34-36) has a thin, very gravelly A horizon that overlies the Km horizon along the scarp. Vegetation consists of creosotebush, mammillaria cactus, and buckwheat. The soil surface is about 90% covered with calcrete fragments ranging from about 1/2 to 10 cm in diameter; the fragments have an etched and pitted appearance.

The scarp was dynamited at this site to give a fresh exposure of the soil. Judging by eye, as much as 1/2 to 1 m of soil may have been eroded along the scarp. Thus the sampled horizons represent a truncated soil, and

Fig. 31. Landscape of the Typic Petrocalcid Tencee 70-3, looking east. Parts of the Rincon Hills are on the skyline. Small white fragments on the surface are calcrete fragments. Photographed April, 1970.

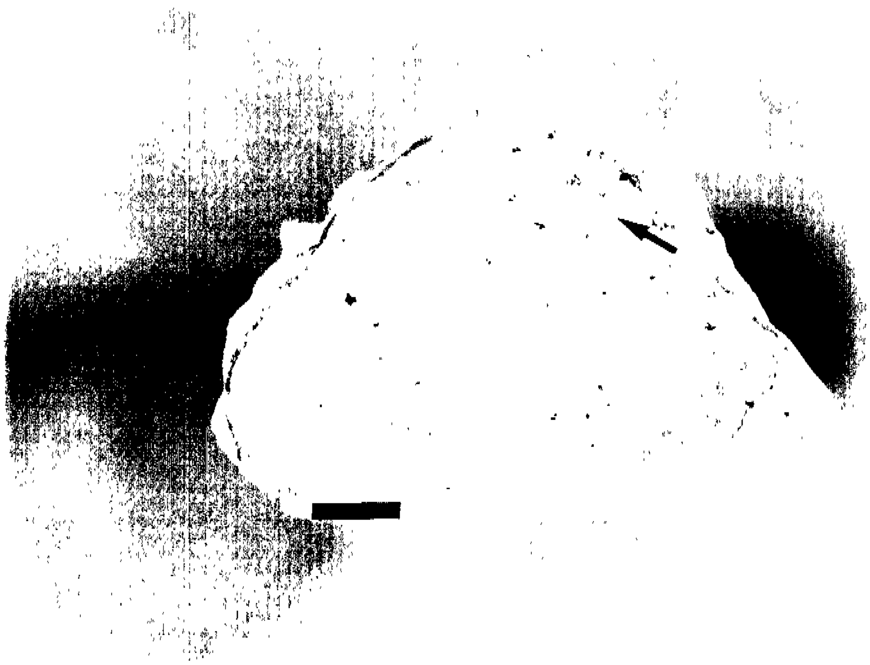

Fig. 32. Polished section of lower zone of K21m horizon of Tencee 70-3. Arrow locates older calcrete fragment within concentrically laminated calcite. Bar scale = 1 cm.

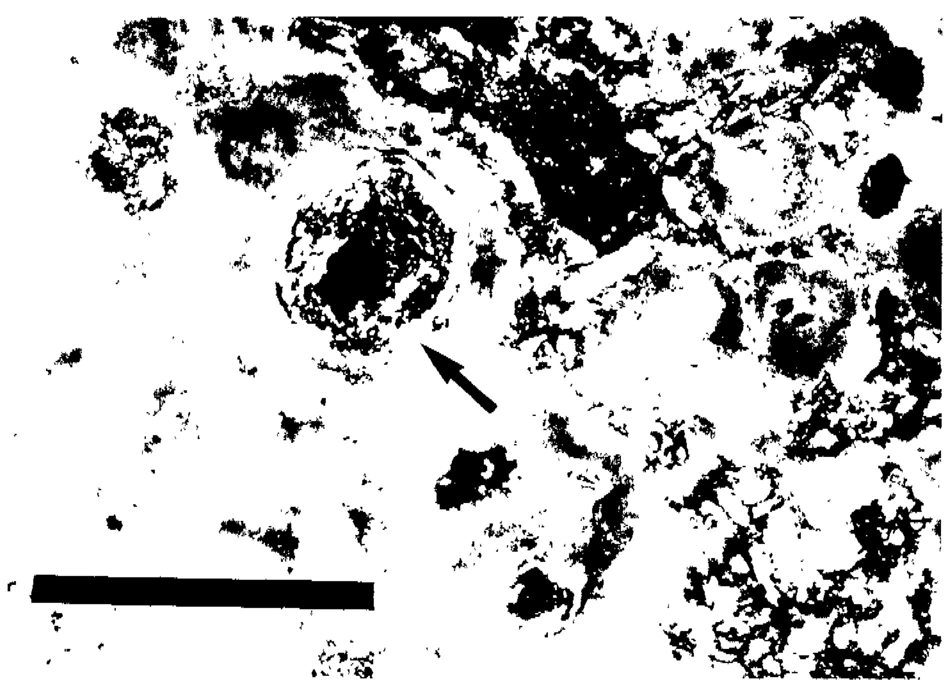

Fig. 33. Thin section of lower zone of K21m horizon of Tencee 70-3. Arrow locates silicate clay oriented in concentric laminae around a void. Crossed polarizers. Bar scale = 0.3 mm.

Fig. 34. View of the scarp at the Typic Petrocalcid Tencee 70-2, looking west. Person at right gives scale and locates Tencee 70-2. Photographed April, 1970.

Fig. 35. View up the scarp at Tencee 70-2, looking north. Note distinct bedded appearance (see description, Appendix). Photographed April, 1970.

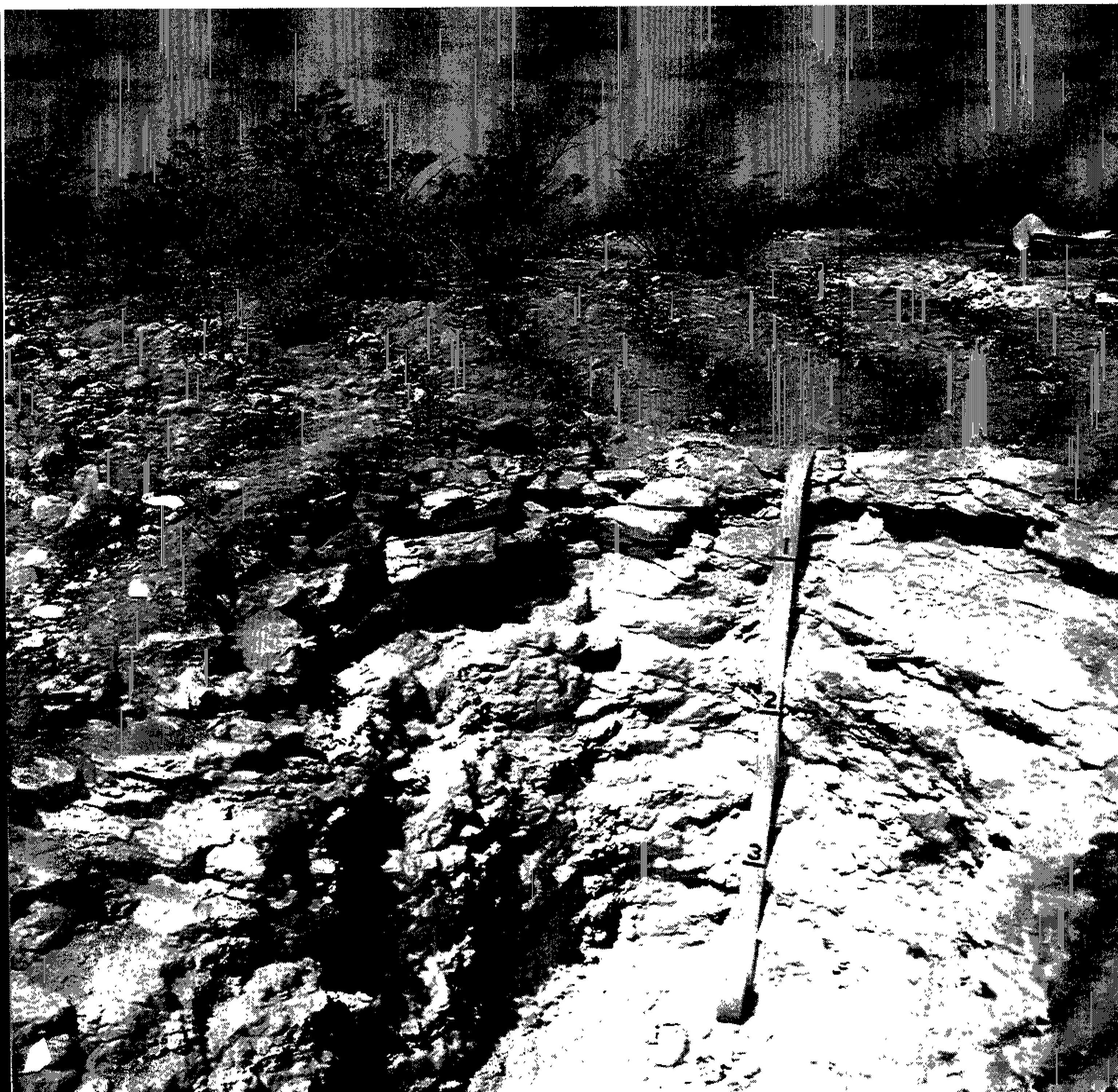

Fig. 36. Upper horizons of the Typic Petrocalcid Tencee 70-2. Only the thin upper subhorizon of the Km horizon is pisolitic. Scale is in feet. Photographed April, 1970.

this is probably the reason why the pisolitic zone is both shallow and thin (description, appendix). The thin A horizon was not sampled.

With depth the distinctly pedogenic nature of the Km horizon, with its carbonate coatings, laminar and massive carbonate, pisoliths and nodules, changes to a cemented horizon that is massive and lacks evident pedogenic features; these horizons are designated R (Soil Survey Division Staff, 1993). The K23y horizon contains gypsum, and a minor amount of silica occurs in the R horizon (description, appendix). Sandy, C-like material, with some carbonate-cemented blocks and plates, occur at 6.4-6.7 cm depth; this is the only pedon sampled that extended into C-like material. This thick pedon contains abundant carbonate throughout (table 4), although some or all of the carbonate in the R horizon may be of ground-water instead of pedogenic origin.

SOILS OF THE ALLUVIAL-FAN PIEDMONT AND THE EASTERN BORDER OF THE BASIN FLOOR: TENCEE AND SIMONA SOILS, 1 1/2 TO 6% SLOPES (D, FIG. 3)

Map unit D is by far the largest unit in the soil map (fig. 3). Soils of unit D occur on the alluvial-fan piedmont and on the eastern border of the basin floor, east of unit C (fig. 3). Slopes range from 1 to 6%, with the steepest slopes occurring on the eastern border of the basin floor. Vegetation consists of creosotebush, snakeweed, prickly pear, Yucca baccata, mammillaria cactus, buckwheat, bush muhly, and mesquite. When the Rincon surface was visited briefly by Gile and Monger in November, 1990, it was observed that many creosotebushes that were prominent in the 1969 and 1970 photographs (e.g., some of those pictured in the frontispiece and in fig. 11) were dead. Inquiry revealed that these shrubs were killed by chemical treatment (Jim McCormick, Bureau of Land Management, 1995, personal communication).

Unit D is dominated by the Typic Petrocalcids Tencee and Simona. Tencee soils in map unit D are illustrated by Tencee 69(70)-4, discussed in map unit A.

EXCHANGE CHEMISTRY, ORGANIC CARBON, AND COLE

Pedons 69-3 and 70-4 have low values of extractable sodium throughout (tables 3 and 4). Extractable sodium is also low in upper horizons of the other seven pedons for which data are available. In pedon 69-1, sodium gradually increases with depth, reaching a maximum of 2.4 me/100g at a depth of 194-235 cm. This attests to the considerable depth of wetting in the Vertisols. Extractable sodium increases to 2.0 and 2.1 me/100g at depths of 86-106 and 104-127 cm in the Petroargids, pedons 69-6 and 69-7. Sodium saturation is less than 10% throughout these three pedons. The increase in sodium is substantial and the sodium saturation is greater than 30% in the Km horizons of the Typic Petrocalcids, pedons 69(70)-4, 69(70)-5, and 70-2, reflecting long-term trapping of sodium in these horizons.

The extractable potassium (table 5) tends to be higher for pedons with higher organic carbon. All soils in the playa (pedons 69-1, 69-2, 69-3, and 70-4) have considerably higher extractable potassium than pedons in other landscape positions. The difference is probably due to greater vegetative density in soils of the playa. It is thought that the higher potassium is associated with a larger rate of organic matter return.

Table 5. Relationships between extractable K and organic C.

Series	Pedon	Extractable K1/	Organic C2/
		%	%
Dalby	69-1	7.2	0.61
Ratliff	69-2	13.1	0.82
Ratliff	69-3	6.1	0.71
Tencee	69(70)-4	5.0	0.41
Tencee	69(70)-5	3.8	0.49
Stellar	69-6	5.9	0.54
Tencee	70-3	3.1	0.46
Hilken, fine analog	70-4	8.1	0.73

1/Weighted average by depth to 100 cm. Extractable K as a percent of the CEC by NH_4OAc

2/Weighted average by depth to 100 cm.

Dalby 69-1 of this area has markedly higher extractable potassium and extractable sodium than Dalby 60-16 of the Desert Project (Gile and Grossman, 1979, p. 651). The extractable bases for 69-1 suggest less deep percolation of water than for 60-16. The carbonate content of Dalby 69-1 also is markedly higher than for 60-16; this is probably due to the parent materials being more calcareous.

Organic carbon content of the A horizon of the Haplocalcids 69-2 and 69-3 is roughly double that of the Haplotorrert 69-1 (table 3). The difference may be due to lesser vegetation at the sampled Haplotorrert (cf. figs. 7, 8, and 10). The A horizon of the Haplotorrert in the Desert Project playa has only 0.6% organic carbon despite having more clay than pedon 69-1. This relatively low organic carbon in the Desert Project Haplotorrert is attributed to scarcity of vegetation in the playa.

Totals of organic carbon are shown in table 6. In all cases, soils of the playa (pedons 69-1, 69-2, 69-3 and 70-4) have substantially more organic carbon than soils not in the playa.

Table 6. Totals of organic C for the analyzed pedons.

Series	Pedon	Organic C1/
		kg/m^2
Dalby	69-1	11.6
Ratliff	69-2	13.4
Ratliff	69-3	11.1
Tencee	69(70)-4	5.0
Tencee	69(70)-5	7.3
Stellar analog	69-6	7.8
Tencee	70-3	7.5
Hilken analog	70-4	10.7

1/

$$\text{Organic C (kg/m}^2) = \frac{L \times OCP \times Db \times \frac{(1 - V{>}2)}{100}}{10}$$

where L is the horizon thickness, OCP is the organic carbon percentage, Db is the moist bulk density of the <2 mm, and V>2 is the volume percent >2 mm. The horizons are summed to the depth of appreciable organic carbon.

COLE (coefficient of linear extensibility) values are highest for the Vertisol pedon 69-1, as would be expected (table 3). COLE values in the upper meter for pedon 69-1 are slightly higher than for the Desert Project Haplotorrert, even though clay in the upper meter averages about 20% less in pedon 69-1.

COLE and clay data illustrate analytical differences between the Haplotorrert and the adjacent Haplocalcid in the playa (table 7). The ratio of COLE to noncarbonate clay is similar for the two soils, suggesting that the difference in percentage of the noncarbonate clay is the principal reason for the difference in COLE.

Table 7. COLE and clay relationships of selected horizons of pedons 69-1 and 69-2.

Pedon	Depth	COLE1/	COLE/Clay2/
	cm		
69-1 (Haplotorrert)	16-110	0.086	0.0022
69-2 (Haplocalcid)	15-88	0.035	0.0016

1/ Weighted average.
2/ Weighted average. Total clay minus carbonate clay.

CHRONOLOGY OF THE RINCON SURFACE

Kortemeier (1982) studied volcanic ash at the Grama Gully site (see Seager and Hawley, 1973, p. 1-19, for photographs and a discussion of this site) and identified it as Bishop ash. The ash has also been identified as Bishop ash by Izett et al. (1988), who dated it as 0.74 million years old. Kortemeier (1982, p. 24) concludes that the Rincon surface formed "sometime in post-Bishop time, probably about 0.6-0.5 million years ago". However, Mack et al. (1993) have shown that Bishop ash at the Grama Gully site occurs in sediments inset against and younger than the soils of nearby La Mesa surface, which is bracketed between 0.78 and 0.9 million years ago by magnetostratigraphy (Mack et al., 1993). In addition, La Mesa surface is known to be younger than the Rincon surface (Hawley, 1965). Morphology and amounts of pedogenic carbonate also indicate that soils of the Rincon surface are considerably older than 0.6-0.5 million years, as discussed in the following section.

Pedogenic carbonate may be used to estimate ages of many soils in arid and semiarid regions (Gile et al., 1971, 1981; Gardner, 1972; Bachman and Machette, 1977; Machette, 1978, 1985; Gile, 1987, 1990; Mayer et al., 1988; Marion, 1989). The determination of total pedogenic carbonate is made according to the formula shown in table 8. For soils that have formed in parent materials with very little or no carbonate, the total carbonate is considered to reflect calcium and carbonate additions of atmospheric origin.

To estimate the age of a soil, its total carbonate is referenced to the carbonate content and rate of accumulation of another soil of approximate known age. Average rates for carbonate accumulation are used in the calculations of estimated age for soils that are older than about 100,000 years. According to Machette's (1985) model, soils older than about 100,000 years should have similar average accumulation rates that can be used to correlate soils locally and to estimate ages of soils that are older than about 100,000 years. Soils of the Rincon surface easily meet this age requirement.

Soils at the south end of the basin-floor remnant (fig. 17) are underlain by and presumably have formed in ancient Rio Grande deposits that contain very little carbonate. No evidence has been found that calcareous sediments from the Caballo Mountains have influenced soil formation at the south end of the basin-floor remnant. Thus virtually all of the carbonate totals in these soils are assumed to represent illuvial carbonate derived from atmospheric additions. Totals of pedogenic carbonate were calculated for two pedons in this area as discussed in the following sections.

<u>Tencee 69(70)-5</u>

Tencee 69(70)-5 (see tables 4, 8, fig. 22, 23; and earlier discussion) is at one of the most stable sites of the basin floor. Calcrete fragments in the A, Bk and K1 horizons consist largely of broken-up parts of former upper subhorizons of the Km horizon, are also of pedogenic origin, and are included in the calculations by appropriate modification of the formula.

Table 8. Calculated totals of pedogenic carbonate for the Typic Petrocalcids Tencee 69(70)-5 and Tencee 70-2. Carbonate content of >2mm material is included for pertinent horizons.

Horizon	Depth	$CaCO_3$	Pedogenic $CaCO_3$ 1/	Estimated bulk density 2/
	cm	%	kg/m^2	g/cm^3
Tencee 69(70)-5				
A	0-5	13	7.8	1.3
A, >2mm	0-5	75	4.4	1.8
Bk	5-25	23	61.6	1.4
Bk, >2mm	5-25	75	53.3	1.8
K1	25-46	46	132.3	1.4
K1, >2mm	25-46	75	148.2	1.8
K21m	46-61	85	328.0	2.6
K22m	61-101	83	843.0	2.57
K23m	101-148	83	847.9	2.2
K24m	148-162	72	198.8	2.0
			2625.3	
Tencee 70-2				
K21m	7-20	85	280.3	2.6
K22m	20-50	88	678.6	2.6
K23	50-90	82	583.2	1.8
K24m	90-170	75	1184.0	2.0
K31	170-250	62	878.4	1.8
K32	250-330	51	720.0	1.8
			4324.5	

1/ The calculation is for a volume element 1 m in horizontal cross section and of variable thickness, according to the formula

$$CaCO_3\ (kg/m^2) = \frac{L \times Db \times \left(1 - \frac{>2mm\ vol.\ \%}{100}\right) \times CaCO_3\ \%}{10}$$

where L is the thickness of the horizon in cm, Db is the bulk density of the fine-earth fabric, $1 - \frac{>2mm\ vol.\ \%}{100}$ is a correction for the volume occupied by the >2 mm material, and $CaCO_3$ is carbonate content of the horizon minus the carbonate content of the parent materials.

2/ Bulk densities assumed from previous work (Gile and Grossman, 1979) except for the K22m of Tencee 69(70)-5, determined by Monger.

All of the pedogenic carbonate in the upper and middle horizons is thought to have been accounted for in the calculations, which show a total of 2625 kg/m^2 of pedogenic carbonate (table 8). But the lowermost sampled horizon extends only to 162 cm depth, where the pedon is still in the K2m position. Thus a considerable amount of pedogenic carbonate would be expected to occur below 162 cm.

For a chronological guide in assessing the rate of carbonate accumulation in soils of the Rincon surface, work by Mack et al. (1993) just south of the Rincon study area and in the Jornada Basin, suggest possible age of lower La Mesa at the Desert Project, although lower La Mesa there is in the Mesilla Basin. The chronology presented by Mack et al. (1993) and pedon 61-8 of lower La Mesa at the Desert Project are tentatively used as guides for estimating the amount of time required for carbonate to accumulate in soils of the Rincon surface. The constructional top of La Mesa sediments in the Jornada Basin is bracketed between 0.78 and 0.9 million years ago (Mack et al., 1993). An average of the two values gives 0.84 million years for purposes of calculation. The beginning of valley entrenchment also marks the beginning of soil formation for soils of La Mesa, because it marks abandonment of the ancient flood plain by the ancestral Rio Grande. Valley entrenchment had begun by 0.74 million years ago as shown by the presence of Bishop ash of that age in an inset fill below La Mesa at the Grama Gully site (Seager and Hawley, 1973; Mack et al., 1993). For purposes of calculation, the beginning of valley entrenchment is estimated by averaging the age of the dated ash (0.74 million years) and the estimated age of the constructional top of La Mesa (0.84 million years). This gives 0.79 million years as an estimated age for La Mesa soils. This age and the carbonate total of 1200 kg/m^2 for lower La Mesa pedon 61-8 give an average accumulation rate of 1.4 kg/m^2/1000 years. At this rate of carbonate accumulation, the 2625 kg/m^2 of carbonate in upper and middle horizons of pedon 69(70)-5 alone would require about 1.87 million years to accumulate. This is evidence that the Rincon surface and its soils are considerably older than 0.6-0.5 million years.

Tencee 70-2

Tencee 70-2 (see tables 4, 8, fig. 34, 35, 36; and earlier discussion) is in a less stable area at the edge of the scarp. Increased slope next to the scarp indicates that as much as 1/2 to 1 meter of material may have been eroded from upper horizons. In addition, less carbonate would be expected to enter the soil along the scarp because of increased runoff next to the scarp. Also, no carbonate in the upper part of the R horizon was included because the pedogenic carbonate could not be feasibly separated from carbonate that may be of ground-water origin. For these reasons, the values for total carbonate and ages are definitely minimum figures.

Even with the losses of pedogenic carbonate noted in the previous paragraph, the total of pedogenic carbonate in Tencee 70-2 is very high (4325 kg/m^2, table 8). At the accumulation rate of 1.4 kg/m^2/1000 years, the carbonate total of 4325 kg/m^2 would require about 3.1 million years to accumulate. Because a substantial amount of pedogenic carbonate cannot be accounted for, the soils at the south end of the basin-floor remnant could be substantially older than 3.1 million years.

SUMMARY AND DISCUSSION

The Rincon surface contains both a relict basin floor and an alluvial-fan piedmont. In addition, a playa occurs in what appears to be the lower part of the fan piedmont. This unusual position for a playa may be due to faulting. Different depths and compaction of alluvium may also be a factor because different depths to bedrock may be involved. Soils of the playa formed in sediments derived primarily from the alluvial-fan piedmont upslope. Soils of the alluvial-fan piedmont formed in dominantly limestone sediments. Soils of the basin floor formed primarily in river deposits emplaced by an ancestral Rio Grande. The basin-floor sediments contain very little calcium, and calcium in the thick carbonate horizons must have been derived largely from atmospheric additions (Gile et al., 1981).

A previous study concluded that the Rincon surface probably formed about 0.6-0.5 million years ago. However, estimates of soil age based on totals of pedogenic carbonate, volcanic ash, magnetostratigraphy and geomorphology all indicate that the Rincon surface is considerably older, probably dating from late Pliocene or earlier.

A number of study trenches were dug with a backhoe in the study area; three of these were later deepened with dynamite. One trench extended completely across the northeast side of the playa and into the adjacent fan piedmont. Several shorter trenches were dug in the southwest side of the playa.

Playa and adjacent fan piedmont

Haplotorrerts occur in the central part of the playa in its northeast side, and grade through Haplocalcids to the Petrocalcids that dominate the fan piedmont (fig. 6). Four pedons were sampled across the northwest end of the trench (fig. 6) which bottomed in an extremely hard petrocalcic horizon.

Pedon 69-1 consists of a land-surface Haplotorrert and two buried soils (table 3; appendix). Due to the soil mixing that takes place in Vertisols, no carbonate horizons are present to suggest possible age of the Haplotorrert. However, several factors suggest that the bulk of the sediments in the Haplotorrert probably date from the late Pleistocene, with a minor amount of Holocene sediments. The boundaries between the Haplotorrert and the bordering Haplocalcids are remarkably abrupt (occurring within a lateral distance of about 30 to 40 cm) and the area is virtually level (fig. 6). The bordering Haplocalcids have either stage III carbonate or stage II horizons that laterally grade into stage III horizons. In low-gravel sediments such as these, stage III horizons are typical of soils of late Pleistocene age in the Desert Project (Gile et al., 1981). Had the sediments been less clayey in the central part of the playa, stage III carbonate might have formed in the area now occupied by Haplotorrerts. The Organ and Isaacks' Ranch cycles of erosion and sedimentation at the Desert Project (100 to 7,000 and 8,000 to 15,000 years BP respectively, Gile et al., 1981) apparently either did not take place in this area, or at most contributed only a few cm of sediments.

The first buried soil beneath the Haplotorrert has a Bt horizon and nodular stage II carbonate. The stage III horizon that occurs laterally in the bordering Haplocalcids is relatively thin, and the first buried soil could be of late or middle Pleistocene age.

The second buried soil has a Bt horizon and an extremely hard petrocalcic horizon with some pisoliths. This may have been the first soil to form in the playa after it developed, and may date from middle or early Pleistocene.

Pedon 69-2 consists of a land-surface Haplocalcid with stage II nodular carbonate and two buried soils (table 3, appendix). A short distance upslope, the stage II carbonate of pedon 69-2 grades into a stage III horizon like that of pedon 69-3. The two buried soils are the same age as those in pedon 69-1 because they were continuously traced from that pedon.

Pedon 69-3 consists of a land-surface Haplocalcid with a stage III carbonate horizon; the upper horizons of the upper of the two buried soils in pedons 69-1 and 69-2; and the buried Km horizon of the lower of the two buried soils, which rises sharply in the northwest end of the study trench. Because the K2mb2 horizon grades directly (with only slight change in slope) to the Km horizon of the fan-piedmont soil just upslope, the K2mb2 horizon is considered to be about the same age as that horizon (late Pliocene).

Pedon 69(70)-4 is the sampled pedon on the fan piedmont (fig. 6) The Km horizon is so hard and dense that it was necessary to dynamite it for examination and sampling. The petrocalcic horizon contains steep laminae thought to represent a former pipe (fig. 14). A nearby pedon has a prominent stage VI horizon with abundant pisoliths (fig. 13). Thick horizontal laminae beneath the pisolitic horizon suggest that such extremely hard, dense horizons may be a major requirement for development of pisolitic morphology above them.

The two buried soils in the playa show that times of major sedimentation into the playa were separated by times of stability and soil formation. The buried soils have argillic horizons, thus contrast with the soils at the playa surface. This evolutionary change from soils with argillic horizons to soils without them later in the history of the playa appears to have been caused by a marked increase in carbonate of the soil parent materials. This in turn may be related to evolution of the soils upslope of the playa, which have many calcrete pebbles both at the surface and at shallow depth. This apparently resulted after a very long period of carbonate accumulation, which would cause the zone of carbonate accumulation to gradually move upward in the soils due to carbonate-plugging in deeper horizons and to volumetric expansion of the original sediments as proposed by Machette (1985). In addition, soil erosion and biotic mixing would tend to bring carbonates closer to the surface where they would be a source of sediments for transport to the playa.

In the playa, the gradual increase in the number of calcrete pebbles towards the fan piedmont upslope indicates that the fan piedmont must have been a major source of sediments in the playa, as does the fact that deposits in the sampled pedons slope into the playa. On the other hand, based on evidence in the southwest side of the playa, to be discussed, some of the fine earth in the playa is thought to have been derived from eolian deposits that were wind-eroded from the Rio Grande Valley to the west. In addition, sediments from the same eolian deposit on the fan piedmont upslope may have been eroded and deposited in the playa.

Most soils in the southeast part of the study trench (zones W-Z, fig. 6) have a petrocalcic horizon, thus differ considerably from most soils in the other parts of the trench. In zone W, the soils are Typic Petrocalcids and the petrocalcic horizon is generally at about 25 to 30 cm depth. A low-gravel horizon, in which the gravel consists of calcrete fragments, extends from 0 to 10 or 15 cm depth. Below this a gravelly or very gravelly horizon overlies the petrocalcic horizon. Both skeletal and nonskeletal soils occur in zone W, and the dominant texture is loam.

In zone X, the low-gravel horizon thickens to the northwest and the petrocalcic horizon deepens, ranging from about 30 to 40 cm depth. These soils are on the edge of the playa (fig. 6), where vegetation and soil moisture indicate the Ustic subgroup. These soils are Ustic Petrocalcids, and the dominant texture is loam.

In zone Y, the low-gravel horizon thickens to slightly more than 50 cm and overlies a very gravelly horizon consisting of rounded calcrete fragments that rest on the petrocalcic horizon. Depth to the petrocalcic horizon ranges from about 50 to 100 cm, and dominant texture is clay loam. In zone Z, the petrocalcic horizon deepens to between about 100 and 150 cm depth. These soils are Ustic Haplocalcids, and dominant textures are clay loam and silty clay loam. The low-gravel horizon thickens to 100 cm or more above a very gravelly horizon that rests on the petrocalcic horizon. As on the northwest side of the trench, the boundary between the Haplocalcids and the Haplotorrerts is abrupt, occurring within 30 to 40 cm.

In contrast to soils in the northeast side of the playa, soils in the southwest side are relatively uniform; most soils have an argillic horizon and a petrocalcic horizon at depths ranging from slightly less than 1 m to about 1.5 m. No evidence of the late Pleistocene cycles of alluviation was found in the southwest side of the playa, where the thick argillic horizon and underlying petrocalcic horizon suggest stable landscapes and soils for a very long period of time. Soils in the adjacent fan piedmont formed in sediments with abundant limestone fragments, and are shallow Petrocalcids with subst ntial pedogenic carbonate that extends to or very near the surface. Desert Project studies show that no argillic horizon formed in late Pleistocene soils with parent materials that contained abundant limestone fragments, even though the landscape was very stable and the soil must have formed partly in a Pleistocene pluvial (Gile et al., 1981). This raises a question as to how the thick argillic horizon could form in a landscape otherwise dominated by both parent material and pedogenic carbonate. East of the Rio Grande Valley in the northern part of the Desert Project, reddish brown argillic horizons were found in eolian deposits that buried soils of older landscapes (Gile, 1994). These eolian deposits were most common on stable landscapes where they were less likely to be eroded. Similarly, the thick argillic horizons that overlie petrocalcic horizons in the southwest side of the playa are attributed to an eolian deposit derived from the Rio Grande Valley. Because of the relatively shallow and thin stage III horizons on the northeast side of the playa, the eolian sedimentation is thought to have occurred primarily in the late Pleistocene. Occurrence in a slight depression that would receive runoff moisture would also help because the extra moisture would move carbonates to greater depth. Areas outside the depressions have much shallower carbonate horizons, which would impede development of the argillic horizon.

Basin floor

Five study trenches were dug in the basin floor, two in map unit B and three in map unit C (fig. 17). Map unit B consists of several small depressions with Ustic Petroargids and Ustic Argic Petrocalcids, and intervening, slightly higher areas with Typic Petrocalcids. Two trenches were dug in the small depressions of map unit B. The trenches extended through the thick argillic horizons but did not penetrate the petrocalcic horizon.

Pedons 69-6 and 69-7 (table 4; appendix) illustrate the Petroargids. These soils, sampled at opposite ends of the same trench, have clay and silty clay Bt horizons and petrocalcic horizons at 130 and 127 cm depth respectively. Stage I filamentary carbonate occurs in the Bt horizon. Position of the stage I horizon and dated soils in the Desert Project indicate that the stage I carbonate is of late or middle Holocene age. A trench in a third pedon in another depression (fig. 17) showed a Petroargid very similar to pedons 69-6 and 69-7. As for soils in the southwest part of the playa, the thick Bt horizon of the depressions is thought to have formed largely in eolian sediments derived from the Rio Grande Valley to the west.

Three trenches were dug for sampling in soils of map unit C, one along and the other two near the scarp (fig. 17). All of the sampled soils are Typic Petrocalcids. Pedon 70-2 (table 4, appendix) occurs along the scarp, where as much as 1/2 to 1 m of soil may have been eroded. Because of erosion, depth to the petrocalcic horizon in only 7 cm, and the stage VI pisolitic zone is also thin. Beneath the K horizon is an apparent R horizon that lacks evident pedogenic features and contains some carbonate thought to be of ground-water origin. Pedon 70-3 (fig. 17) slopes slightly to the east. This may mark the formation of a surface and soil that are younger than Rincon, and may explain the lack of a stage VI pisolitic zone. The thick petrocalcic horizon of pedon 70-3 has only stage V morphology, in which there has been recementation of brecciated fragments, but only incipient development of concentric laminae around the fragments.

Pedon 69(70)-5 (table 4, appendix) was dug in a level area away from the scarp. The area appears to be a relatively stable site, one that should reflect the effects of pedogenesis over a very long period of time. Although the area is stable-appearing, the shallow carbonates, which would inhibit formation of a Bt horizon, and lack of a depression have apparently precluded development of the argillic horizon as in soils of map units A and B. This soil has one of the thickest observed pisolitic zones (76 cm). The K1, K21m and K22m horizons are dominated by stage VI pisoliths. The K23m horizon lacks pisoliths and consists of alternating subhorizons of laminar and massive plugged horizons. Microscopic features of the petrocalcic horizon include massive calcite; framework grains with dissolution features; biologically-induced structures; laminae of silicate clay and carbonate; red laminae with iron oxide staining; and black filaments, laminae and irregular masses composed of manganese oxide.

Illuviation, brecciation, and cementation

Two general illuvial processes of soil formation appear to be operating over most of the area at the present time. One illuvial process is dominated wholly or almost wholly by carbonate accumulation, as illustrated by Haplocalcids and Typic Petrocalcids. In the other illuvial process, silicate clay, manganese oxide and iron oxide are illuviated along with the carbonate, as shown by Petroargids and Argic Ustic Petrocalcids. The illuviation of silicate clay, involved in the development of Bt horizons, is still continuing at a few stable sites with argillic horizons. But most soils are Typic Petrocalcids, and at least some of these have evidence of a former time of silicate clay accumulation in the form of scattered reddish zones with illuvial clay that are still evident in the petrocalcic horizons.

This evolutionary change from soils with argillic horizons to soils without them has been caused in some instances by soil erosion (e.g., along the high scarp cut in the basin-floor soils on the south margin of the remnant), and in others by biotic mixing. In other places the change to carbonate illuviation alone appears to have been caused primarily or wholly by long-continued carbonate accumulation: the zone of carbonate accumulation, so dense and carbonate-plugged that the soil solution could no longer penetrate it, was forced upward to a position so near the soil surface that the flocculating effect of carbonate precluded the illuviation of silicate clay.

Petrocalcids with thick petrocalcic horizons are the dominant soils. Both stage V and VI carbonate horizons occur in most of the studied petrocalcic horizons. The stage VI carbonate has common 5YR and 2.5YR hues, pisoliths, and highest values of carbonate, bulk density and hardness. The pisoliths are commonly engulfed, separated and cemented by carbonate. The stage V carbonate commonly overlies the stage VI pisolitic zone, penetrates it as crack fillings, and underlies it as coatings on the undersides of fragments. The stage V carbonate also has pisoliths, is dominated by 7.5YR or 10YR hues, and is not as hard as the stage VI carbonate.

Features similar to the stage VI pisolitic zone have been reported elsewhere (e.g., Bretz and Horberg, 1949; Swineford et al., 1958; Bachman and Machette, 1977; Hay and Reeder, 1978; and Machette, 1985). The pisoliths occur in a cemented self-breccia like that described by Bretz and Horberg (1949) in an arrangement they termed "Rock House structure". Shape of the pisoliths ranges from round or nearly round to ellipsoidal to subangular blocky. Alternating concentric laminae of brown, red, black, and lighter colors are common. The various laminar colors must reflect composition of the soil solution from which they were deposited. Although carbonate is by far the dominant component, brown laminae contain more clay, silt, and organic carbon than lighter-colored laminae (Gile and Grossman, 1979, p. 856). As in soils, red laminae may contain less organic carbon because organic carbon can mask red colors. Black laminae, filaments, and masses of irregular shape are attributed to the presence of manganese oxide, as indicated by chemical tests of laminae. Bretz and Horberg (1949) also found black coatings on fragments to consist of manganese oxide.

All observed pisolitic zones were underlain by dense, indurated laminar horizons. Thus, prior development of an underlying dense horizon is apparently required for development of the pisolitic zone, with its very high bulk density and carbonate content, and its very low porosity and permeability. This precursor horizon may be viewed as a sort of super-plugged horizon; it is similar to the stage III plugged horizon in that it severely restricts vertical water movement in the soil, but to a greater degree. Brecciation and recementation of upper parts of petrocalcic horizons appear to be major processes involved in development of the stage VI pisolitic zones in the study area. During pluvials, soil water can reach deep petrocalcic horizons much oftener than during interpluvial times, and cracks can be more readily penetrated by soil water, carbonate, clay and roots. Repetition of this penetration would force blocks and plates away from the petrocalcic horizon, eventually forming a continuous brecciated horizon above it. Brecciation as a gradual, long-continued process would explain some of the wide variation in degree of rounding as a function of the chronology of separation from the petrocalcic horizon and subsequent rounding of the brecciated fragments. During and after formation of the brecciated horizon, repeated wetting and drying of the brecciated fragments would result in formation of laminar coatings on them. In stable, undissected areas during pluvials there must also have been substantial lateral movement of the soil solution along the top of the petrocalcic horizon, favoring deep carbonate accumulation in low areas (such as pipes) in the microrelief of the petrocalcic horizon.

With a change to drier climates, the wetting fronts would be lifted and the brecciated zone would be cemented by accumulation of carbonates between the brecciated fragments. Long-continued carbonate accumulation in the brecciated zone, underlain as it is by materials already-carbonate-plugged, would result in development of the pisolitic zone. In many places more than one cycle of brecciation and recementation are evident, and may be evidence of alternating pluvial and interpluvial climates.

In addition to change to drier climates, long-continued carbonate accumulation in a given zone would tend to result in shallower depths of wetting over time because of the gradually increasing fineness and decreasing porosity of the zone of carbonate accumulation itself. This would eventually result in petrocalcic horizons so shallow that soil water and roots could penetrate them even during interpluvial times, and this is the typical situation at present in the extensive shallow Petrocalcids of the study area.

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S69NM-013-001
Soil Series: Dalby
Classification: Typic Haplotorrert, fine, montmorillonitic, thermic.
Location: SW1/4 SE1/4 Sec. 24, T.18S., R.3W, center of east half of playa.
Geomorphic Surface: Playa in shallow depression on Rincon surface.
Land Form: Playa (central part).
Elevation: 4650 feet.
Parent Materials: Playa sediments of mixed origin, apparently derived from erosion of soils upslope. 0-194 cm, mostly late Pleistocene, minor amount Holocene; 194-325 cm, late or middle Pleistocene; 325-351 cm, middle or early Pleistocene. Parent materials below 337 cm are undifferentiated Camp Rice basin fill.

Vegetation: Mainly burrograss, with scattered clumps of tobosa. Most of the area is occupied by grass clumps except for scattered depressions, which are usually barren, or nearly so, and other smaller, barren areas ranging from 5 to 20 cm wide.

Collected by: L. H. Gile, R. B. Grossman and J. W. Hawley, November 17, 1969.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface. Depressions are common. The depressions range from 1 to 5 meters apart. Smaller depressions range from 10 to 50 cm deep and 25 to 30 cm across; they often have vertical walls. Larger depressions range up to about 5 meters long, 2 meters wide and 20 to 30 cm deep. These large depressions often have smaller depressions at the ends or sides. The soil surface is fairly level and smooth between the depressions. The surface is weakly cracked into polygons, 2 to 10 cm in diameter.

A 0 to 3 cm. Light brownish gray (10YR 6.5/2, dry) or dark grayish brown (10YR 4/2, moist) loam; weak thin and medium platy structure; slightly hard; few roots; effervesces strongly; abrupt smooth boundary.

Bw1 3 to 16 cm. Light brownish gray (10YR 6/2, dry) or dark grayish brown (10YR 4/2, moist) clay; weak medium prismatic structure, parting to weak medium subangular blocky; very hard; roots common; effervesces strongly; clear wavy boundary.

Bw2 16 to 31 cm. Brown (9YR 5.5/3, dry; 9YR 4.5/3, moist) clay; weak coarse prismatic structure, parting to weak medium and fine subangular blocky; very hard; few roots; effervesces strongly; clear wavy boundary.

Bw3 31 to 72 cm. Light brown (7.5YR 6/4 dry) or brown (7.5YR 4.5/4, moist) clay; weak very coarse prismatic structure, with prisms ranging from 10 to 30 cm diameter; prisms part to moderate platy and wedge-shaped forms, some of which adhere together and others that are readily separated with the fingers; plates and wedges range from about 1/2 to 2 cm thick; in places these forms are roughly horizontal and in others, they slope at angles most commonly ranging from about 10 to 20 degrees from the horizontal; very hard; very few roots; cracks are most apparent in this horizon; cracks between coarsest prisms range from about 1/2 to 1-1/2 cm wide, with smaller prisms being more tightly fitted;slickensides occur on some ped faces; effervesces strongly; clear wavy boundary.

Bw4 72 to 110 cm. Pinkish gray (7.5YR 6/2, dry) or dark brown (7.5YR 4/3, moist); clay; weak very coarse prismatic structure, with prisms ranging from about 10 to 30 cm diameter; plates and wedges tend to be thicker than in the Bw3 horizon with thickness dominantly ranging from ab ut 1 to 2 cm; wedges and plates range in slope fr m horizontal to 30 degrees; very hard; no roots; visible cracks range from about 1/4 to 1 cm across, and gradually become thinner towards the lower part of the horizon;slickensides occur on some peds; efferv sces strongly; clear wavy b undary.

BC 110 to 159 cm. Brown (7.5YR 5.5/4, dry; 7.5YR 4.5/4, moist) silty clay; weak very coarse prismatic structure; commonly massive internally but there is a tendency to weak platiness, with plates 1/4 to 2 cm thick; very hard; no roots; a very few fine (1-2 mm) hard carbonate nodules; cracks from above generally terminate in this horizon or in places in the underlying horizon; there are a very few wedges, but both plates and wedges are horizontal or nearly so; edges of plates are visible on the faces of broken fragments, but plates usually adhere; effervesces strongly; clear wavy boundary.

BCky 159 to 194 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 4.5/4, moist) clay; very weak coarse prismatic structure, parting to very weak coarse subangular blocky; some of the blocks break into weak plates about 1/2 to 2 cm thick and 5 to 10 cm across, but the plates often adhere to each other; very hard; no roots; few carbonate filaments and a few carbonate nodules, 1 to 3 mm diameter; discontinuous coatings of gypsum on a very few ped faces; a few manganese filaments, mainly in lower part; effervesces strongly; clear wavy boundary.

Btk1b 194 to 235 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 4.6/4, moist) clay; weak coarse prismatic structure, parting to weak medium subangular blocky; hard and very hard; no roots; a few fine carbonate nodules, ranging from about 1 to 5 mm diameter; manganese coatings on some peds and there are common manganese filaments and grain coatings within peds; effervesces strongly; clear wavy boundary.

Btk2b 235 to 278 cm. Light reddish brown (5YR 6/4, dry) or reddish brown (5YR 5/4, moist) clay; weak medium prismatic, parting to weak medium subangular blocky; hard; no roots; some peds have smooth, reflective surfaces; a few carbonate nodules and filaments; scattered manganese coatings on and within peds; mainly calcareous, a few parts noncalcareous; clear wavy boundary.

Btk3b 278 to 306 cm. Light reddish brown (5YR 5.5/4, dry) or reddish brown (5YR 4.5/4 moist) sandy clay loam; weak medium prismatic structure, parting to weak medium subangular blocky; hard; no roots; a few carbonate nodules and cylindroids 1/2 to 1 cm diameter; peds have smooth reflective surfaces; common manganese coatings on ped surfaces; manganese also occurs as scattered patches and grain coatings within peds; mostly noncalcareous between carbonate nodules; clear wavy boundary.

Btk4b 306 to 325 cm. Dominantly reddish brown (5YR 4/4 , moist) and pink (7.5YR 8/4, 7.5YR 7/4, dry) gravelly sandy clay loam; weak medium and fine subangular blocky structure between coarse fragments; firm; no roots; coarse fragments are extremely hard, carbonate-cemented fragments; coarse fragments coated with clay and manganese; manganese coatings on peds;common carbonate nodules in fine earth between coarse fragments; noncalcareous in many places between carbonate concentrations, remainder effervesces strongly; clear wavy boundary.

Btkb2 325 to 337 cm. Light reddish brown (5YR 6/4, dry) or reddish brown (5YR 5/4, moist) sandy clay loam; weak medium subangular blocky structure; firm; no roots; few carbonate filaments and fine carbonate nodules; black manganese occurs as soft masses, 1 to 5 mm diameter, with abrupt boundaries to adjacent fine earth; manganese occupies about 5 percent of the horizon; mostly noncalcareous but effervesces strongly in some parts, particularly near carbonate nodules; abrupt smooth boundary.

K2mb2 337 to 351 cm. Dominantly pink (7.5YR 8/4, dry; 7.5YR 7/4, moist) carbonate-cemented material; indurated and extremely hard; in places there are cracks into which clay has penetrated; in places is underlain by a zone of rounded, extremely hard, carbonate-cemented fragments that are clay-coated.

Remarks. Evidence of the uppermost buried soil consists of shifts in particle size and structure, and noncalcareous zones within the buried soil. The Btkb1 horizon is thought to have once been noncalcareous but to have been recharged with carbonate moved downward during pedogenesis in overlying horizons. The Btk1b horizon is th same age as the Btk1b (224 to 268 cm) of 69-7-2 and the Btkb (157 to 173 cm) of 69-7-3. The gravelly layer in the Btk4b horizon marks the lower part of the first buried soil. Similarly, the Btkb2 (325 to 337 cm) is the same age as the Btk1b2 (289 to 305 cm) horizon of 69-7-2. Both of the buried soils can be traced laterally along the deepest part of the trench. The lowermost buried soil is not present in pedon 69-7-3 because of shallowness of the petrocalcic horizon.

Any evidence of a lithologic discontinuity in the material above the Btk1b horizon has probably been largely destroyed by churning of the horizon. Thickness of the deposit suggests long-continued accumulation of fine-textured sediments.

S69NM-013-001 *** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Dalby, fine, montmorillonitic, thermic Typic Haplotorrert

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 809, SAMPLES 40A 6120- 6132
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

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			(- - -TOTAL	- - -)		(- -CLAY-	-)	(- -SILT-	-)	(- - - -	- -SAND-	-	- - - -	-)	(-COARSE FRACTIONS(MM)-)				(>2MM)
			CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC	- - - - WEIGHT			- - - -	WT
SAMPLE NO.	DEPTH (CM)	HORIZON	LT .002	.002 -.05	.05 -2	LT .0002	LT .002	.002 -.02	.02 -.05	.05 -.10	.10 -.25	.25 -.50	.5 -1	1 -2	2 -5	5 -20	20 -75	.1- 75	PCT OF WHOLE SOIL
			<- - - -	- - - -	- - - -	- - - -	PCT OF <2MM	(3A1) - -	- - - -	- - - -	- - - -	- - - -	- - - -	- ->	<- PCT OF	<75MM(3B1)->			
40A6120S	0- 3	A	25.9	49.1	25.0	2.5	4.0	28.8	20.3	16.4	6.9	1.1	0.4	0.2	--	--	--	9	--
40A6121S	3- 16	Bw1	44.4	38.3	17.3	7.6	8.0	24.5	13.8	9.8	5.8	1.0	0.5	0.2	--	--	--	7	--
40A6122S	16- 31	Bw2	47.4	36.0	16.6	12.0	10.0	23.5	12.5	9.5	5.6	1.0	0.3	0.2	--	--	--	7	--
40A6123S	31- 72	Bw3	48.4	36.0	15.6	12.7	10.0	23.0	13.0	8.9	5.2	0.9	0.4	0.2	--	--	--	7	--
40A6124S	72-110	Bw4	48.5	37.3	14.2	15.0	10.0	24.2	13.1	8.7	4.1	0.7	0.4	0.3	--	--	--	5	--
40A6125S	110-159	BC	45.8	39.5	14.7	12.6	10.0	25.3	19.2	9.3	3.9	0.7	0.4	0.4	--	--	--	5	--
40A6126S	159-194	BCky	45.4	38.1	16.5		9.0	24.1	14.0	9.9	4.8	0.9	0.5	0.4	--	--	--	7	--
40A6127S	194-235	Btk1b	45.3	38.3	16.4		7.0	24.3	14.0	10.1	4.2	0.8	0.7	0.6	--	--	--	6	--
40A6128S	235-278	Btk2b	40.4	34.4	25.2		TR	22.5	11.9	12.0	8.4	2.6	1.5	0.7	--	--	--	13	--
40A6129S	278-306	Btk3b	30.9	21.1	48.0		TR	11.5	9.6	14.5	20.2	6.7	3.9	2.7	--	--	--	33	--
40A6130S	306-325	Btk4b	26.6	20.7	52.7		3.0	14.3	6.4	6.6	10.2	5.5	10.7	19.7	14	16	28	77	58
40A6131S	325-337	Btkb2	34.1	15.9	50.0		--	8.2	7.7	16.5	21.4	5.5	3.9	2.7	6	6	--	41	12
40A6132S	337-351	K2mb2													--	--	--		--
40A6132S	337-351														--	--	--		--

			(- - - -	- - - -	- - - -	- - - -	- - -BUFFERED	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	)	
			(- - -TOTAL	- - -)		(- -CLAY-	-)	(- -SILT-	-)	(- - - -	- -SAND-	-	- - - -	-)	
			CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC	
SAMPLE NO.	DEPTH (CM)	HORIZON	LT .002	.002 -.05	.05 -2	LT .0002	LT .002	.002 -.02	.02 -.05	.05 -.10	.10 -.25	.25 -.50	.5 -1	1 -2	
			<- - - -	- - - -	- - - -	- - - -	PCT OF <2MM	(3A1) - -	- - - -	- - - -	- - - -	- - - -	- - - -	- ->	
40A6120S	0- 3	A	29.5	43.6	26.9	5.5		27.9	15.7	17.9	7.3	1.2	0.5	TR	
40A6121S	3- 16	Bw1	46.7	33.2	20.1	17.1		20.0	13.2	11.9	6.7	1.1	0.3	0.1	
40A6122S	16- 31	Bw2	48.3	32.6	19.1	23.2		20.3	12.3	11.1	6.4	1.2	0.4	TR	
40A6123S	31- 72	Bw3	48.9	33.4	17.7	22.7		20.5	12.9	10.8	5.5	1.0	0.4	TR	
40A6124S	72-110	Bw4	48.9	34.9	16.2	4.0		21.4	13.5	10.6	4.6	0.7	0.3	TR	
40A6125S	110-159	BC	46.1	37.2	16.7	5.3		22.1	15.1	11.1	4.6	0.7	0.2	0.1	
40A6126S	159-194	BCky	45.1	35.7	19.1			20.8	14.9	12.2	5.7	0.9	0.2	0.1	
40A6127S	194-235	Btk1b	47.8	34.4	17.8			20.6	13.8	11.6	5.1	0.8	0.3	TR	
40A6128S	235-278	Btk2b	44.7	30.2	25.1			19.0	11.2	12.4	8.8	2.6	1.1	0.1	
40A6129S	278-306	Btk3b	33.7	18.9	47.4			10.2	8.7	16.0	21.5	7.1	2.5	0.3	
40A6130S	306-325	Btk4b	51.5	13.0	35.5			7.3	5.7	12.6	16.3	4.8	1.6	0.2	
40A6131S	325-337	Btkb2	39.5	11.8	48.7			6.8	5.0	18.3	22.4	5.5	2.2	0.3	
40A6132S	337-351	K2mb2													--

AVERAGES, DEPTH 25-100: PCT CLAY 38 PCT .1-75MM 6

S69NM-013-001

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Dalby, fine, montmorillonitic, thermic Typic Haplotorrert

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 809, SAMPLES 40A 6120- 6132
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

DEPTH (CM)	-1-- ORGN C	-2-- TOTAL N	-3-- EXTR P	-4-- TOTAL S	-5-- (- - DITH-CIT - -) EXTRACTABLE FE	-6-- AL	-7-- MN	-8-- (RATIO/CLAY) CEC	-9-- 15 BAR	-10- (ATTERBERG - LIMITS -) LL	-11- PI	-12- (- BULK DENSITY -) FIELD MOIST	-13- 1/3 BAR	-14- OVEN DRY	-15- COLE WHOLE SOIL	-16- (- - -WATER CONTENT - -) FIELD MOIST	-17- 1/10 BAR	-18- 1/3 BAR	-19- 15 BAR	-20- WRD WHOLE SOIL
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM -->				PCT <0.4MM		<- - G/CC	- - ->		CM/CM	<- - -PCT OF	<2MM	- ->		CM/CM
0- 3	2.05				0.7			1.03	0.53										13.8	
3- 16	0.90				0.6			0.59	0.36										16.1	
16- 31	0.63				0.5			0.55	0.34				1.37	1.70	0.075		36.0	30.7	16.3	0.20
31- 72	0.51				0.5			0.54	0.34				1.43	1.83	0.091		30.9	28.3	16.6	0.17
72-110	0.45				0.5			0.54	0.36				1.37	1.75	0.085		32.3	30.5	17.3	0.18
110-159	0.20				0.4			0.56	0.36				1.38	1.70	0.072		33.5	30.9	16.4	0.20
159-194	0.19				0.4			0.55	0.35				1.51	1.68	0.036		36.6	31.2	15.8	0.23
194-235	0.11				0.4			0.58	0.36										16.5	
235-278	0.07				0.7			0.71	0.40				1.50	1.72	0.047			24.8	16.1	0.13
278-306	0.03				0.5			0.73	0.39										12.2	
306-325	0.04				0.2			0.74	0.42										11.2	
325-337	0.08				0.4			0.83	0.43										14.8	
337-351					0.1															

DEPTH (CM)	(- NH4OAC EXTRACTABLE BASES -) CA	MG	NA	K	SUM BASES	ACID-ITY	EXTR AL	(- - - -CEC - - -) SUM CATS	NH4-OAC	BASES + AL	AL SAT	-BASE SAT- SUM	NH4 OAC	CO3 AS CACO3 <2MM	RES. OHMS /CM	COND. MMHOS /CM	(- - - -PH - - -) CACL2 .01M	H2O
	<- - - - - - - - - - - -				-MEQ / 100 G		- - - - - - - - - - - -			->	<- - - - -	-PCT	- - - -	->			1:2	1:1
0- 3		1.8	0.1	3.7					26.6			100	100	9			7.7	8.1
3- 16		2.2	0.2	2.7					26.1			100	100	14			7.6	7.7
16- 31		2.5	0.3	1.9					25.9			100	100	15			7.6	7.9
31- 72		2.8	0.5	1.7					26.0			100	100	14			7.6	8.1
72-110		3.0	1.4	1.5					26.1			100	100	15			7.6	8.0
110-159		3.0	2.2	1.3					25.8			100	100	16			7.7	7.9
159-194		2.9	2.3	1.1					25.0			100	100	15			7.6	7.6
194-235		3.0	2.4	1.0					26.3			100	100	13			7.6	7.6
235-278		2.7	1.9	1.1					28.6			100	100	5			7.6	7.9
278-306		2.0	1.3	0.8					22.6			100	100	7			7.6	8.1
306-325		1.7	1.1	0.6					19.6			100	100	64			7.7	8.0
325-337		2.4	1.7	0.9					28.4			100	100	16			7.4	7.7
337-351														66				

S69NM-013-002

Soil Series: Ratliff
Classification: Ustic Haplocalcid, fine-loamy, mixed, th rmic.
Location: SW1/4 SE1/4 Sec. 24, T.18S., R.3W, 61 feet north of 69-7-1.
G omorphic Surface: Playa in shallow depression on Rincon surface.
Land Form: Playa (transitional between central part and edge of playa).
Elevation: 4650 feet.
Parent Materials: Playa sediments of mixed origin, apparently derived from erosion of soils upslope. 0-224 cm, late Pleistocene; 224-289 cm, late or middle Pleistocene; 289-356 cm, middle or early Pleistocene. Parent materials below 318 cm are undifferentiated Camp Rice basin fill.

Vegetation: Mostly burrograss and tobosa, with a few snakeweed. There are scattered barren areas 5 to 30 cm wide.

Collected by: L. H. Gile, R. B. Grossman and J. W. Hawley, November 18, 1969
Described by: L. H. Gile and R. B. Grossman.

Soil Surface: Weakly cracked into polygons 2 to 10 cm wide.

<u>A 0 to 4 cm</u>. Light brownish gray (10YR 6.5/2, dry) or dark grayish brown (10YR 4/2, moist) silty clay loam; weak medium and thin fine platy structure; soft; few roots; effervesces strongly; abrupt smooth boundary.

<u>Bwl 4 to 15 cm</u>. Light brownish gray (10YR 6/2, dry) or dark grayish brown (10YR 4/2, moist) loam; very weak coarse prismatic structure, parting to weak coarse subangular blocky; very hard; roots common; effervesces strongly; clear wavy boundary.

<u>Bw2 15 to 38 cm</u>. Pale brown (9YR 6/3, dry) or dark brown (9YR 4/3, moist) clay loam; very weak coarse prismatic structure, parting to weak coarse subangular blocky; very hard; few roots; effervesces strongly; clear wavy boundary.

<u>Bw3 38 to 60 cm</u>. Light brown (7.5YR 6/3, dry) or brown (7.5YR 5/4, moist) clay loam; very weak coarse prismatic structure, parting to weak coarse and medium subangular blocky; very hard; f w roots; effervesces strongly; clear wavy boundary.

<u>Bw4 60 to 88 cm</u>. Light brown (8YR 6/3, dry) or dark brown (8YR 4.5/3, moist) clay loam; weak coarse prismatic structure, parting to weak coarse subangular blocky; very hard; few roots; very few carbonate filaments; effervesces strongly; clear wavy boundary.

<u>Bk1 88 to 122 cm</u>. Pinkish gray (8YR 7/2, dry) or brown (8YR 5/4, moist); clay loam; moderate medium prismatic structure, parting to weak fine and medium subangular blocky; hard; no r ots; few white (10YR 9/2, dry) or very pale brown (10YR 8/4, moist); carbonate nodules and vertical cylindroids, 1/2 to 1 cm diameter, cylindroids at least 2 to 3 cm long; effervesces str ngly; clear wavy boundary.

<u>Bk2 122 to 168 cm</u>. Pinkish gray (7.5YR 7/2, dry) or brown (7.5YR 5/4, moist) clay loam; moderate fine and medium prismatic structure, parting to moderate fine and very fine angular blocky; hard; no roots; few carbonate nodules and vertical cylindroids, same size as above; effervesces strongly; clear wavy boundary.

<u>Bk3 168 to 224 cm</u>. Light brown (7.5YR 6/4, dry) or brown (7.5YR 5/4, moist) clay loam; moderate fine and medium prismatic structure; no roots; very hard; few carbonate nodules and cylindr ids; many of the carbonate cylindroids extend vertically into the overlying horizon; prisms in this horizon are oriented 10 to 20 degrees to the north instead of being vertical; effervesces weakly between nodules; clear wavy boundary.

Btk1b 224 to 268 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 5/4, moist); loam; weak coarse prismatic stucture, parting to weak medium subangular bl cky; hard; no roots; few carbonate nodules and filaments; few extremely hard, carbonate-cemented fragments, 1 to 5 cm diameter, with filamentary coatings of manganese; effervesces strongly; clear wavy boundary.

Btk2b 268 to 289 cm. Reddish brown (6YR 4.5/4, moist) gravelly sandy clay loam; fine earth occurs in lenses from 1 to 10 cm thick; firm; no roots; few carbonate filaments and few manganese filaments; coarse fragments are extremely hard, carbonate-cemented, and are coated with carbonate and manganese; fine earth zones largely noncalcareous; parts around and near coarse fragments effervesce strongly; clear wavy boundary.

Btk1b2 289 to 305 cm. Dominantly brown (7.5YR 5/4, moist) sandy clay loam; partly carbonate-impregnated from pedogenesis in overlying horizons; massive; firm; no roots; few carbonate nodules, some of which are soft and some indurated; few manganese coatings on weak fracture planes; effervesces strongly; clear wavy boundary.

Btk2b2 305 to 318 cm. Dominantly reddish brown (6YR 4.5/4, moist) sandy clay loam; massive; firm; no roots; few carbonate nodules and filaments; manganese coatings n peds and some manganese coatings on grains within peds; a few bodies of manganese, which are roughly spherical, 1 to 5 mm diameter, soft and black; many parts noncalcareous; abrupt wavy boundary.

Klb2 318 to 336 cm. Closely fitted blocks of extremely hard, carbonate-cemented material about 5 or 6 thick and having lateral dimensions of about 5 to 15 cm; carbonate-cemented material contains a mixture of laminar, massive and nodular forms which commonly have 7.5YR or 10YR hue; dark, high-manganese laminae occur in some blocks; although firmly packed by fine earth in cracks between the fragments, they can be removed with a hammer and induration is not continuous; underlying material is like that of the Klb2 horizon that occurs laterally and is described below.

K1b2 318 to 356 cm. Pink (7.5YR 8/4, dry) or light brown (7.5YR 6/4, moist) with some material of 5YR hue; carbonate-cemented fragments that are easily removed with a hammer; massive and weak subangular blocky; some fragments are extremely hard, others only slightly hard; no roots; laterally the lower part of this horizon extends beneath the extremely hard lens of Klb2 described above.

S69NM-013-002

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Ratliff, fine-loamy, mixed, thermic Ustic Haplocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 810, SAMPLES 40A 6133- 6146
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (CM)	HORIZON	(- - -TOTAL - - -) CLAY LT .002	SILT .002 -.05	SAND .05 -2	(- -CLAY- -) FINE LT .0002	CO3 LT .002	(- -SILT- -) FINE .002 -.02	COARSE .02 -.05	(- - - - -SAND- - - - - -) VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	(-COARSE FRACTIONS(MM)-) - - - - WEIGHT - - - - 2 -5	5 -20	20 -75	.1- 75	(>2MM) WT PCT OF WHOLE SOIL
			<- - - -	- - - -	- - - -	- - - -	- PCT OF	<2MM	(3A1) - -	- - - -	- - - -	- - - -	- - - -	- ->	<- PCT OF	<75MM(3B1)->			
40A6133S	0- 4	A	27.8	53.8	18.4	3.3	2	33.8	20.0	12.4	4.9	0.8	0.2	0.1	--	--	--	6	--
40A6134S	4- 15	Bwl	22.4	40.9	36.7	2.5	4	22.4	18.5	19.7	13.5	2.2	0.8	0.5	6	--	--	22	6
40A6135S	15- 38	Bw2	28.8	33.5	37.7	7.4	7	16.3	17.2	17.8	15.6	2.5	0.9	0.9	9	--	--	27	9
40A6136S	38- 60	Bw3	27.8	31.1	41.1	0.2	7	15.1	16.0	18.8	17.8	2.9	0.9	0.7	6	1	--	28	7
40A6137S	60- 88	Bw4	28.3	34.0	37.7		6	18.2	15.8	19.4	14.7	2.5	0.8	0.3	--	--	--	18	--
40A6138S	88-122	Bk1	35.6	36.3	28.1		13	25.0	11.3	13.5	10.8	2.4	1.1	0.3	--	--	--	15	--
40A6139S	122-168	Bk2	38.5	36.7	24.8		14	28.0	8.7	12.1	9.7	2.1	0.7	0.2	--	--	--	13	--
40A6140S	168-224	Bk3	39.2	36.6	24.2		11	27.6	9.0	12.2	8.7	2.0	0.9	0.4	--	--	--	12	--
40A6141S	224-268	Btk1b	23.9	27.5	48.6		2	14.4	13.1	23.2	17.8	5.0	2.1	0.5	1	2	--	28	3
40A6142S	268-289	Btk2b	22.5	19.6	57.9		2	10.2	9.4	18.7	25.8	8.8	3.5	1.1	3	16	--	51	19
40A6143S	289-305	Btk1b2	20.9	22.2	56.9		2	14.1	8.1	15.6	25.8	8.8	4.0	2.7	7	15	--	54	22
40A6144S	305-318	Btk2b2	24.4	16.2	59.4		1	9.9	6.3	15.8	29.2	9.4	3.6	1.4	3	8	--	50	11
40A6145S	318-336	K1b2													--	--	--		--
40A6146S	318-356	K1b2													12	29	10		51

BUFFERED

SAMPLE NO.	DEPTH (CM)	HORIZON	(- - -TOTAL - - -) CLAY LT .002	SILT .002 -.05	SAND .05 -2	(- -CLAY- -) FINE LT .0002	CO3 LT .002	(- -SILT- -) FINE .002 -.02	COARSE .02 -.05	(- - - - -SAND- - - - - -) VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	
			<- - - -	- - - -	- - - -	- - - -	- PCT OF	<2MM	(3A1) - -	- - - -	- - - -	- - - -	- - - -	- ->	
40A6133S	0- 4	A	23.4	57.2	19.4	1.9		36.4	20.8	12.3	5.0	1.1	0.8	0.2	
40A6134S	4- 15	Bwl	22.3	38.2	39.5	16.4		21.2	17.0	21.6	14.7	2.5	0.6	0.1	
40A6135S	15- 38	Bw2	26.6	31.2	42.2	11.6		15.0	16.2	20.9	17.5	3.0	0.7	0.1	
40A6136S	38- 60	Bw3	24.8	28.9	46.3	11.3		13.5	15.4	22.0	20.2	3.3	0.7	0.1	
40A6137S	60- 88	Bw4	26.1	32.4	41.5	11.3		12.8	19.6	21.7	16.5	2.6	0.6	0.1	
40A6138S	88-122	Bk1	34.0	28.9	37.1			12.8	16.1	19.2	14.6	2.6	0.6	0.3	
40A6139S	122-168	Bk2	37.3	26.1	36.6			11.9	14.2	18.2	14.6	3.0	0.7	0.2	
40A6140S	168-224	Bk3	41.3	26.3	32.4			13.7	12.6	17.2	12.1	2.6	0.5	TR	
40A6141S	224-268	Btk1b	24.7	24.4	50.9			9.9	14.5	25.1	18.6	5.3	1.7	0.2	
40A6142S	268-289	Btk2b	22.8	16.9	60.3			6.2	10.7	20.8	27.2	9.1	2.8	0.4	
40A6143S	289-305	Btk1b2	25.4	14.0	60.6			4.8	9.2	18.3	29.6	9.7	2.6	0.4	
40A6144S	305-318	Btk2b2	27.1	11.6	61.3			4.1	7.5	17.7	31.0	9.6	2.7	0.3	
40A6145S	318-336	K1b2													--
40A6146S	318-356	K1b2													51

AVERAGES, DEPTH 25-100: PCT CLAY 22 PCT .1-75MM 22

S69NM-013-002

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Ratliff, fine-loamy, mixed, thermic Ustic Haplocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 810, SAMPLES 40A 6133- 6146
- GENERAL METHODS 1B1A, 2A1, 2B

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NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

DEPTH (CM)	-1-- ORGN C PCT	-2-- TOTAL N <2MM	-3-- EXTR P PPM	-4-- TOTAL S	-5-- DITH-CIT EXTRACTABLE FE (PERCENT OF <2MM)	-6-- DITH-CIT AL	-7-- DITH-CIT MN	-8-- (RATIO/CLAY) CEC	-9-- (RATIO/CLAY) 15 BAR	-10- ATTERBERG LIMITS LL (PCT <0.4MM)	-11- PI	-12- BULK DENSITY FIELD MOIST (G/CC)	-13- 1/3 BAR	-14- OVEN DRY	-15- COLE WHOLE SOIL CM/CM	-16- WATER CONTENT FIELD MOIST (PCT OF <2MM)	-17- 1/10 BAR	-18- 1/3 BAR	-19- 15 BAR	-20- WRD WHOLE SOIL CM/CM
0- 4	4.23				0.6				0.56										15.5	
4- 15	1.06				0.6				0.51				1.43	1.56	0.029		24.1	23.8	11.4	0.17
15- 38	0.75				0.6				0.40				1.39	1.55	0.037		22.6	26.6	11.6	0.20
38- 60	0.54				0.5				0.37				1.50	1.63	0.028		22.4	19.7	10.4	0.13
60- 88	0.43				0.4				0.37				1.48	1.66	0.039		24.2	23.5	10.4	0.19
88-122	0.31				0.4				0.31										11.0	
122-168	0.18				0.4				0.29										11.3	
168-224	0.11				0.4				0.32										12.5	
224-268	0.04				0.4				0.39										9.3	
268-289	0.04				0.4				0.39										8.8	
289-305	0.04				0.2				0.44										9.1	
305-318	0.04				0.2				0.41										10.1	
318-336	0.08																			
318-356	0.08																			

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA (MEQ / 100 G)	MG	NA	K	SUM BASES	ACID-ITY	EXTR AL	CEC SUM CATS	CEC NH4-OAC	BASES + AL	AL SAT	BASE SAT SUM (PCT)	BASE SAT NH4 OAC	CO3 AS CACO3 <2MM	RES. OHMS /CM		COND. MMHOS /CM		PH CACL2 .01M 1:2	PH H2O 1:1
0- 4		2.0 B	0.1	3.3					31.0			100	100	10					7.5	7.8
4- 15		1.5	0.1	2.4					21.7			100	100	6					7.6	7.9
15- 38		1.4	0.1	1.7					18.4			100	100	12					7.6	7.9
38- 60		1.4	0.1	1.4					16.1			100	100	13					7.7	8.1
60- 88		1.9	0.1	1.6					15.9			100	100	12					7.7	8.2
88-122		2.4	0.2	1.5					16.7			100	100	28					7.7	8.1
122-168		3.6	0.2	1.3					18.2			100	100	32					7.7	8.0
168-224		4.7	0.2	1.2					20.2			100	100	28					7.7	8.1
224-268		4.2	0.4	1.1					16.3			100	100	7					7.6	8.1
268-289		3.8	0.4	0.9					15.2			100	100	19					7.7	8.2
289-305		4.1	0.5	0.7					16.1			100	100	33					7.7	8.2
305-318		4.8	0.6	0.8					19.7			100	100	20					7.8	8.2
318-336														81						
318-356														71						

ANALYSES: S= ALL ON SIEVED <2MM BASIS

A - DETERMINED ON WHOLE MATERIAL GROUND TO PASS 80 MESH
B - METHOS 6N4C FOR CA AND 6O4C FOR MG APPLIES TO ALL HORIZONS

S69NM-013-003

Soil Series: Ratliff
Classificati n: Ustic Haplocalcid, fine-loamy, mixed, thermic.
Location: SW1/4 SE1/4 Sec. 24, T.18S., R.3W, 93 feet north of 69-7-1.
Geomorphic Surface: Playa in depression on Rincon surface.
Land Form: Playa (near edge).
Elevation: 4650 feet.

Parent Materials: Playa sediments of mixed origin, above 183 cm, apparently derived from erosion of soils upslope. Parent materials below 183 cm are undifferentiated Camp Rice basin fill. 0-144 cm, late Pleistocene; 144-173 cm, late or middle Pleistocene; 173-197 cm, late Pliocene.

Vegetation: Mainly burrograss, with scattered tobosa and snakeweed; there are scattered barren areas 10 to 30 cm wide.

Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, November 19, 1969.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface. Cracked into polygons 3 to 10 cm wide.

A 0 to 5 cm. Light brownish gray (10YR 6.5/2, dry) or dark grayish brown (10YR 4.5/2, moist) loam; weak medium and thin platy structure; slightly hard; few roots; effervesces strongly; abrupt smooth boundary.

BA 5 to 15 cm. Brown (10YR 5.5/3, dry) or dark brown (10YR 4/3, moist) loam; very weak coarse prismatic structure, massive internally; hard; roots common; a few subrounded and subangular extremely hard carbonate-cemented coarse fragments, mostly less than 1 cm in diameter; effervesces strongly; clear wavy boundary.

Bw1 15 to 38 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 4.5/4, moist) loam; weak coarse prismatic structure, parting to very weak medium subangular blocky; hard; few roots; a few subrounded and subangular, extremely hard, carbonate-cemented coarse fragments, mostly less than 1 cm in diameter; effervesces strongly; clear wavy boundary.

Bw2 38 to 61 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 5/4, moist) loam; massive; slightly hard; few roots; a few subrounded and subangular; extremely hard, carbonate-cemented coarse fragments, mostly less than 1 cm in diameter; effervesces strongly; clear smooth boundary.

K1 61 to 72 cm. Dominantly light gray (10YR 7/2, dry) or light brown (10YR 6/3, moist) clay loam; weak fine and medium subangular blocky structure; slightly hard; few roots; a few subrounded and subangular, extremely hard, carbonate-cemented coarse fragments, mainly less than 1 cm in diameter; a few white (10YR 9/2, dry) carbonate nodules; effervesces strongly; clear smooth boundary.

K2 72 to 105 cm. Dominantly white (10YR 9/2, dry) or very pale brown (10YR 8/3, moist) with lesser amount of light gray (10YR 7/2, dry) or light brown (10YR 6/3, moist) clay loam; weak medium subangular blocky structure; hard and slightly hard; few roots; a few subrounded and subangular, extremely hard, carbonate-cemented coarse fragments, mainly less than 1 cm in diameter; effervesces strongly; clear wavy boundary.

K3 105 to 144 cm. Dominantly pinkish white (7.5YR 9/2, dry; 7.5YR 7/2, moist) with lesser amount of light brown (7.5YR 6/4, dry) or brown (7.5YR, 5/4, moist) clay loam; hard; few roots; a few subrounded and subangular, extremely hard, carbonate-cemented coarse fragments, mainly less than 1 cm in diameter; a few white (10YR 9/2, dry) carbonate nodules; effervesces strongly; clear wavy boundary.

Bkb 144 to 157 cm. Dominantly pinkish white (7.5YR 6.5/4, dry) or brown (7.5YR 5.5/4, moist) clay loam; w ak coarse prismatic structure, parting to weak medium subangular blocky; hard; f w roots; few carbonate filaments and nodules; effervesces strongly; clear wavy boundary.

Btkb 157 to 173 cm. Dominantly brown (7.5YR 5/4, moist) clay loam; weak medium prismatic structure, parting to weak medium subangular blocky; hard and very hard; few r ots; a few rounded, carbonate-cemented fragments in lower part; about 20 percent carbonate nodules; most effervesce strongly, but there are a very few noncalcareous parts; abrupt wavy boundary.

K1b2 173 to 183 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 5/4, moist) and pink (7.5YR 9/4, dry; 7.5YR 8/4, moist) very gravelly clay loam; weak fine subangular bl cky structure between coarse fragments, which are extremely hard and carbonate-cemented; fine earth is tightly packed between coarse fragments and is firm; a few fine roots, which have penetrat d the fine earth in cracks between fragments; coarse fragments consist largely of plates ranging up to 6 cm thick and 15 cm diameter; internally the plates consist of laminar and massive material of 10YR hue, with colors of 10YR 8/3, dry and 10YR 8/4, dry, being most common, and minor amounts of 7.5YR hue; some fragments are smaller and rounded, and have laminar coatings up to 1 cm thick; some of interiors contain dark manganese zones; laminar zone common on tops of largest fragments; effervesces strongly; abrupt wary boundary.

K2mb2 183 to 197 cm. Laminar and massive, extremely hard, carbonate-cemented material, with some nodular forms continuously cemented with the matrix, somewhat more of 7.5YR and 5YR hue than in K1 horizon; no roots; effervesces strongly.

S69NM-013-003

*** PRIMARY CHARACTERIZATI N DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Ratliff, fine-loamy, mixed, thermic Ustic Haplocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 811, SAMPLES 40A 6147- 6157
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
			(- - -TOTAL	- - -)		(- -CLAY-	-)	(- -SILT-	-)	(- - - -	- -SAND-	-	- - - -	-)	(-COARSE FRACTIONS(MM)-)				(>2MM)
			CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC	- - - - WEIGHT		- - - -		WT
SAMPLE NO.	DEPTH (CM)	HORIZON	LT .002	.002 -.05	.05 -2	LT .0002	LT .002	.002 -.02	.02 -.05	.05 -.10	.10 -.25	.25 -.50	.5 -1	1 -2	2 -5	5 -20	20 -75	.1- 75	PCT OF WHOLE
			<- - - - -	- - - - -	- - -	PCT OF <2MM	(3A1)	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- ->	<- PCT OF	<75MM(3B1)->			SOIL
40A6147S	0- 5	A	26.1	55.5	18.4		4.0	36.4	19.1	12.3	4.6	0.7	0.6	0.2	--	--	--	6	--
40A6148S	5- 15	BA	20.6	35.3	44.1		4.0	19.2	16.1	21.4	18.1	2.9	1.2	0.5	4	1	--	27	5
40A6149S	15- 38	Bw1	23.0	32.9	44.1		7.0	17.3	15.6	19.9	19.0	3.2	1.3	0.7	5	3	--	30	8
40A6150S	38- 61	Bw2	23.9	30.5	45.6		10.0	16.9	13.6	18.9	19.8	3.5	1.7	1.7	6	7	--	36	13
40A6151S	61- 72	K1	30.6	32.4	37.0		18.0	21.5	10.9	15.1	15.8	3.1	1.7	1.3	6	5	--	30	11
40A6152S	72-105	K2	31.1	37.7	31.2		20.0	29.4	8.3	12.3	13.4	2.9	1.5	1.1	5	3	--	25	8
40A6153S	105-144	K3	31.0	33.2	35.8		17.0	25.5	7.7	13.3	16.5	3.6	1.3	1.1	3	3	--	27	6
40A6154S	144-157	Bkb	29.5	30.2	40.3		13.0	22.1	8.1	13.9	17.8	4.4	2.1	2.1	5	3	--	32	8
40A6155S	157-173	Btkb	30.4	33.5	36.1		8.0	22.8	10.7	13.9	13.9	4.1	2.5	1.7	4	5	--	29	9
40A6156S	173-183	K1b2	28.0	36.7	35.3		11.0	25.6	11.1	13.5	13.3	3.7	2.2	2.6	10	29	--	52	39
40A6157S	183-197	K2mb2													--	--	--		--

			(- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	-BUFFERED	- - - - -	- - - - -	- - - - -	- - - - -	)
			(- - -TOTAL	- - -)		(- -CLAY-	-)	(- -SILT-	-)	(- - - -	- -SAND-	-	- - - -	-)
			CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC
SAMPLE NO.	DEPTH (CM)	HORIZON	LT .002	.002 -.05	.05 -2	LT .0002	LT .002	.002 -.02	.02 -.05	.05 -.10	.10 -.25	.25 -.50	.5 -1	1 -2
			<- - - - -	- - - - -	- - -	PCT OF <2MM	(3A1)	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- ->
40A6147S	0- 5	A	27.8	54.2	18.0			31.3	22.9	12.6	4.6	0.6	0.1	0.1
40A6148S	5- 15	BA	19.6	33.4	47.0			15.2	18.2	24.1	19.4	2.8	0.6	0.1
40A6149S	15- 38	Bw1	20.3	29.1	50.6			11.6	17.5	24.2	22.4	3.2	0.7	0.1
40A6150S	38- 61	Bw2	19.3	27.3	53.4			9.8	17.5	24.1	25.0	3.5	0.6	0.2
40A6151S	61- 72	K1	21.6	25.6	52.8			9.0	16.6	22.9	24.9	4.0	0.8	0.2
40A6152S	72-105	K2	25.4	23.8	50.8			10.5	13.3	21.0	24.4	4.3	0.9	0.2
40A6153S	105-144	K3	26.9	20.9	52.2			9.3	11.6	19.9	25.4	5.3	1.2	0.4
40A6154S	144-157	Bkb	26.2	19.2	54.6			7.9	11.3	19.4	27.3	6.2	1.4	0.3
40A6155S	157-173	Btkb	35.1	23.3	41.6			12.3	11.0	18.2	17.5	4.4	1.2	0.3
40A6156S	173-183	K1b2	32.9	21.1	46.0			9.8	11.3	20.1	19.6	4.7	1.2	0.4
40A6157S	183-197	K2mb2												

AVERAGES, DEPTH 25-100: PCT CLAY 13 PCT .1-75MM 30

S69NM-013-003

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Ratliff, fine-loamy, mixed, thermic Ustic Haplocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 811, SAMPLES 40A 6147- 6157
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

DEPTH (CM)	-1-- ORGN C PCT	-2-- TOTAL N <2MM	-3-- EXTR P PPM	-4-- TOTAL S <- PERCENT	-5-- DITH-CIT EXTRACTABLE FE OF	-6-- DITH-CIT EXTRACTABLE AL	-7-- DITH-CIT EXTRACTABLE MN <2MM -->	-8-- (RATIO/CLAY) CEC	-9-- (RATIO/CLAY) 15 BAR	-10- (ATTERBERG - LIMITS -) LL PCT <0.4MM	-11- (ATTERBERG - LIMITS -) PI	-12- BULK DENSITY FIELD MOIST <- - G/CC	-13- BULK DENSITY 1/3 BAR	-14- BULK DENSITY OVEN DRY - - ->	-15- COLE WHOLE SOIL CM/CM	-16- WATER CONTENT FIELD MOIST <- - - PCT OF	-17- WATER CONTENT 1/10 BAR	-18- WATER CONTENT 1/3 BAR <2MM	-19- WATER CONTENT 15 BAR - ->	-20- WRD WHOLE SOIL CM/CM
0- 5	4.06				0.6			1.10	0.55										14.3	
5- 15	1.24				0.5			0.89	0.49				1.41	1.51	0.022		24.1	23.7	10.0	0.19
15- 38	0.62				0.4			0.64	0.41				1.41	1.48	0.016			19.3	9.5	0.14
38- 61	0.46				0.5			0.51	0.37				1.39	1.44	0.011			24.7	8.9	0.22
61- 72	0.43				0.3			0.34	0.29										8.8	
72-105	0.31				0.2			0.33	0.26				1.41	1.48	0.016		27.7	22.2	8.2	0.20
105-144	0.16				0.3			0.38	0.28										8.6	
144-157	0.11				0.3			0.45	0.30										8.8	
157-173	0.11				0.3			0.60	0.35										10.7	
173-183	0.19				0.3			0.51	0.34										9.5	
183-197	0.12				TR															

DEPTH (CM)	NH4OAC EXTRACTABLE BASES CA	MG	NA	K	SUM BASES	ACID-ITY	EXTR AL	CEC SUM CATS	CEC NH4-OAC	CEC BASES + AL	AL SAT	BASE SAT SUM	BASE SAT NH4 OAC	CO3 AS CACO3 <2MM	RES. OHMS /CM	COND. MMHOS /CM	PH CACL2 .01M 1:2	PH H2O 1:1
	<- - - - - - - - - - -	- -	MEQ / 100 G	- -	- -	- -	- -	- -	- -	- ->	<- - - - -	PCT	- -	- ->				
0- 5		1.8	0.2	2.6					28.6			100	100	12			7.5	7.8
5- 15		1.0	0.2	1.2					18.3			100	100	12			7.5	7.9
15- 38		0.9	0.2	1.0					14.7			100	100	15			7.6	8.1
38- 61		0.8	0.2	0.8					12.3			100	100	21			7.5	7.9
61- 72		0.7	0.2	0.5					10.3			100	100	38			7.6	8.1
72-105		0.8	0.2	0.5					10.2			100	100	48			7.7	8.2
105-144		1.5	0.2	0.5					11.9			100	100	40			7.6	8.0
144-157		2.0	0.2	0.5					13.4			100	100	31			7.6	8.0
157-173		2.7	0.2	0.7					18.1			100	100	32			7.7	8.0
173-183		1.8	0.2	0.6					14.3			100	100	59			7.7	8.1
183-197														84				

ANALYSES: S= ALL ON SIEVED <2mm BASIS

Soil Series: Tencee
Classification: Typic Petrocalcid, loamy-skeletal, carbonatic, thermic, shallow.
Location: SW1/4 SE1/4 Sec. 24, T.18S., R.3W, 164 feet north of 69-1.
Geomorphic Surface: Rincon.
Land Form: Edge of alluvial-fan piedmont sloping 1-1 1/2% to the south.
Elevation: 4650 feet.
Parent Materials: Camp Rice alluvial-fan sediments of late Pliocene age derived from limestone.

Vegetation: Creosotebush, buckwheat, tarbush, prickly pear, mammillaria cactus, small clumps of bush muhly around the bases of some creosotebush.

Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, November 19, 1969.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface: About 70 percent covered with extremely hard, subangular, carbonate-cemented fragments most of which range from 1/2 to 3 cm in diameter.

A 0 to 5 cm. Light brownish gray (10YR 6.5/2, dry) or dark grayish brown (10YR 4/2, m ist) gravelly very fine sandy loam; soft; few roots; vesicular in part, with vesicles about 1 mm diameter; effervesces strongly; abrupt smooth boundary.

K11 5 to 18 cm. Light brown (7.5YR 6.5/3, dry) or brown (7.5YR 5/3, moist) very gravelly very fine sandy loam; massive, breaking into a loose mass of soft fine and very fine crumbs; soft; roots common; coarse fragments are rounded and subangular, extremely hard, carbonate-cemented fragments which are discontinuously coated with weakly adhering fine earth; effervesces strongly; clear wavy boundary.

K12 18 to 37 cm. Dominantly white (10YR 9/3, dry) or very pale brown (10YR 6/3, moist) disc ntinuously carbonate-cemented material; cemented material is massive, is very and extremely hard, but is readily removed from the horizon with a knife; few roots between the cemented parts; about 10 percent of the horizon consists of fine earth with texture of very gravelly light loam, which has penetrated cracks separating the carbonate-cemented material, and is a loose mass of soft fine and very fine crumbs; fine roots are concentrated on top of the underlying laminar horizon in many places; effervesces strongly; abrupt wavy boundary.

K21m 37 to 44 cm. Dominantly white (10YR 9/2, dry), and very pale brown (10YR 8/4, dry) extremely hard carbonate laminae; no roots; vertical, white crack fillings about 1/2 mm thick extending into the horizon in places; there are a few harder nodular parts that break into fragments showing nodular interiors, mainly 10YR hue but some of 7.5YR and 5YR; effervesces strongly; abrupt wavy boundary.

K22 44 to 64 cm. Dominantly white (10YR 9/2, dry) or light gray (10YR 7/2, moist) disc ntinuously carbonate-cemented material consists of formerly continuous laminar zones, now fractured; grades laterally into continuously indurated material; fragments are very or extremely hard but can be removed with a knife; a few roots which have penetrated along the tops of the discontinuous laminar zones and there are also thin (1-4 mm) layers of fine earth along with the roots; horizon is discontinuous, occurs in places where roots and fine earth have penetrated, and laterally grades into continuously indurated K22m; effervesces strongly; abrupt smooth boundary.

K23m 64 to 84 cm. Dominantly very pale brown (10YR 8/3, dry; 10YR 7/3, moist) carbonate-cemented material; breaks out as extremely hard plates and as tightly fitted angular and subangular blocks, which are more easily removed than are the large plates; extremely hard; no roots; a few laminated nodules, with some 5YR hue; effervesces strongly; clear wavy boundary.

K24m 84 to 97 cm. Dominantly very pale brown (10YR 8/3, dry) or light yellowish brown (10YR 6/4, moist) with parts lighter and darker than this; carbonate-cemented material; breaks out as plates ranging from about 3 to 10 cm in diameter; extremely hard; no roots; a few laminar horizons, separated by nonlaminar material, dip about 60 percent to the north, effervesc s strongly; clear wavy boundary.

K25m 97 to 131 cm. Dominantly very pale brown (10YR 8/3, dry; 10YR 7/3, moist) and pale brown (10YR 6/3, dry) or brown (10YR 5/3, moist) carbonate-cemented material; consists largely of laminar carbonate, with some nonlaminar zones; extremely hard; no roots; some laminae are more steeply dipping (range from 60 to 100 percent) than in K24m horizon; effervesces strongly.

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 612, SAMPLES 40A 6158- 6166
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SAMPLE N .	DEPTH (CM)	HORIZON	-4-- TOTAL CLAY LT .002	-5-- TOTAL SILT .002 -.05	-6-- TOTAL SAND .05 -2	-7-- CLAY FINE LT .0002	-8-- CLAY CO3 LT .002	-9-- SILT FINE .002 -.02	-10- SILT COARSE .02 -.05	-11- SAND VF .05 -.10	-12- SAND F .10 -.25	-13- SAND M .25 -.50	-14- SAND C .5 -1	-15- SAND VC 1 -2	-16- COARSE FRACTIONS(MM) WEIGHT 2 -5	-17- 5 -20	-18- 20 -75	-19- .1- 75	-20- (>2MM) WT PCT OF WHOLE SOIL
			<- - - -	- - - -	- - - -	- - - -	PCT OF <2MM	(3A1) - -	- - - -	- - - -	- - - -	- - - -	- - - -	- ->	<- PCT OF	<75MM(3B1)		->	
40A6158S	0- 5	A	10.4	24.7	64.9		3.0	8.4	16.3	29.6	27.3	4.6	2.2	1.2	10	22	--		32
40A6159S	5- 18	K11	16.0	29.0	55.0		5.0	11.4	17.6	25.8	22.6	3.7	1.7	1.2	11	36	--		47
40A6160S	18- 37	K12													8	35	34		77
40A6161S	37- 44	K21m													--	--	--		--
40A6162S	44- 64	K22													15	34	23		72
40A6163S	64- 84	K23m													--	--	--		--
40A6164S	84- 97	K24m													--	--	--		--
40A6165S	97-131	K25m													--	--	--		--
40A6166S	84- 97														--	--	--		--

DEPTH (CM)	-1-- ORGN C	-2-- TOTAL N	-3-- EXTR P	-4-- TOTAL S	-5-- DITH-CIT EXTRACTABLE FE	-6-- AL	-7-- MN	-8-- (RATIO/CLAY) CEC	-9-- 15 BAR	-10- (ATTERBERG - LIMITS -) LL	-11- PI	-12- (BULK DENSITY) FIELD MOIST	-13- 1/3 BAR	-14- OVEN DRY	-15- COLE WHOLE SOIL	-16- (WATER CONTENT) FIELD MOIST	-17- 1/10 BAR	-18- 1/3 BAR	-19- 15 BAR	-20- WRD WHOLE SOIL
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM	-->			PCT <0.4MM		<- - G/CC	- -	->	CM/CM	<- - -PCT	OF <2MM		- ->	CM/CM
0- 5	0.51				0.4			1.04	0.57										5.9	
5- 18	0.85				0.4			0.76	0.48										7.6	
18- 37	0.27				TR														10.0	
37- 44	0.43				TR														7.3	
44- 64	0.23				TR														10.9	
64- 84	0.19				TR														7.8	
84- 97	0.23				TR														4.8	
97-131	0.15				0.1														6.6	
84- 97																			3.1	

AVERAGES, DEPTH 25- 37: PCT CLAY 0 PCT .1-75MM 770

S69NM-013-004

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 812, SAMPLES 40A 6158- 6166
- GENERAL METHODS 1B1A, 2A1, 2B

DEPTH (CM)	-1-- CA	-2-- MG	-3-- NA	-4-- K	-5-- SUM BASES	-6-- ACID-ITY	-7-- EXTR AL	-8-- SUM CATS	-9-- CEC NH4-OAC	-10- BASES + AL	-11- AL SAT	-12- BASE SAT SUM	-13- BASE SAT NH4 OAC	-14- CO3 AS CACO3 <2MM	-15- RES. OHMS /CM	-16-	-17- COND. MMHOS /CM	-18-	-19- PH CACL2 .01M	-20- PH H2O
	<-	-	-	-	-MEQ / 100 G	-	-	-	-	->	<-	-PCT	-	->					1:2	1:1
0- 5		0.8	0.2	0.9					10.8			100	100	10					7.8	8.4
5- 18		0.9	0.2	1.0					12.2			100	100	18					7.7	8.1
18- 37		0.9	0.2	0.5					10.4			100	100	72					7.7	8.0
37- 44		0.4	0.2	0.2					2.9			100	100	85					7.8	8.2
44- 64		1.3	1.6	0.2					5.1			100	100	85					7.9	8.1
64- 84		0.9	1.5	0.1					3.5			100	100	70					7.7	8.2
84- 97		0.6	1.2	0.1					2.2			100	100	85					7.9	8.4
97-131		0.7	1.8	0.1					3.1			100	100	85					8.0	8.3
84- 97		0.5	0.5	0.1					3.3			100	100	85					7.8	8.4

ANALYSES: S= ALL ON SIEVED <2mm BASIS

S69NM-013-005

Soil Series: Tencee
Classification: Typic Petrocalcid, loamy-skeletal, carbonatic, thermic, shallow.
Location: NE1/4 SE1/4 Sec. 25, T.18S., R.3W
Geomorphic Surface: Rincon.
Land Form: Relict basin floor, level.
Elevation: 4620 feet.
Parent Materials: Camp Rice basin-floor sediments of late Pliocene age, and of mixed origin.

Vegetation Mainly creosotebush; few buckwheat and mammillaria cactus.
C llected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, November 20, 1969, and April 7, 1970.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface. About 20-30% covered with subangular coarse fragments of carbonate-cemented material, mainly less than 3 cm in diameter; about 30% of the soil surface is slightly rounded and covered with black algae, occupying slight highs in the microrelief, with an amplitude of 1 to 2 cm; areas between the algae forms are lower and smooth-appearing; soil surface cracked into polygons, from 3 to 10 cm wide.

A 0 to 5 cm. Light brownish gray (10YR 6.5/2, dry) or dark brown (10YR 4/3, moist) very fine sandy loam; moderate thin and very thin platy structure; soft; very few roots; effervesces strongly; abrupt smooth boundary.

Bk 5 to 25 cm. Light brown (7.5YR 6.5/4) or brown (7.5YR 5/4, moist) loam; weak medium subangular blocky; slightly hard; few roots; few carbonate filaments and patchy coatings on ped faces; horizon ranges from about 20 to 27 cm thick at sampling site; effervesces strongly; abrupt smooth boundary.

K1 25 to 46 cm. Light brown (7.5YR 6.5/4, dry) or brown (7.5YR 5/4, moist) very gravelly clay loam; massive and soft between coarse fragments; few roots; coarse fragments consist of extremely hard, carbonate-cemented fragments, some of which are platy, and other spherical; plates have smooth upper surfaces, often with a concentration of fine roots, while the bottoms commonly have a pustular appearance, with pustules having an amplitude of several mm; most of the coarse fragments have a distinctive carbonate morphology characterized by pisoliths and matrix material that are cemented together and are continuously indurated and in which concentrically laminated pisoliths having laminae of 5YR or 2.5YR hue alternate with lighter-col red laminae of 10YR hue; there are occasional black laminae that apparently contain abundant manganese; pisoliths are often spherical but blocky forms also occur; most pisoliths range from about 1/4 to 2 cm in diameter; pisoliths are commonly cemented in a brownish matrix that usually has 7.5YR hue and that has few or no laminae; both pisoliths and matrix are extremely hard and dense; some of the plates consist partly of younger carbonate which occurs as crack fillings in the older carbonate, and which is softer (though still indurated), less dense and of 10YR hue; the carbonate-cemented fragments commonly have coating of younger carbonate, 1 to 5 mm thick; effervesces strongly; abrupt wavy boundary.

K21m 46 to 61 cm. The uppermost 1 mm to 1 cm consists of a continuous laminar horizon ranging in dry color from 10YR 8/3 to 10YR 8/4 or 10YR 7/3; underlying material is continuously indurated pisoliths and matrix material having morphology similar to the older type described in the carbonate-cemented fragments of the K1 horizon; pisoliths and matrix are extremely hard and c ntinuously cemented together so that when broken, the fracture plane passes through matrix and pisoliths alike; most common colors of the concentric laminae are 2.5YR 4/6, dry; 5YR 5/4, dry, and 10YR 8/3, dry with one of the first two commonly alternating with the latter, which c ntrasts sharply with the redder, darker laminae; grossly platy, with indurated plates ranging from about 2 to 10 cm thick; between the plates are thin zones of soft, light-colored fine earth; extrem ly hard; no roots; pisoliths are commonly spherical; most range from about 2 mm to 2 cm in diameter with one having diameter of about 10 cm as viewed in cross section; laminae range in macroscopic thickness from about 1/2 mm to 1/2 cm, with the most common of the pisoliths--usually about 1/2 to 1 cm thick--having concentric laminae that are about 1/2 mm thick;

occasionally this kind of morphology is separated by crack fillings and small (several cm wide) pocket fillings f younger, laminar, and massive carbonate of 10YR hue; some parts have pale yellow (2.5Y 7/3) crack fillings <1 mm thick; lower parts of the plates have pustular appearance, with pustules having an amplitude of several mm; effervesces strongly ; clear wavy boundary.

K22m 61 to 101 cm. Dominantly light brown (7.5 YR 6/4, dry) to pink (7.5YR 8/4, dry) carbonate-cemented material, breaks out as plates somewhat thicker than in the K21m; contains both recemented, laminated pisoliths and laminar carbonate; extremely hard; no roots; reddish yellow (2.5YR-5YR 5/6, moist) material occurs both as pisoliths coatings and as nearly horizontal laminae; some laminae and coating are black; pisoliths commonly range from about 1/2 to 2 cm in diameter; effervesces strongly; clear wavy boundary.

K23m 101 to 148 cm. Dominantly white (10YR 8/3, dry) or light gray (10YR 7/3, m ist) carbonate-cemented material without the laminated pisoliths, alternating subhorizons of laminar and massively-cemented nonlaminar material; breaks out as platy units about 2 to 20 cm thick; extremely hard; no roots; between some of the plates there are thin (from 1 to 4 cm thick) zones of fine earth (soft K-fabric), with occasional small, very hard plates; effervesces strongly; clear wavy boundary.

K24m 148 to 162 cm. Description of grab sample at the base of the pit: color ranges from white (10YR 9/3, dry) or very pale brown (10YR 8/3, moist to pink (5YR 8/4,dry; 7.5YR 7/4, moist) breaks out partly as massive material and partly as weak blocks, 1 to 4 cm thick; occasional spots of very dark grayish brown (10YR 3/2, moist); extremely hard; no r ots; effervesces strongly.

S69NM-013-005

*** PRIMARY CHARACTERIZATION DATA ***

(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid IID

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 813, SAMPLES 40A 6167- 6175
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	-4-- CLAY LT .002	-5-- SILT .002 -.05	-6-- SAND .05 -2	-7-- FINE CLAY LT .0002	-8-- CO3 CLAY LT .002	-9-- FINE SILT .002 -.02	-10- COARSE SILT .02 -.05	-11- VF SAND .05 -.10	-12- F SAND .10 -.25	-13- M SAND .25 -.50	-14- C SAND .5 -1	-15- VC SAND 1 -2	-16- WEIGHT 2 -5	-17- WEIGHT 5 -20	-18- WEIGHT 20 -75	-19- .1-75	-20- (>2MM) WT PCT OF WHOLE SOIL
			(- - -TOTAL - - -)			(- -CLAY- -)		(- -SILT- -)		(- - - - - -SAND- - - - - -)					(-COARSE FRACTIONS(MM)-)				
			<- - - - - - - PCT OF <2MM (3A1) - - - - - - ->												<- PCT OF <75MM(3B1)->				
40A6167S	0- 5	A	14.6	37.3	48.1		3.0	19.3	18.0	25.2	17.5	3.0	1.6	0.8	5	7	--	32	12
40A6168S	5- 25	Bk	19.9	37.8	42.3		3.0	19.1	18.7	23.0	14.7	2.7	1.3	0.6	8	12	--	35	20
40A6169S	25- 46	Kl													11	42	--		53
40A6170S	46- 61	K21m													--	--	--		--
40A6171S	0- 25		17.5	36.6	45.9		5.0	18.1	18.5	24.2	16.1	3.1	1.6	0.9	8	17	--	41	25
40A6172S	25- 46														--	--	--		--
40A6173S	61-101	K22m													--	--	--		--
40A6174S	101-148	K23m													--	--	--		--
40A6175S	148-162	K24m													--	--	--		--

DEPTH (CM)	-1-- ORGN C PCT	-2-- TOTAL N <2MM	-3-- EXTR P PPM	-4-- TOTAL S	-5-- DITH-CIT EXTRACTABLE FE	-6-- AL	-7-- MN	-8-- (RATIO/CLAY) CEC	-9-- 15 BAR	-10- (ATTERBERG - LIMITS -) LL	-11- PI	-12- (- BULK DENSITY -) FIELD MOIST	-13- 1/3 BAR	-14- OVEN DRY	-15- COLE WHOLE SOIL CM/CM	-16- (- - -WATER CONTENT - -) FIELD MOIST	-17- 1/10 BAR	-18- 1/3 BAR	-19- 15 BAR	-20- WRD WHOLE SOIL CM/CM
				<- PERCENT OF <2MM -->						PCT <0.4MM		<- - G/CC - - ->				<- - -PCT OF <2MM - ->				
0- 5	0.72				0.4			1.18	0.57										8.3	
5- 25	0.78				0.5			0.94	0.53										10.6	
25- 46	1.13				0.3														11.2	
46- 61	0.21				0.1														3.8	
0- 25	0.86				0.4				0.56										9.8	
25- 46	0.31				TR															
61-101	0.15				TR														4.3	
101-148	0.15				0.1														3.5	
148-162	0.08				TR														7.5	

AVERAGES, DEPTH 25- 46: PCT CLAY 0 PCT .1-75MM 53

*** PRIMARY CHARACTERIZATION DATA ***

S69NM-013-005 Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid PRINT DATE 01/12/94

USDA-SCS-NSSC-SOIL SURVEY LABORATORY ; PEDON 40A 813, SAMPLE 40A 6167- 6175

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	(- NH4OAC EXTRACTABLE BASES -)					ACID-	EXTR	(- - - -CEC - - -)			AL	-BASE SAT-		CO3 AS	RES.		COND.		(- - - -PH - - -)	
DEPTH (CM)	CA	MG	NA	K	SUM BASES	ITY	AL	SUM CATS	NH4- OAC	BASES + AL	SAT	SUM	NH4 OAC	CACO3 <2MM	OHMS /CM		MMHOS /CM		CACL2 .01M	H2O
	<- - - - - - - - - - - - - -MEQ / 100 G									- - - - - - - - - - - - ->	<- - - - - -PCT			- - - - ->					1:2	1:1
0- 5		1.1	0.2	1.1					17.2			100	100	13					7.8	8.3
5- 25		1.5	0.2	0.6					18.7			100	100	23					7.8	8.2
25- 46		1.5	0.3	0.3					13.5			100	100	46					7.8	8.1
46- 61		0.4	0.2	0.1					3.8			100	100	85					7.9	8.5
0- 25														19						
25- 46														82						
61-101		0.8	0.6	0.1					1.9			100	100	83					7.9	8.7
101-148		0.6	0.4	0.1					3.4			100	100	83					7.8	8.3
148-162		1.2	0.9	0.1					3.0			100	100	72					7.9	8.5

ANALYSES: S= ALL ON SIEVED <2mm BASIS

S69NM-013-006

Soil Series: Stellar, deep petrocalcic analog
Classification: Ustic Petroargid, fine, mixed, thermic.
L cation: SE1/4 NE1/4 S c. 25, T.18S., R.3W., north nd of trench at which pedon S69-7-7 was sampled.
Ge morphic Surface: Depression in Rincon surface.
Land Form: Broad, very shallow depression.
Elevation: 4620 feet.
Parent Materials: 0-106 cm, eolian sediments from the Rio Grande Valley; below 106 cm, Camp Ric basin-floor sediments of mixed origin. 0-106 cm, mostly late Pleistocene, minor amount of middle and early Pleistocene; 106-130 cm, late Pliocene.

Vegetation: Mainly burrograss. There are a very few tobosa clumps, mammillaria cactus, creosot bush, and tarbush. There are occasional barren patches, 5 to 10 cm wide between grass clumps. Tobosa clumps spaced from about 2 to 10 feet apart, shrubs from about 5 to 20 feet apart. T bosa clumps are quite dense and range from 10 to 74 cm wide.

Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, November 20, 1969.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface. The surface is about 50 percent occupied by grass clumps; and is smooth and barren between clumps; surface is cracked into polygons from 3 to 8 cm wide.

E 0 to 5 cm. Light brownish gray (10YR 6.5/2, dry) or dark grayish brown (10YR 4/2, m ist) clay loam; massive and weak very thin platy structure; slightly hard; few roots; effervesces weakly in upper part, lower part usually noncalcareous; abrupt smooth boundary.

Bt1 5 to 14 cm. Brown (7.5 YR 5.5/3, dry) or dark brown (7.5YR 4/3, moist) clay; very weak coarse prismatic structure, parting to weak medium and coarse subangular blocky; hard; roots common; generally noncalcareous, a few places effervesce weakly; clear wavy boundary.

Bt2 14 to 36 cm. Brown (9YR 5.5/3, dry) or dark brown (9YR 3.5/3, moist) clay; weak coarse prismatic structure, parting to moderate fine and medium subangular blocky; hard; roots ommon; peds have smooth, weakly reflective surfaces; effervesces strongly; clear wavy boundary.

Bt3 36 to 57 cm. Brown (9YR 5.5/3, dry) or dark brown (9YR 3.5/3, moist) clay; weak coarse prismatic structure, commonly parting to weak medium subangular blocky but with some weak medium platy, especially in lower part; a few horizontal wedges in lower part, 3 or 4 cm long and 1 to 2 cm wide at their widest ends; very hard; few roots; many peds have smooth, reflective surfaces; effervesces strongly; clear wavy boundary.

Btk 57 to 86 cm. Brown (10YR 5.5/3, dry) or dark brown (10YR 4/3, moist) clay; massive; hard; v ry few roots; common carbonate filaments; effervesces strongly; clear wavy boundary.

Bt 86 to 106 cm. Brown (10YR 5.5/3, dry) or dark brown (7.5YR 4/3, moist) clay; moderate fine and very fine subangular and angular blocky structure; slightly hard; very few r ots; peds have smooth, reflective surfaces; some peds have thin patchy coatings of manganese; generally noncalcareous; clear smooth boundary.

K1b 106 to 130 cm. Dominantly light brown (7.5YR 6.5/4, dry) or brown (7.5YR 5.4, moist) with smaller amount brown (7.5 YR 5.5/4, dry and 4.5/4, moist) clay; weak medium and fine subangular blocky structure; slightly hard; no roots; a few carbonate nodules that are white (10YR 9/3, dry) or very pale brown (10YR 8/3, moist), effervesces strongly.

Remarks. This horizon dips into a small pipe, where sampled; laterally the upper part of the K1b horizon grades into a K1b horizon which consists of closely fitted blocks of once-continuously cemented material which n w breaks out as clay- and carbonate-coat d blocks 10 to 20 cm diameter.

S69NM-013-006

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Stellar, deep petrocalcic analog, fine, mixed, thermic Ustic Petroargid

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 814, SAMPLES 40A 6176- 6182
- GENERAL METHODS 1B1A, 2A1, 2B

-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (CM)	HORIZON	(- - -TOTAL CLAY LT .002	SILT .002 -.05	SAND .05 -2 - - -)	(- -CLAY- FINE LT .0002	CO3 LT .002 -)	(- -SILT- FINE .002 -.02	COARSE .02 -.05 -)	(- - - - -SAND- VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2 - - - - -)	(-COARSE FRACTIONS(MM)-) - - - - WEIGHT 2 -5	5 -20	20 -75	.1- 75 - - - -	(>2MM) WT PCT OF WHOLE SOIL
			<- - - -	- - - -	- - - -	- -	PCT OF	<2MM	(3A1) -	- - -	- - -	- - -	- - -	- ->	<- PCT OF	<75MM	(3B1)	->	SOIL
40A6176	0- 5	E	27.6	43.5	28.9	3.6		28.2	15.3	16.3	9.7	2.0	0.8	0.1	--	--	--	13	--
40A6177	5- 14	Bt1	43.3	36.6	20.1	11.3		24.2	12.4	11.4	6.7	1.5	0.5	TR	--	--	--	9	--
40A6178	14- 36	Bt2	47.5	35.4	17.1	23.6		23.6	11.8	9.9	5.5	1.2	0.4	0.1	--	--	--	7	--
40A6179	36- 57	Bt3	46.1	38.8	15.1	19.7		26.1	12.7	9.4	4.4	1.0	0.3	TR	--	--	--	6	--
40A6180	57- 86	Btk	45.1	42.5	12.4			30.2	12.3	7.6	3.7	0.8	0.3	TR	--	--	--	5	--
40A6181	86-106	Bt	45.0	40.6	14.4			27.8	12.8	8.4	4.6	1.0	0.4	TR	--	--	--	6	--
40A6182	106-130	Klb	46.8	24.8	28.4			14.7	10.1	13.1	11.0	2.6	1.2	0.5	--	--	--	15	--

DEPTH (CM)	ORGN C PCT	TOTAL N <2MM	EXTR P PPM	TOTAL S <-	(- - DITH-CIT EXTRACTABLE FE PERCENT	AL OF	- -) MN <2MM -->	(RATIO/CLAY) CEC	15 BAR	(ATTERBERG - LIMITS - LL PCT	) PI <0.4MM	(- BULK FIELD MOIST <- -	DENSITY 1/3 BAR G/CC	-) OVEN DRY - - ->	COLE WHOLE SOIL CM/CM	(- - -WATER FIELD MOIST <- -	CONTENT 1/10 BAR -PCT OF	1/3 BAR <2MM	- -) 15 BAR - ->	WRD WHOLE SOIL CM/CM
0- 5	1.18				0.8			0.99	0.45										12.4	
5- 14	0.76				0.9			0.75	0.36										15.8	
14- 36	0.71				0.9			0.64	0.35				1.34	1.63	0.067		34.4	29.7	16.5	0.18
36- 57	0.59				1.0			0.66	0.37										17.0	
57- 86	0.35				0.9			0.66	0.36										16.3	
86-106	0.24				0.9			0.68	0.36										16.1	
106-130	0.15				0.4			0.44	0.29										13.6	

AVERAGES, DEPTH 5- 55: PCT CLAY 46 PCT .1-75MM 7

S69NM-013-006

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Stellar, deep petrocalcic analog, fine, mixed, thermic Ustic Petroargid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 814, SAMPLES 40A 6176- 6182
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL C NSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	(- NH4OAC EXTRACTABLE BASES -)					ACID-	EXTR	(- - - -CEC - - -)			AL	-BASE SAT-		CO3 AS	RES.		COND.	(- - - -PH - - -)		
DEPTH (CM)	CA	MG	NA	K	SUM BASES	ITY	AL	SUM CATS	NH4-OAC	BASES + AL	SAT	SUM	NH4 OAC	CACO3 <2MM	OHMS /CM		MMHOS /CM		CACL2 .01M	H2O
	<- - - - - - - - - - - - -MEQ / 100 G - - - - - - - - - - - - ->										<- - - - - -PCT - - - - ->								1:2	1:1
0- 5	21.4	1.9	0.2	2.8	26.3			26.3	27.4			100	96	--					7.7	8.2
5- 14	26.6	2.6	0.2	2.4	31.8			31.8	32.6			100	98	TR					7.7	8.1
14- 36		3.5	0.7	1.7					30.5			100	100	3					7.6	8.0
36- 57		4.0	1.3	1.7					30.5			100	99	3					7.6	7.9
57- 86		4.2	1.7	1.6					29.7			100	99	2					7.6	8.0
86-106		4.2	2.0	1.6					30.7			100	95	1					7.6	8.0
106-130		3.2	1.8	1.0					20.6			100	100	11					7.6	8.4

S69NM-013-007

Soil Series: Stellar, deep petrocalcic anal g
Classification: Ustic Petroargid, fine, mixed, thermic.
Location: SE1/4 NE1/4 Sec. 25, T.18S., R.3W., south end of trench at which pedon S69NMex 7-6 was sampled.
Geomorphic Surface: Depression in Rincon surface.
Land Form: Broad, very shallow depression.
Elevation: 4620 feet.
Parent Materials: 0-104 cm, eolian sediments from the Rio Grande Valley; below 104 cm, Camp Rice basin-floor sediments of mixed origin. 0-104 cm, mostly late Pleistocene, with minor amount of middle and early Pleistocene; 104-127 cm, late Pliocene.

Vegetation: Mainly burrograss. There are a very few tobosa clumps, mammillaria cactus, creosotebush, and tarbush. There are occasional barren patches, 5 to 10 cm wide, between grass clumps. Tobosa clumps spaced from about 2 to 10 feet apart, shrubs from about 5 to 20 feet apart. Tobosa clumps are quite dense and range from 10 to 75 cm wide.

Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, November 20, 1969.

Described by: L. H. Gile and R. B. Grossman.

Soil Surface. The surface is about 50 percent occupied by grass clumps; smooth and barren between clumps; surface is cracked into polygons from 3 to 8 cm wide.

E 0 to 6 cm. Light brownish gray (10YR 6.5/2, dry) or dark grayish brown (10YR 4/2, moist) clay loam; massive and weak thin and medium platy structure; soft; few roots; upper part effervesces weakly, lower part effervesces weakly or is noncalcareous; abrupt smooth boundary.

Bt1 6 to 15 cm. Brown (9YR 5.5/3, dry) or dark brown (9YR 3.5/3, moist) clay; very weak coarse prismatic structure, parting to weak coarse subangular blocky; hard; roots common; effervesces weakly; clear wavy boundary.

(Note: remainder of profile is as described for 69-7-6, except for Klb)

Klb 104 to 127 cm. Dominantly reddish brown (5YR 5/4, moist 5YR 4/4, dry) very gravelly clay; coarse fragments are extremely hard carbonate-cemented fragments; fine earth between coarse fragments is weak fine and very fine subangular blocky; slightly hard; very few roots; coarse fragments are rounded and are coated with clay and manganese; some peds hav reflective surfaces, some peds coated with manganese and in places there are a few carbonate filaments; coarse fragments have a partial to complete laminar coating, up to several mm thick, and many have a partial to complete coating of black manganese-impregnated carbonat , 1 to 2 mm thick; effervesces strongly.

Remarks: This pedon was partially sampled for comparison with adjacent pedon 69-6, which has a noncalcareous Bt1 horizon. The Klb horizon described above is about 75 cm wide and laterally alternating with a Klb horizon consisting of closely fitted, carbonate-cemented blocks 10 t 20 cm in diameter.

S69NM-013-007

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A ***
(DONA ANA C UNTY, NEW MEXICO)

PRINT DATE 09/28/93

Stellar, deep petrocalcic analog, fine, mixed, thermic Ustic Petroargid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 817, SAMPLES 40A 6202- 6204
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
S IL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
						(- - -TOTAL	- - -)	(- -CLAY-	-)	(- -SILT-	-)	(- - - -	- -SAND- -	- - - -	-)	(-COARSE FRACTIONS(MM)-)				(>2MM)		
						CLAY LT .002	SILT .002 -.05	SAND .05 -2	FINE LT .0002	CO3 LT .002	FINE .002 -.02	COARSE .02 -.05	VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	- - - - WEIGHT 2 -5	5 -20	20 -75	- - - - .1- 75	WT PCT OF WHOLE SOIL
						<- - - - - - -	- - - - - - -	- PCT OF <2MM	(3A1) - - -								->	<- PCT OF	<75MM(3B1)->			SOIL
40A6202S	0- 6	E				27.6	41.7	30.7	3.8		25.6	16.1	17.3	10.3	2.1	0.9	0.1	--	--	--	13	--
40A6203S	6- 15	Bt1				45.7	35.1	19.2	16.5		24.2	10.9	10.9	6.4	1.3	0.5	0.1	--	--	--	8	--
40A6204S	104-127	Ktb				53.8	24.9	21.3	19.1		14.9	10.0	9.9	8.2	1.8	0.7	0.7	5	32	--	44	37

DEPTH (CM)	ORGN C	TOTAL N	EXTR P	TOTAL S	(- - DITH-CIT FE	EXTRACTABLE AL	- -) MN	(RATIO/CLAY) CEC	15 BAR	(ATTERBERG - LIMITS - LL	) PI	(- BULK FIELD MOIST	DENSITY 1/3 BAR	-) OVEN DRY	COLE WHOLE SOIL	(- - -WATER CONTENT FIELD MOIST	1/10 BAR	1/3 BAR	- -) 15 BAR	WRD WHOLE SOIL
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM -->				PCT <0.4MM		<- - G/CC	- - -	->	CM/CM	<- - -PCT OF	<2MM	- -	->	CM/CM
0- 6	1.14				0.7			0.98	0.58										16.0	
6- 15	0.83				1.0			0.68	0.33										15.3	
104-127	0.24				0.4			0.58	0.35										18.7	

AVERAGES, DEPTH 6- 15: PCT CLAY 46 PCT .1-75MM 8

*** PRIMARY CHARACTERIZATION DATA ***

S69NM-013-007 Stellar, deep petrocalcic analog, fine, mixed, thermic Ustic Petroargid PRINT DATE 01/12/94

USDA-SCS-NSSC-SOIL SURVEY LABORATORY ; PEDON 40A 817, SAMPLE 40A 6202- 6204

DEPTH (CM)	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	(- NH4OAC EXTRACTABLE BASES -)					ACID-	EXTR	(- - - -CEC - - -)			AL	-BASE SAT-		CO3 AS	RES.		COND.	(- - - -PH - - -)		
	CA	MG	NA	K	SUM BASES	ITY	AL	SUM CATS	NH4-OAC	BASES + AL	SAT	SUM	NH4 OAC	CACO3 <2MM	OHMS /CM		MMHOS /CM		CACL2 .01M	H2O
	<- - - - - - - - - - - - -MEQ / 100 G - - - - - - - - - - - - ->										<- - - - - -PCT - - - - ->								1:2	1:1
0- 6		2.4	0.3	3.2					27.1			100	100	1					7.6	7.9
6- 15		2.8	0.3	2.6					31.2			100	100	2					7.5	7.9
104-127		4.7	2.1	1.7					31.4			100	100	14					7.6	7.9

ANALYSES: S= ALL ON SIEVED <2mm BASIS

Soil Series: Tencee
Classification: Typic Petrocalcid, loamy-skeletal, carbonatic, thermic, shallow.
Location: SE1/4 NE1/4 Sec. 30, T.18S., R.2W., south edge of basin-floor remnant, along the scarp; about 250 feet east of 1/4 section corner between secs. 25 and 30.
Ge morphic Surface: Rincon.
Land Form: Relict basin floor.
Elevation: 4600 feet.
Parent Materials: Camp Rice basin-floor sediments of mixed origin and of late Pliocene age.

Vegetation: Creosotebush, buckwheat, mammillaria cactus.
Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, April 8, 1970.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface. About 90 percent covered by fragments of broken petrocalcic horizon, ranging from about 1/2 to 10 cm in diameter; fragments have an etched and pitted appearance.

A 0.0 to 0.07 m. Light brownish gray (10YR 6/1, dry) or dark grayish brown (10YR 4/2, moist) very gravelly heavy fine sandy loam; weak medium platy structure and weak very fine crumb; soft; effervesces strongly; clear smooth boundary.

K21m 0.07 to 0.2 m. Dominantly very pale brown (10YR 7/3, dry) or pale brown (10 YR 6/3, moist) with lesser amount of pink (7.5YR 7/4, dry) or light brown (7.5YR 6/4, moist) and small parts reddish brown (5YR 5.54, dry; 5YR 4.5/4, moist) occurring mainly as laminar carbonate, both nearly horizontally and as concentrically laminated parts of pisoliths, extremely hard; no roots; there are some black filaments and stainings; in places, the horizon is weakly cracked into plates 5 to 10 cm thick and 10 to 20 cm across; these are difficultly removed from the horizon and commonly have thin (about 1 mm) coatings of white (10YR 9/2, dry; 10YR 8/2, moist) carbonate; effervesces strongly; clear wavy boundary.

K22m 0.2 to 0.5 m. Ranges from very pale brown (10YR 8/3, dry) to dark brown (10YR 4/3, dry) laminar material; breaks out as platy units from 2 to 10 cm in diameter; extremely hard; no roots; a few laminae are of 5YR hue; a few parts of nonlaminar, massively carbonate-cemented material and a few recemented pisoliths; effervesces strongly; clear wavy boundary.

K23v 0.5 to 0.9 m. Dominantly white (10YR 8/2, dry) or very pale brown (10YR 7/3, moist) carbonate-cemented material that breaks out both as lenses, 2 to 4 cm thick, and as discrete platy fragments mainly from 5 to 10 cm across and 2 to 3 cm thick; these lenses and plates have smooth surfaces with occasional slight pockets, several mm deep and a few mm across; several discontinuous lenses (1-2 cm thick) apparently consisting primarily of gypsum, with some carbonate; the material is removed easily with the fingers or small knife, and breaks out as fine earth and as soft, or slightly hard fragments that are weakly cemented; no roots; upper part of the horizon contains some discontinuous laminar carbonate; apparent gypsum is noncalcareous or effervesces weakly; rest effervesces strongly; gradual wavy boundary.

K24m 0.9 to 1.7 m. Dominantly white (10YR 8/2, dry) or very pale brown (10YR 7/3, moist) carbonate-cemented material; breaks out as subangular blocky fragments, ranging from 1 to 5 cm diameter; fragments are indurated and extremely hard; no roots; fragments coated with thin (< 1 mm thick) carbonate coatings, white (10YR 9/2, dry; 10YR 8/2, moist), few black mottles, 1 to 5 mm diameter and coatings along cleavage planes; effervesces strongly; gradual boundary.

K31 1.7 to 2.5 m. Dominantly white (10YR 8/2, dry) or light gray (10YR 7/2, dry); and very pale brown (10YR 7/3, moist) or pale brown (10YR 6/3, mo st) breaks out as subangular fragments ranging from about 1 to 5 cm diameter, with occasional continuously cemented bodies up to 20 cm diameter; large parts of the horizon easily removed with a hammer; extr mely hard;

no roots; common thin (< 1 mm thick) white (10YR 8/2, moist) carbonate coatings on fragments; hard; some fragments have thin, partial coatings that are noncalcareous and appear to be gypsum; in places the whitest coating material occurs in continuous bodies from 1 to 20 mm across; most effervesces strongly; gradual wavy boundary.

K32m 2.5 to 3.3 m. Dominantly very pale brown (10YR 8/3, dry; 10YR 7/3, moist) carbonate-cemented material; breaks out as subangular blocky fragments, mainly ranging fr m about 2 to 10 cm in diameter, with coatings of white (10YR 9/2, dry; 10YR 8/2, moist) extremely hard; no roots; a few subangular volumes, 1 mm to 2 cm diameter, that are light brown (7.5YR 6/4, dry) or brown (7.5YR 5/4, moist) and that effervesce weakly or are noncalcareous; most effervesce strongly; some material, white (10YR 8/2, dry) or pinkish gray (10YR 7/3, moist) is noncalcareous after several acid treatments; gradual wavy b undary.

Rk 3.3 to 3.7 m. Dominantly pinkish gray (7.5YR 7/3, dry; 7.5YR 6/3, moist) fragments of carbonate-cemented rock like the underlying R1, separated by volumes of white (10YR 9/3, dry) or very pale brown (10YR 8/3, moist) pedogenic carbonate; carbonate occurs as nodular forms, veins, filaments, and coatings on rock fragments; no roots; effervesces strongly; gradual wavy boundary.

R1 3.7 to 4.9 m. Pinkish gray (7.5YR 7/2, dry; 7.5YR 6/3, moist) carbonate-cemented rock; very coarse prisms are apparent on weathered face; rock breaks out as massive fragments, but with some in upper part being coarsely blocky; extremely hard; no roots; empty vesicles up to 1 mm high and 10 mm long, both horizontal and vertical; nearly all is calcareous, but a few zones lining joint planes are noncalcareous and appear to be linings of silica; gradual wavy boundary.

R2 4.9 to 5.4 m. White (10YR 8/1, dry) light gray (10YR 7/2, moist) carbonate-cemented rock; platy, with plates ranging from about 0.5 to 5 cm thick; extremely hard, but more easily removed with a hammer than adjacent horizons; no roots; a few of the plates are wedge-shaped on their ends; effervesces strongly; clear wavy boundary.

R3 5.4 to 6.1 m. White (10YR 8/1, dry) or light gray (10YR 7/2, moist) carbonate-cemented rock; prismatic, with prisms ranging from about 30 to 50 cm across; within the prisms the material breaks out massively or in weak subangular blocks; common empty vesicles, up to 1 mm high and 1 to 10 mm in lateral dimension; effervesces strongly; gradual wavy boundary.

R4 6.1 to 6.4 m. White (10YR 8/2, dry) or light brownish gray (10YR 6/2, moist) carbonate-cemented rock; extremely hard; no roots; broken vertically into segments ranging from 20 to 30 cm across; the segments have thin carbonate coatings; effervesces strongly; clear smooth boundary.

C 6. 4 to 6.7 m. Light gray (10YR 7/2, dry) or grayish brown (10YR 5/2, moist) sand; massive; soft; no roots; about half of the horizon consists of carbonate-cemented blocks and plates up to 20 cm diameter; some tubular masses are cemented together and range from 2 to 10 cm diameter; individual tubes are 2 to 4 mm diameter; noncalcareous or effervesces weakly.

Remarks: The R horizons may owe some of their character to pedogenetic processes; they can be continuously traced all along the southern face of the scarp. Because of the lack of demonstrable soil horizons, however, all are designated R. Because of erosion near the scarp, about 1/2 to 1 meter of upper horizons has probably been truncated from this ped n, when compared to higher stabler sites away from the scarp.

A fresh exposure for sampling purposes was obtained by blasting a series of steps down the face of the scarp.

S70NM-013-002

*** PRIMARY CHARACTERIZATION DATA ***

(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid

SSL - PROJECT ,
- PEDON , SAMPLES 70L 275 - 284
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	-1-- TOTAL CLAY LT .002	-2-- TOTAL SILT .002 -.05	-3-- TOTAL SAND .05 -2	-4-- CLAY FINE LT .0002	-5-- CLAY CO3 LT .002	-6-- SILT FINE .002 -.02	-7-- SILT COARSE .02 -.05	-8-- SAND VF .05 -.10	-9-- SAND F .10 -.25	-10- SAND M .25 -.50	-11- SAND C .5 -1	-12- SAND VC 1 -2	-13- COARSE FRACTIONS (MM) WEIGHT 2 -5	-14- WEIGHT 5 -20	-15- WEIGHT 20 -75	-16- WEIGHT .1- 75	-17- (>2MM) WT PCT OF WHOLE SOIL
			<- - - PCT OF <2MM (3A1) - - ->												<- PCT OF <75MM(3B1)->				
70L 275S	7- 20	K21m																	--
70L 276S	20- 50	K22m																	--
70L 277S	50- 90	K23y																	--
70L 278S	90-170	K24m																	--
70L 279S	170-250	K31																	--
70L 280S	250-330	K32m																	--
70L 281S	330-370	Rk																	--
70L 282S	370-370	R1																	--
70L 283S	370-490	R2																	--
70L 284S	-	R3																	--

DEPTH (CM)	ORGN C PCT	TOTAL N <2MM	EXTR P PPM	TOTAL S	DITH-CIT EXTRACTABLE FE	AL	MN	(RATIO/CLAY) CEC	15 BAR	(ATTERBERG - LIMITS -) LL	PI	(- BULK DENSITY -) FIELD MOIST	1/3 BAR	OVEN DRY	COLE WHOLE SOIL CM/CM	(- - WATER CONTENT - -) FIELD MOIST	1/10 BAR	1/3 BAR	15 BAR	WRD WHOLE SOIL CM/CM
				<- PERCENT OF <2MM -->						PCT <0.4MM		<- - G/CC - - ->				<- - -PCT OF <2MM - ->				
7- 20	0.15				0.1															
20- 50	0.23				TR															
50- 90	0.15				TR															
90-170	0.11				TR															
170-250	0.08				0.1															
250-330	0.08				TR															
330-370	0.08				TR															
370-370	0.04				0.2															
-	0.04				0.1															
-	0.04				0.1															

AVERAGES, DEPTH 6- 15: PCT CLAY 46 PCT .1-75MM 8

S70NM-013-002

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid

SSL - PROJECT ,
- PEDON , SAMPLES 70L 275 - 284
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

DEPTH (CM)	-1-- (- NH4OAC EXTRACTABLE BASES -) CA	-2-- MG	-3-- NA	-4-- K	-5-- SUM BASES	-6-- ACID-ITY	-7-- EXTR AL	-8-- (- - - -CEC SUM CATS	-9-- NH4-OAC	-10- BASES + AL - - -)	-11- AL SAT	-12- -BASE SUM	-13- SAT- NH4 OAC	-14- CO3 AS CACO3 <2MM	-15- RES. OHMS /CM	-16-	-17- COND. MMHOS /CM	-18-	-19- (- - - -PH - - -) CACL2 .01M	-20- H2O
	<- - - - - - - - - - - - -MEQ / 100 G									- - - - - - - - - - - ->	<- - - - - -PCT			- - - ->					1:2	1:1
7- 20														85						
20- 50														88						
50- 90														82						
90-170														75						
170-250														62						
250-330														51						
330-370														64						
370-370														63						
-														77						
-														20						

ANALYSES: S= ALL ON SIEVED <2mm BASIS

Soil Series: Tencee
Classification: Typic Petrocalcid, loamy-skeletal, carbonatic, thermic, shallow.
Location: SE1/4 NE1/4 Sec. 30, T.18S., R.2W., 250 feet n rth of scarp.
Geomorphic Surface: Rincon.
Land Form: Relict basin floor.
Elevation: 4600 feet.
Parent Materials: Camp Rice basin-floor sediments of mixed origin and of late Pliocene age.

Vegetation: Creosotebush, mammillaria cactus, few small poor-looking tarbush, few buckwheat, few clumps fluffgrass.

Collected by: L. H. Gile, R. B. Grossman and J. W. Hawley, April 8, 1970.
Described by: L. H. Gile and R. B. Grossman.

S il Surface: About 40 percent covered with angular to subangular carbonate-cemented fragments, which commonly have an etched and pitted appearance. Most are from 1/2 to 3 cm in diameter, with a few up to 10 cm in diameter.

A 0 to 4 cm. Dominantly pinkish gray (7.5YR 6/2, dry) or dark brown (7.5YR 4/2, moist) with a few browner parts; loam; some parts massive and soft, others are a loose mass of very fine soft crumbs; few roots; effervesces strongly; abrupt smooth boundary.

BK 4 to 10 cm. Pinkish gray (7.5YR 6/2, dry) or brown (7.5YR 5/4, moist) gravelly loam; slightly hard; massive; roots common; gravel consists of subangular carbonate-cemented fragments mainly from 1 to 5 cm diameter with a few larger than this; effervesces strongly; clear wavy boundary.

K11 10 to 28 cm. Pinkish gray (7.5YR 6/3, dry) or brown (7.5YR 5/4, moist) very gravelly loam; massive; soft; roots common; gravel consists partly of rounded carbonate-cemented fragments, but there are also common platy fragments up to 10 cm long and 5 cm thick; many of the plates are oriented horizontally; upper 1 to 2 cm of many plates have laminar carbonate, oriented horizontally with the material beneath being nonlaminar, massively cemented material; eff rvesces strongly; clear wavy boundary.

K12 28 to 42 cm. Light brown (7.5YR 6/4, dry) or brown (7.5YR 5/4, moist) very gravelly loam; fine earth massive and soft; roots common; fine roots on top of the underlying K21m horizon; carbonate-cemented fragments are mostly platy, and up to 20 cm across 5 cm thick, with occasional finer fragments; the upper 1 to 2 cm of many plates consist largely of laminar carb nate, with remainder nonlaminar, massively cemented material; effervesces strongly; abrupt sm oth boundary.

K21m 42 to 102 cm. Dominantly white (10YR 9/2, dry; 10YR 8/2, moist) carbonate-cemented material; upper cm is laminar, rest is largely massively cemented and nonlaminar; material breaks out as indurated platy units ranging from about 3 to 15 cm thick; extremely hard; no roots; efferv sces strongly; clear wavy boundary.

K22m 102 to 156 cm. Dominantly light gray (10YR 7/2, dry) or pale brown (10YR 6/3, moist) carbonate-cemented material; breaks out as weak plates and blocks from about 2 to 10 cm thick, which are thinly coated with white (10YR 9/2, dry; 10YR 8/2, moist) carbonate; extremely hard; a few fine roots which appear dead, effervesces strongly; clear wavy boundary.

K23 156 to 206 cm. Dominantly very pale brown (10YR 8/3, dry) or pale brown (10YR 6/3, moist) carbonate-cemented material; breaks out mainly as carbonate-cemented plates, 2 to 10 cm thick and up to 30 cm across; scattered loose zones of sandy loam, same color as above, occur between some plates; slightly to extremely hard; few roots; effervesces strongly; a few parts eff rvesce only weakly, then not at all and appear to be fine-grained gypsum.

S70NM-013-003

*** P R I M A R Y   C H A R A C T E R I Z A T I O N   D A T A ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 815, SAMPLES 40A 6183- 6193
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (CM)	HORIZON	(- - -TOTAL - - -) CLAY LT .002	SILT .002 -.05	SAND .05 -2	(- -CLAY- -) FINE LT .0002	CO3 LT .002	(- -SILT- -) FINE .002 -.02	COARSE .02 -.05	(- - - - - -SAND- - - - - -) VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	(-COARSE FRACTIONS(MM)-) WEIGHT 2 -5	5 -20	20 -75	.1- 75	(>2MM) WT PCT OF WHOLE SOIL
			<- - - - - - - - - - -	- PCT OF <2MM	(3A1)	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - ->	<- PCT OF	<75MM(3B1)	->	SOIL
40A6183S	0- 4	A	13.0	34.4	52.6		3.0	14.8	19.6	27.0	20.0	3.3	1.6	0.7	7	12	--	40	19
40A6184S	4- 10	BK	25.7	33.8	40.5		5.0	19.0	14.8	19.6	16.0	2.9	1.3	0.7	6	20	--	41	26
40A6185S	10- 28	K11	26.3	36.2	37.5		9.0	18.4	17.8	19.5	12.9	2.7	1.6	0.8	9	31	--	51	40
40A6186S	28- 42	K12													12	50	--		62
40A6187S	42-102	K21m													--	--	--		--
40A6188S	102-156	K22m													--	--	--		--
40A6189S	156-206	K23													--	--	--		--
40A6190S	0- 18		19.0	34.1	46.9		4.0	17.0	17.1	23.6	17.8	3.1	1.5	0.9	5	16	--	39	21
40A6191S	0- 10														4	11	--		15
40A6192S	0- 10														--	--	--		--
40A6193S	0- 18														--	--	--		--

DEPTH (CM)	ORGN C	TOTAL N	EXTR P	TOTAL S	(- - DITH-CIT - -) EXTRACTABLE FE	AL	MN	(RATIO/CLAY) CEC	15 BAR	(ATTERBERG - LIMITS -) LL	PI	(- BULK DENSITY -) FIELD MOIST	1/3 BAR	OVEN DRY	COLE WHOLE SOIL	(- - -WATER CONTENT - -) FIELD MOIST	1/10 BAR	1/3 BAR	15 BAR	WRD WHOLE SOIL
	PCT	<2MM	PPM	<- PERCENT	OF	<2MM -->				PCT	<0.4MM	<- - G/CC	- - -	->	CM/CM	<- - -PCT OF	<2MM	- -	->	CM/CM
0- 4	0.66				0.5			1.22	0.96										12.5	
4- 10	1.19				0.4			0.91	0.51										13.2	
10- 28	1.16				0.4			0.78	0.38										10.0	
28- 42	0.62				0.1														9.9	
42-102	0.11				0.1														15.9	
102-156	0.15				0.1														19.2	
156-206	0.11				0.1														18.5	
0- 18	0.86				0.5				0.53										10.0	
0- 10					TR															
0- 10	0.26																			
0- 18																				

AVERAGES, DEPTH 25- 42: PCT CLAY 3 PCT .1-75MM 60

*** PRIMARY CHARACTERIZATION DATA ***

S70NM-013-003 | Tencee, loamy-skeletal, carbonatic, thermic, shallow Typic Petrocalcid | PRINT DATE 01/12/94

USDA-SCS-NSSC-SOIL SURVEY LABORATORY ; PEDON 40A 815, SAMPLE 40A 6183- 6193

DEPTH (CM)	-1-- (- NH4OAC EXTRACTABLE BASES -) CA	-2-- MG	-3-- NA	-4-- K	-5-- SUM BASES	-6-- ACID-ITY	-7-- EXTR AL	-8-- (- - - -CEC SUM CATS	-9-- NH4-OAC	-10- BASES + AL - - -)	-11- AL SAT	-12- -BASE SUM	-13- SAT- NH4 OAC	-14- CO3 AS CACO3 <2MM	-15- RES. OHMS /CM	-16-	-17- COND. MMHOS /CM	-18- (- - - -PH	-19- CACL2 .01M	-20- H2O - - -)
	<- - -	- - -	- - -	- - -	-MEQ /	100 G -	- - -	- - -	- - -	- - ->	<- - -	- -PCT	- - -	- ->					1:2	1:1
0- 4		1.0	0.2	1.0					15.9			100	100	22					7.7	8.2
4- 10		1.9	0.2	0.9					23.5			100	100	29					7.7	8.0
10- 28		2.0	0.3	0.4					20.5			100	100	51					7.6	7.8
28- 42		1.2	0.2	0.2					5.8			100	100	79					7.6	7.9
42-102		1.2	0.7	0.1					3.2			100	100	67					7.8	8.0
102-156		1.3	1.2	0.1					3.4			100	100	63					7.8	8.0
156-206		1.2	1.5	0.1					3.6			100	100	63					7.9	7.9
0- 18														31					7.7	8.1
0- 10																				
0- 10														85						
0- 18														13						

ANALYSES: S= ALL ON SIEVED <2mm BASIS

S70NM-013-004

Soil Series: Hilken, fine anal g
Classification: Argic Ustic Petrocalcid, fine, mixed, thermic.
Location: SE1/4 SE1/4 Sec. 24, T.18S., R.2W., about 150 feet west of pedon 69-1.
Geomorphic Surface: Playa in shallow depression on Rincon surface.
Land Form: Playa (western part).
Elevation: 4650 feet.
Parent Materials: 0-93 or 117 cm, eolian sediments from the Rio Grande Valley;below, playa sediments of mixed origin; apparently derived from erosion of soils upslope. 0-93 or 117 cm, mostly late Pleistocene, minor amount of middle or early Pleistocene; below, late Pliocene.

Vegetation: Burrograss, tobosa, snakeweed; a few barren spots 20 to 30 cm wide.

Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, April 9. 1970.

Soil Surface. Cracked into polygons 1 to 5 cm in diameter.

E 0 to 7 cm. Light brownish gray (10YR 6/2, dry) or dark grayish brown (10YR 3.5/2, moist), silt loam; weak thin and very thin platy structure; slightly hard; few roots; effervesces strongly; abrupt smooth boundary.

BAt 7 to 16 cm. Pinkish gray (7.5YR 6/2, dry) or dark brown (7.5YR 4/2, moist), silty clay loam; weak medium prismatic structure, parting to weak medium subangular blocky; hard; roots common; few very fine tubular pores; noncalcareous; clear smooth boundary.

Bt1 16 to 25 cm. Brown (7.5YR 5.5/2, dry) or dark brown (7.5YR 3.5/2, moist), silty clay loam; weak medium prismatic structure, parting to very weak medium and coarse subangular blocky; very hard; roots common; few fine tubular pores; weakly reflective faces on some peds; noncalcareous; clear wavy boundary.

Bt2 25 to 46 cm. Brown (8YR 5.5/2, dry) or dark brown (8YR 3.5/2, moist), silty clay loam moderate coarse prismatic structure, parting to weak coarse subangular blocky; very hard; few roots; few very fine tubular pores; effervesces strongly; clear wavy boundary.

Bt3 46 to 71 cm. Pinkish gray (8YR 6/2, dry) or dark brown (8YR 4/2, moist) silty clay; weak medium prismatic structure, parting to weak medium subangular blocky; very hard; few roots; few very fine tubular pores; effervesces strongly; clear wavy boundary.

Btk1 71 to 93 cm. Brown (7.5YR 5.5/4 dry) or dark brown (7.5YR 3.5/4, moist) clay loam; weak medium subangular blocky structure; hard; few roots; few carbonate filam nts; some peds have smooth, reflective faces; effervesces strongly; abrupt smooth boundary.

K21mb 93 to 117 cm. Dominantly pale brown (10YR 6.5/3 dry; 10YR 5.5/3) moist, carbonate-cemented material; the horizon consists of large, tightly fitted plates 40 to 80 cm across and about 10 cm thick; extremely hard; no roots; tops of the plates are very smooth, with slight undulations; some of the slight depressional areas in tops of the plates have small holes, 1 to 4 mm diameter, that extend a few mm into the Km horizon; tops of the plates are usually capped by red (2.5YR 5/6 dry) laminae, ranging from 1 to 4 mm thick, which overlies a set of laminae about 1 cm thick, of 10YR hue, ranging from very pale brown (10YR 8/3) t pale brown (10YR 6/3, dry); bottoms of the plates usually have a laminar coating of 10YR hue; reddish brown laminae occur discontinuously on the bottom of the plate; some reddish clay adhering to bottoms of the plates; effervesces strongly; abrupt wavy boundary to underlying K22mb horizon.

Btk2 93 to 117 cm. Brown (7.5YR 5.5/4, dry) or dark brown (7.5YR 3.5/4, moist), very gravelly clay; massive; v ry hard; few r ots; carbonate-cemented fragments, rounded, are the gravel fraction; most effervesces strongly or weakly but a few parts noncalcareous. This horizon is discontinuous and occurs in a small pocket in the top of the K21mb horizon.

S70NM-013-004

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Hilken, fine analog, fine, mixed, thermic Argic Ustic Petrocalcid

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 816, SAMPLES 40A 6194- 6201
- GENERAL METHODS 1B1A, 2A1, 2B

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SAMPLE NO.	DEPTH (CM)	HORIZON	-4-- TOTAL CLAY LT .002	-5-- TOTAL SILT .002 -.05	-6-- TOTAL SAND .05 -2	-7-- CLAY FINE LT .0002	-8-- CLAY CO3 LT .002	-9-- SILT FINE .002 -.02	-10- SILT COARSE .02 -.05	-11- SAND VF .05 -.10	-12- SAND F .10 -.25	-13- SAND M .25 -.50	-14- SAND C .5 -1	-15- SAND VC 1 -2	-16- COARSE FRACTIONS (MM) WEIGHT 2 -5	-17- WEIGHT 5 -20	-18- WEIGHT 20 -75	-19- WEIGHT .1- 75	-20- (>2MM) WT PCT OF WHOLE SOIL
			<- - - - PCT OF <2MM (3A1)											- - ->	<- PCT OF <75MM(3B1)->				
40A6194S	0- 7	E	25.8	52.4	21.8	2.8		36.4	16.0	15.6	5.1	0.7	0.3	0.1	--	--	--	6	--
40A6195S	7- 16	BAt	34.2	46.8	19.0	6.4		31.7	15.1	13.5	4.6	0.6	0.2	0.1	--	--	--	5	--
40A6196S	16- 25	Bt1	36.6	45.9	18.0	10.3		31.1	14.3	12.8	4.3	0.6	0.2	0.1	--	--	--	5	--
40A6197S	25- 46	Bt2	40.3	41.4	18.3	15.5		27.1	14.3	12.3	4.8	0.8	0.3	0.1	--	--	--	6	--
40A6198S	46- 71	Bt3	40.5	42.6	16.9	14.1		26.6	16.0	10.8	4.7	1.0	0.3	0.1	--	--	--	6	--
40A6199S	71- 93	Btk1	35.4	43.9	20.7	13.4		24.2	19.7	12.4	6.3	1.4	0.4	0.2	--	--	--	8	--
40A6200S	93-117	K2mb	43.4	39.4	17.2			20.4	19.0	10.3	5.3	1.2	0.3	0.1	8	29	--	41	37
40A6201S	93-117	Btk2													--	--	--		--

DEPTH (CM)	-1-- ORGN C PCT	-2-- TOTAL N <2MM	-3-- EXTR P PPM	-4-- TOTAL S	-5-- DITH-CIT EXTRACTABLE FE	-6-- DITH-CIT EXTRACTABLE AL	-7-- DITH-CIT EXTRACTABLE MN	-8-- (RATIO/CLAY) CEC	-9-- (RATIO/CLAY) 15 BAR	-10- ATTERBERG LIMITS LL	-11- ATTERBERG LIMITS PI	-12- BULK DENSITY FIELD MOIST	-13- BULK DENSITY 1/3 BAR	-14- BULK DENSITY OVEN DRY	-15- COLE WHOLE SOIL	-16- WATER CONTENT FIELD MOIST	-17- WATER CONTENT 1/10 BAR	-18- WATER CONTENT 1/3 BAR	-19- WATER CONTENT 15 BAR	-20- WRD WHOLE SOIL
	PCT	<2MM	PPM	<- PERCENT OF <2MM -->						PCT <0.4MM		<- - G/CC	- - ->		CM/CM	<- - -PCT OF <2MM - ->				CM/CM
0- 7	1.83				0.8			1.16	0.60				1.15						15.5	
7- 16	0.63				0.9			0.96	0.46				1.29	1.48	0.047		35.1	31.6	15.8	0.20
16- 25	0.92				1.0			0.89	0.42				1.35						15.4	
25- 46	0.84				1.0			0.72	0.39				1.38	1.63	0.057		30.3	27.2	15.7	0.16
46- 71	0.64				1.0			0.65	0.37				1.45	1.70	0.054		28.2	26.8	15.1	0.17
71- 93	0.44				0.9			0.65	0.36				1.5						12.8	
93-117	0.44				0.8			0.64	0.35				1.5						15.3	
93-117																				

AVERAGES, DEPTH 7- 57: PCT CLAY 39 PCT .1-75MM 6

S70NM-013-004

*** PRIMARY CHARACTERIZATION DATA ***
(DONA ANA COUNTY, NEW MEXICO)

PRINT DATE 01/12/94

Hilken, fine analog, fine, mixed, thermic Argic Ustic Petrocalcid

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL SURVEY LABORATORY
NATIONAL SOIL SURVEY CENTER
LINCOLN, NEBRASKA 68508-3866

SSL - PROJECT 40A 1, (NL40) SSIR SAMPLES
- PEDON 40A 816, SAMPLES 40A 6194- 6201
- GENERAL METHODS 1B1A, 2A1, 2B

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	(- NH4OAC EXTRACTABLE BASES -)					ACID-	EXTR	(- - - -CEC - - -)			AL	-BASE SAT-		CO3 AS	RES.		COND.	(- - - -PH - - -)		
DEPTH (CM)	CA	MG	NA	K	SUM BASES	ITY	AL	SUM CATS	NH4- OAC	BASES + AL	SAT	SUM	NH4 OAC	CACO3 <2MM	OHMS /CM		MMHOS /CM		CACL2 .01M	H2O
	<- - - - - - - - - - - - -MEQ / 100 G - - - - - - - - - - - ->										<- - - - -PCT - - - ->								1:2	1:1
0- 7		1.9	0.2	4.0					30.0			100	99	4					7.5	7.8
7- 16	23.5	2.0	0.2	3.6	29.3			29.3	32.7			100	98	TR					7.3	7.9
16- 25	25.4	2.4	0.2	2.9	30.9			30.9	32.6			100	95	--					7.4	7.7
25- 46		2.6	0.2	2.2					29.0			100	100	3					7.6	7.9
46- 71		2.8	0.2	2.0					26.4			100	100	5					7.6	7.9
71- 93		2.5	0.2	1.6					23.1			100	100	6					7.5	7.9
93-117		3.1	0.2	1.6					27.8			100	100	8					7.4	8.0
93-117														TR						

ANALYSES: S= ALL ON SIEVED <2mm BASIS

CLAY MINERALOGY AT THE DESERT PROJECT AND THE RINCON SURFACE STUDY AREA

H.C. Monger and W.C. Lynn

ABSTRACT

The Desert Project and Rincon study area contain soils that span a variety of ages and parent materials. Soil ages range from Historical (since 1850) to late Pliocene or older. Parent materials include ancestral Rio Grande alluvium, alluvium derived from monzonite, rhyolite, and sedimentary rocks (predominately limestone), and monzonite residuum. Although a substantial amount of work on clay mineralogy has been done at the Desert Project, much of it is scattered throughout a number of publications, and some of it has never been published. Therefore, the purpose of this paper is to bring together in one place all the information on clay mineralogy at the Desert Project and Rincon study area. Most of the clay mineralogy for the 154 analyzed samples is in narrative form. However, 53 x-ray diffraction (XRD) patterns were available for peak-area measurements. Part A of this paper consists of graphs generated from those XRD patterns that illustrate clay mineralogy as a function of age, parent material, and depth. Part B is an archive of the narrative clay mineralogy from 140 samples analyzed by the Soil Conservation Service.

Mica, kaolinite, and smectite are the most abundant clay minerals in soils of the Desert Project and Rincon study area. Mica and kaolinite are ubiquitous and their concentrations change little with depth, age, and parent materials. The amount of smectite, however, increases with age and in B and K horizons. Less common clay minerals include a mixed-layer clay, palygorskite, sepiolite, chlorite, regularly interstratified mica-montmorillonite, and vermiculite. The mixed-layer clay is associated with alluvium derived from Paleozoic sedimentary rocks. Palygorskite is the dominant clay mineral in the petrocalcic horizon of a mid-Pleistocene lower La Mesa soil formed in ancestral Rio Grande alluvium. Both palygorskite and sepiolite occur in the petrocalcic horizon of an upper La Mesa soil of early Pleistocene age. Dust trap material collected in 1965 and 1966 contained small amounts of mica with lesser amounts of kaolinite and poorly crystalline smectite.

In general, Desert Project and Rincon soils contain a mixture of inherited and neoformed clays. Mica, kaolinite, and the mixed-layer mineral appear to be largely inherited from dust and sedimentary parent materials, including older soils. Kaolinite, however, also appears to be neoformed along with smectite, and vermiculite in monzonite residuum of mountain slopes and pediments. Other notable neoformed clays are palygorskite and sepiolite in the calcareous zones of mid-Pleistocene and older soils, and smectite in B and K horizons of late Pleistocene and older soils.

INTRODUCTION

During the period from 1957 to 1972, 50 pedons, 131 soil horizons, 2 grab samples, and 7 dust trap samples were analyzed for clay mineralogy as part of the USDA-SCS Desert Project. Most of the analysis was conducted at USDA Soil Survey Labs in Lincoln, Nebraska and Beltsville, Maryland. An additional 3 pedons and 14 soil horizons were analyzed in the late 1980's at New Mexico State University, making a total of 154 samples with clay mineral information. X-ray diffractograms for which peak areas could be measured were available for 53 horizons.

X-ray diffractograms were studied to relate clay mineral content, as indicated by peak areas, to parent material, age, and depth. This report also compiles narrative clay mineralogy on Desert Project soils from various sources, mainly Gile and Grossman (1979). This compilation includes soils associated with the Rincon geomorphic surface (Gile et al., this volume).

METHODS

Samples analyzed

Clay mineralogy samples were taken from soils and dust trap sediments in the Desert Project area of southern New Mexico and the Rincon geomorphic surface study area approximately 25 km northwest (Fig. 1). Fifty-four sample sites, composed of 49 pedons and 5 dust traps, are in the Desert Project (Fig. 2). Two additional dust trap sites are north of the Desert Project area in the Jornada del Muerto Basin (Gile and Grossman, 1979). Table 1 lists soil ages and Table 2 lists clay mineralogy samples from the Desert Project area. Kinds of parent materials are identified in the first section of Part A. Rincon study area samples consisted of four pedons and two grab samples.

Horizon samples are identified by depth and the original horizon designation. The sample analyzed by X-ray diffraction was the clay fraction (<2μm). Unless specified otherwise, carbonates were not removed from samples analyzed at the USDA laboratories. Carbonates were removed from samples analyzed at New Mexico State University and by Vanden Heuvel (1966).

Sources of clay mineral information

X-ray diffraction patterns produced by the SCS were available for 19 sites in the Desert Project (circled numbers in Fig. 2). Three additional pedons (numbers 28,44,and 52 in Figure 2) were analyzed at New Mexico State University (Monger et al., 1987; Monger and Daugherty, 1991). Sites with narrative clay mineral information were produced by mineralogists at USDA-SCS laboratories at Lincoln, Nebraska and Beltsville, Maryland. Their results are reported in pedon descriptions in the Desert Project

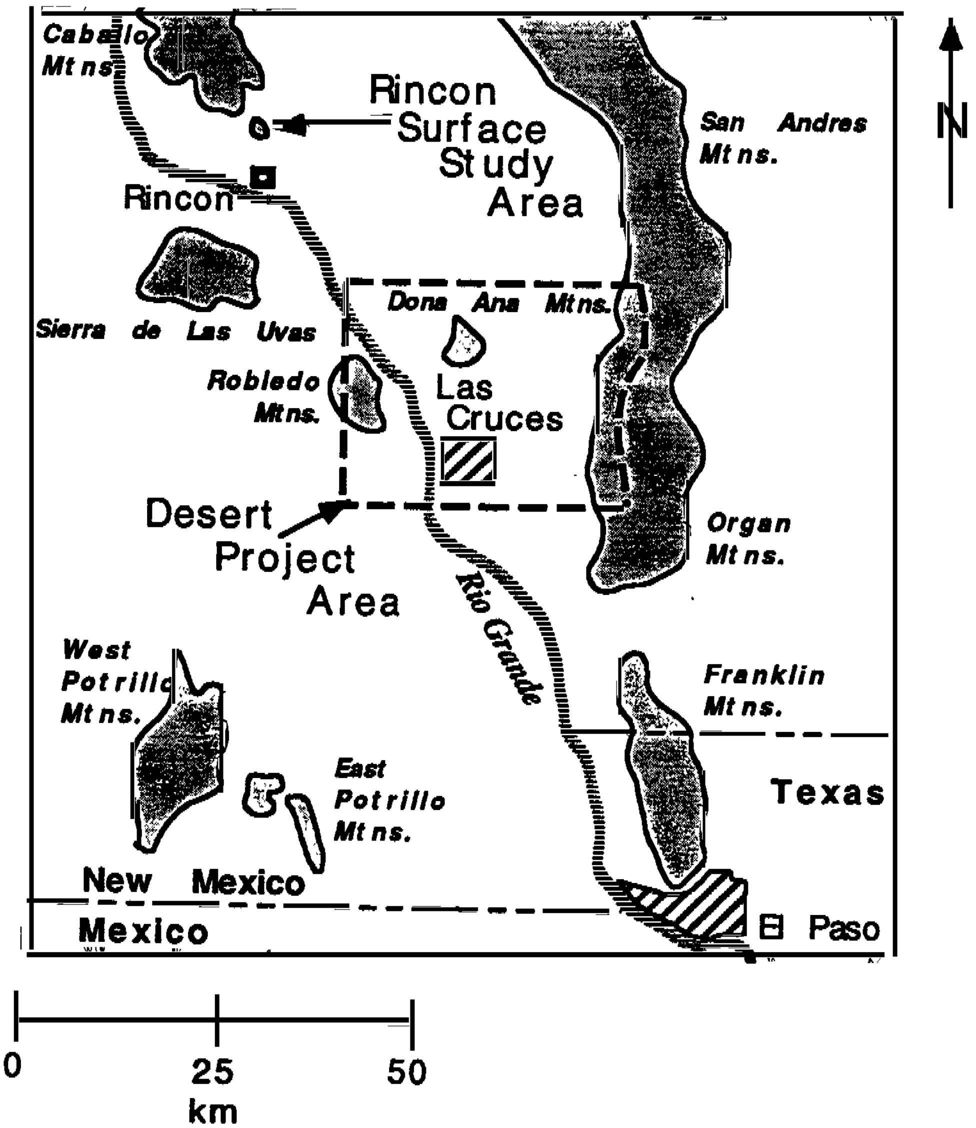
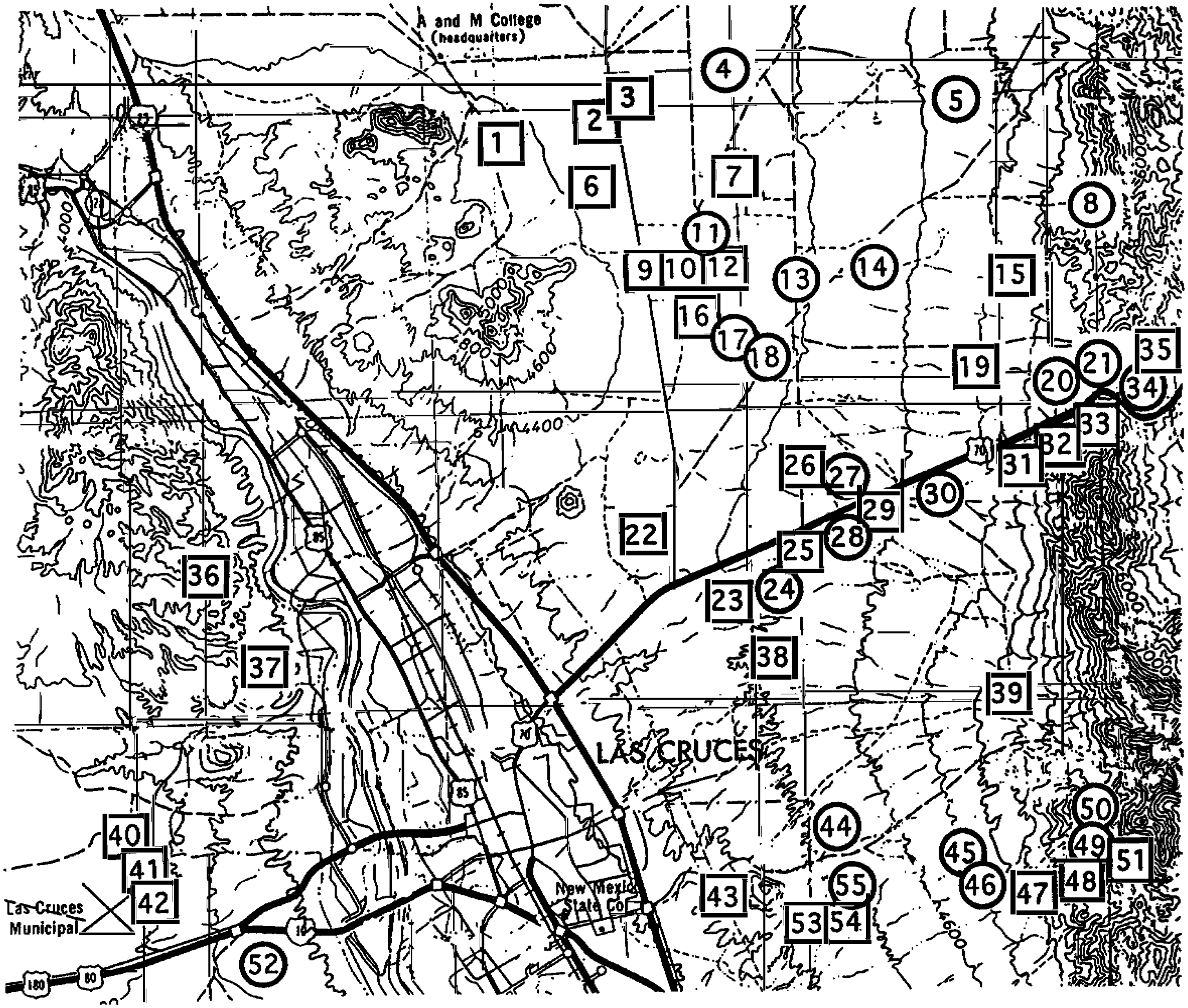


Figure 1. Location of Desert Project and Rincon geomorphic surface study area.



Legend:

1	Dust trap 7	45	67-4
2	61-3	46	59-15
3	61-1	47	60-4
4	65-5	48	Cady Site
5	65-1	49	59-14
6	Dust trap 5	50	60-5
7	60-18	51	Dust trap 1
8	60-19	52	Lower La Mesa (NMSU)
9	60-21		
10	60-17	53	59-11
11	66-6	54	59-13
12	66-7	55	59-16
13	60-14		
14	60-15		
15	60-20		
16	60-16		
17	68-9		
18	68-4		
19	59-4		
20	59-2		
21	70-1		
22	65-7		
23	60-6		
24	60-7		
25	59-6		
26	59-8		
27	62-3		
28	Hwy 70 (NMSU)		
29	59-7		
30	60-13		
31	60-8		
32	60-9		
33	66-15		
34	66-9		
35	66-10		
36	Dust trap (discontinued)		
37	66-5		
38	59-9		
39	Dust trap 2		
40	Dust trap 3		
41	61-7		
42	68-8		
43	60-2		
44	Powerline Bkm and CR paleosol 2Btb (NMSU)		

Figure 2. Locations of pedons and dust traps for which clay mineral information is available in this report (excluding sit 36 which is a discontinued dust trap). Circles repres nt sites for which X-ray diffractograms were available for peak area measurements. Squares signify sites having descriptive information on clay mineralogy. Not shown and north of this map are two dust trap sites and the Rincon pedons.

Soil Monograph (Gile and Grossman, 1979), with some unpublished correspondence. Additional published data on the upper La Mesa soils is in Vanden Heuvel (1966). Of the 22 sites for which x-ray diffraction patterns were available for this study, over half of the sites also contained narrative information provided by the Lincoln and Beltsville labs. Clay mineralogy data on the Rincon soils has not been previously published.

Table 1. Estimated age of geomorphic surfaces and their soils (from Gile et al., 1981; Mack et al., 1993; Gile et al. 1995).

Geomorphic Surface	Soil Age (yrs B.P.)
Fillmore	100 to 7,000
Organ	100 to 7,000
Lake Tank	present to late Pleistocene
Leasburg	8,000 to 15,000
Isaacks' Ranch	8,000 to 15,000
Petts Tank	25,000 to 150,000
Picacho	25,000 to 150,000
Jornada II	25,000 to 150,000
Tortugas	150,000 to 250,000
Jornada I	250,000 to 400,000
Dona Ana	greater than 400,000
La Mesa	500,000 to 900,000
Lower La Mesa	500,000 to 900,000
Upper La Mesa	2,000,000 to 2,500,000
Jornada-La Mesa	Jornada I or La Mesa undifferentiated

Id ntification of clay minerals

Clay minerals based on x-ray diffraction were identified by the following criteria of Carroll (1970), Whittig and Allardice (1986), Moore and Reynolds (1989), Barnhisel and Bertsch (1989), Sawhney (1989), and Singer (1989).

Mica: 1.0 nm plane spacing that was unaffected by chemical or heat treatments.

Kaolinite: 0.7 nm plane spacing that was unaffected by chemical treatments, but destroyed by heating to 500°C.

Chlorite: 1.4 nm plane spacing that was unaffected by chemical and heat treatments.

Smectite: A 1.4 to 1.6 nm air-dry plane spacing that expanded to approximately 1.8 nm with glycerol solvation and collapsed to 1.2 nm with K saturation and 1.0 nm with heating to 500°C.

Table 2. Clay mineralogy samples for the Desert Project area contained in this report. Samples are listed according to parent material, age, pedon, and horizon. In PART A, sample depths are in cm. Samples from the Rincon study area are listed in Table 5.

PART A

XRD Patterns
Monzonite Alluvium
Organ
59-2 A12 (3-20)
" C3 (132-173)
68-4 A2 (5-15)
" B2t (28-46)
62-3 B22t (20-30)
(buried Jornada II)
" VB22b (102-112)

Isaacks' Ranch
Hwy 70 Bt (30)
" Btk (75)

Jornada II
60-7 B22tca (33-43)
" K11 (cylin) (43-66)
60-13 B21t (8-28)
" K2 (71-86)
68-9 B22t (13-18)
" C2ca (157-185)
(buried Jornada II)
Hwy 70 2Bt (65)
" 2Btk(80)

Jornada I
(buried Jornada I)
Hwy 70 3Bt (220)

Monzonite Residuum

Jornada I
66-9 B22t (15-33)
" B33 (84-122)
" B34 (122-198)
" R (198-234)
70-1 A2 (0-5)
" B2t (11-21)
" R2t (93-118)

Rhyolite Alluvium
Organ
67-4 B2t (18-30)
(buried Jornada II)
" Btb (147-178)

Picacho
59-16 B22tca (15-28)
" K3 (64-127)

Jornada II
59-15 B22t (24-43)
" K&C (71-109)

Jornada I
59-14 B21t (46-76)
" Cca (147-173)
Powerline Bkm (400)

Dona Ana
60-5 A2 & B21t (20-38)
" K22m (71-86)
CR paleosol 2Btb (480)

Sed.-Ig. Alluvium
Organ
66-6 B21 (15-33)
(buried Jornada II
" IIC5b (300-325)
60-15 B21 (20-38)
" C (86-112)
65-1 B22ca (38-66)
60-14 B21 (25-56)
(buried Jornada II)
" IIBb (122-140)
60-19 A12ca (20-48)
" C2ca (102-124)

Jornada II
65-5 B22tca (24-41)

Ancestral Rio Grande Alluvium
Lower La Mesa
LLM A(0-5)
" Bk1 (5-16)
" Bk4 (37-50)
" Btk3 (78-100)
" Bkm2 (136-153)
" B'tk3 (225-255)
" C1 (348-362)

PART B

Narrative Information
Monzonite Alluvium
Organ
59-2 A12
59-2 A13
" C3
59-4 C1ca
59-8 B22t
60-8 B21t
" IICca
62-3 B22t
" IIIC2ca
(buried Jornada II)
" VB22b)
68-4 A2
" B2t

Isaacks' Ranch
59-6 B21tca
59-7 B22tca

Jornada II
(buried Jornada II)
59-6 B2tb
60-6 B22tca
60-7 B22tca
" IIIK32b
" K11 (cylin)
68-9 B22t
" Bca
" C2ca

Jornada I
59-6 B2tb2

Jornada
60-9 B22t

Monzonite Residuum
Mountain slopes and summits (undifferentiated)
66-9 B22t
" B33
" B34
" R
66-10 B22t
" R2
66-15 IIB2t & A
" R2

Jornada pediment
70-1 A2
" B1t
" B2t
" B3tca
" R1tca
" R2t

Rhyolite Alluvium
Organ
60-4 B22
67-4 B2t
" C2ca
(buried Jornada II)
" Btb

Picacho
59-13 K2
59-16 B22tca
" K3
" K21m
60-2 K

Jornada II
59-15 B22t
" K & C

Jornada I
59-14 B21t
" Cca
Cady
site A1
" B1
" B21
" B22
" B23
" B24
" C
" Cca

Dona Ana
60-5 K1

Sedimentary-Igneous Alluvium
Organ
60-14 B21
" B22
(buried Jornada II)
" IIBb
60-15 B21
" C
60-19 A12ca
" A13ca
" C2ca
65-1 A
" B22ca
(buried Jornada II)
" Btcab
" IIK31b
66-6 B21
(buried Jornada II)
" B22cab
" IIC5b
(buried Jornada I)
" IIIK22b2
66-7 B21ca
(buried Jornada II)
" IIIB2cab
" IIIC1cab
" IVC3cab

Lake Tank
60-16 C1

Picacho
66-5 B22ca

Petts Tank
60-17 B22

Jornada II
60-18 B2tca
" K22
" IICca
65-5 B22tca
" K22
Jornada
60-20 K22m

Ancestral Rio Grande Alluv
Tortugas
59-11 C3ca

Jornada-La M
61-1 K31

Upper La Me
61-7 A
" B1t
" B21t
" B22t
" K21
(lam)
" K21
" K22
" K23
" K31
" K32
" C1ca
" C2
68-8 B1t
" K &

La Mesa
65-7 B22t
" K12
" K22
" K33

Mixed Igneou Alluvium
Tortugas
59-9 IIB22

Jornada I
60-21 B21
" K22
61-3 B21t
" B23t

Dust Trap

7 traps

Vermiculite: A 1.4 nm plane spacing that does not expand with glycerol solvation, but contracts to 1.0 nm with K-sat 25°C or 300°C heating.

Mixed-layer: A 1.4 nm plane spacing that does not expand with glycerol solvation, does not collapse with 300°C heating, but does collapse totally or partially to 1 nm with heating to 500°C (Fig. 3).(Note that 10 Å equal 1 nm.) The mineral may be a randomly interstratified chlorite-vermiculite (Sawhney, 1989), a hydroxy-interlayer vermiculite (Barnhisel and Bertsch, 1989), or some other chlorite-like mineral.

Palygorskite: Plane spacings of 1.04, 0.64, and 0.54, and 0.446 nm that were unaffected by glycerol solvation and cation saturation.

Sepiolite: A strong maximum plane spacing at 1.24 nm with moderate reflections at 0.449, 0.429, 0.402, 0.374, 0.334, and 0.318 nm that were unaffected by glycerol solvation and cation saturation.

M asurement of XRD peak areas

For the purpose of semi-quantitative comparisons, XRD peak areas from x-ray diffraction patterns were measured (Fig. 3). XRD patterns were available for 53 samples (22 pedons). The locations of these pedons and the relative proportions of the three dominant clay minerals (kaolinite, mica, and smectite) are presented in Figure 4.

The peak areas were measured by multiplying the peak height above an estimated baseline by peak breadth (i.e., the peak width at half the peak height) (Moore and Reynolds, 1989). The peak areas were measured on patterns for glycerol saturated samples for the first-order peaks listed in the section on identification of clay minerals. A base line was drawn as shown in Fig. 3. Although Moore and Reynolds (1989) recommended avoiding low angle peaks (below about 12° 2θ, roughly 0.74 nm), (001) peaks were used because of the high background for second and third-order peaks (Fig. 3). Glycerol solvated samples were used because only mica occupies the 1.0 nm peak location with this treatment. Areas were measured in arbitrary units of the same scale. All graphs are based on the same arbitrary units.

In making the following observations based on peak area, it is assumed that there was uniformity in pretreatments, sample length and thickness, particle size, diffractometer settings, peak interference problems, and background intensities. Measurements of XRD peak areas are semi-quantitative at best. This technique, however, does provide a method for visualizing the relative amounts of various clay minerals (Birkeland, 1984; Moore and Reynolds, 1989).

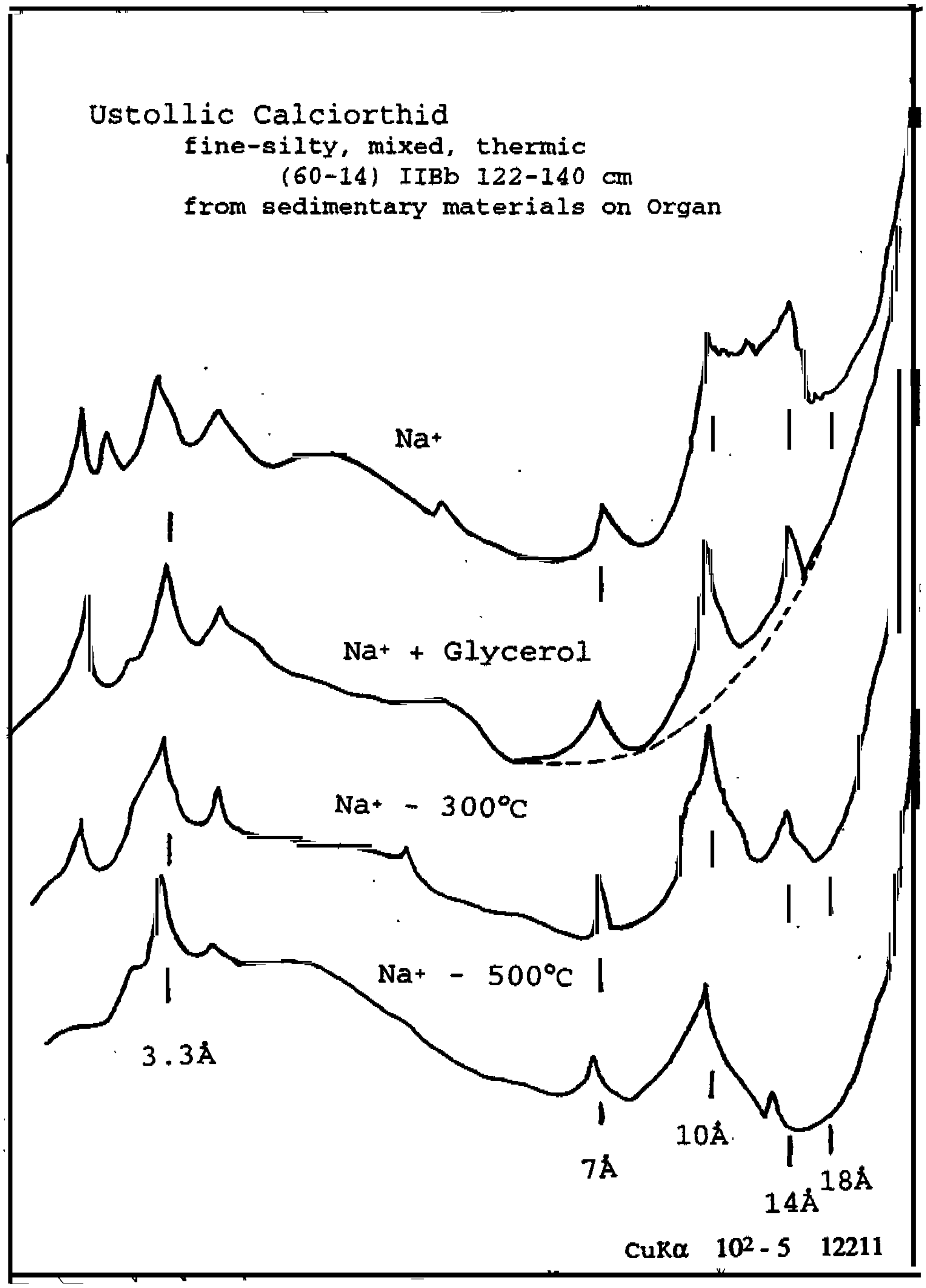


Figure 3. Example of a SCS Desert Project x-ray diffractogram on which XRD peak areas were measured. This XRD patterns illustrates the presence of the mixed-layered clay mineral that is common in alluvium derived partly from Paleozoic sedimentary rocks. The mixed-layered clay is characterized by a 14 Å peak that does not expand with solvation, does not collapse with 300°C heating, but does collapse partially with 500°C heating. Dashed line on Na^+ glycerol sample represents the baseline from which peak areas were measured.

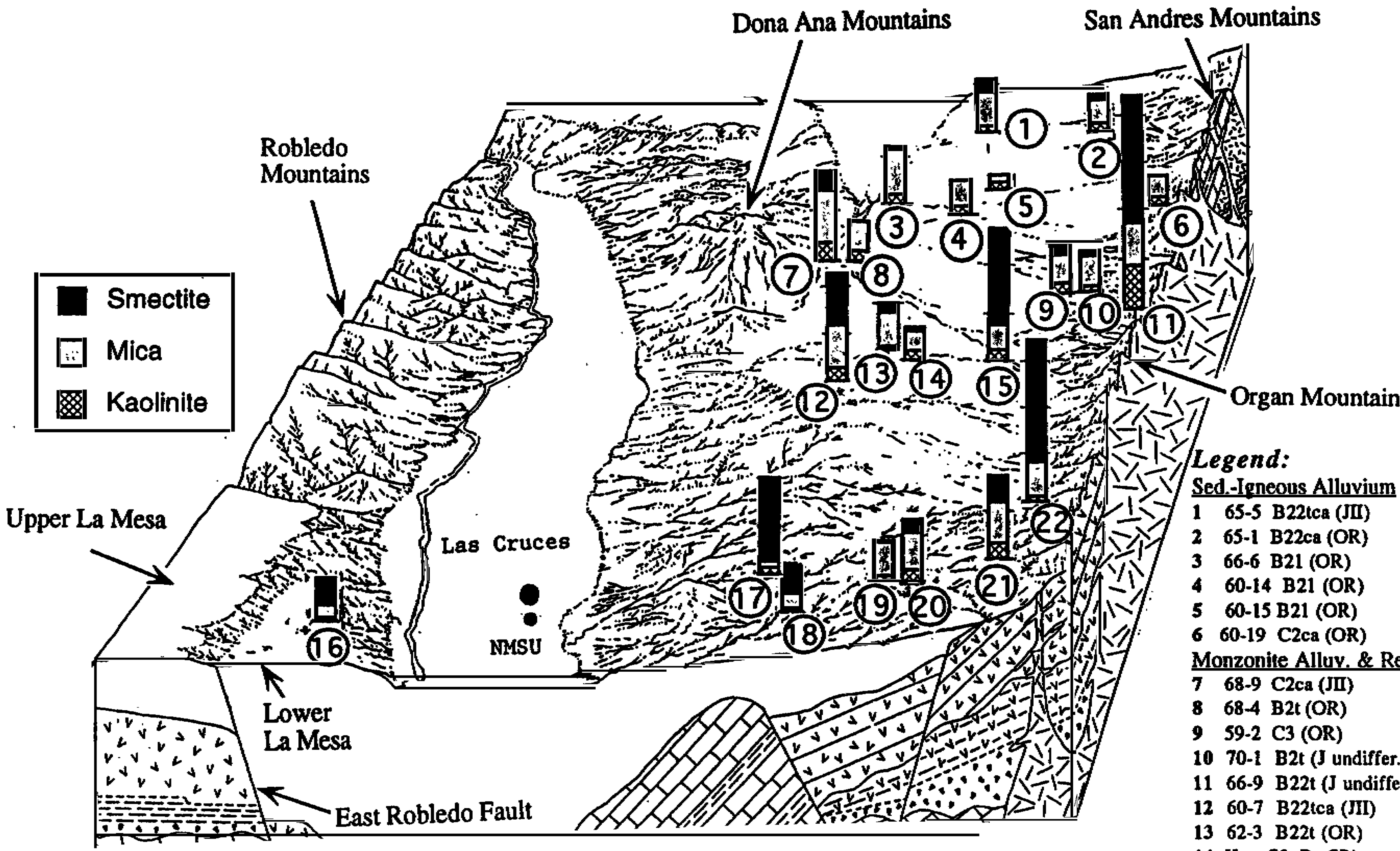


Figure 4. Block diagram of the Desert Project area and stacked columns illustrating the relative distribution of kaolinite, mica, and smectite for selected subsurface horizons listed in Legend. Abbreviations of geomorphic surfaces are contained within parentheses. Several sites contained more than one subsurface horizon. Those subsurface horizons chosen for this figure were those that had experienced the greatest degree of pedogenesis (i.e., B or K horizons rather than C horizons, if available). The stacked columns illustrate that smectite is generally more variable than kaolinite and mica.

RESULTS AND DISCUSSION

Part A. Clay mineral distribution based on XRD peak areas

In Part A, clay mineral distribution based on peak areas is discussed in terms of changes with parent material, age, and depth.

Clay mineralogy and parent materials

A variety of igneous and sedimentary bedrock units occur in the Desert Project (Gile et al., 1981; Seager et al., 1987). A major source of soil parent material is alluvium derived from the Organ Mountains (Fig. 1). The Organ Mountains are mainly composed of monzonitic rocks of the Organ batholith in the northern and central sections and rhyolitic volcanic rocks in the southern section (Seager, 1981). Another source of igneous parent material is the Dona Ana Mountains (Fig. 1). The Dona Ana Mountains have lithologic characteristics similar to the Organ Mountains, which in addition to igneous rocks contain outcrops of late Paleozoic carbonate and clastic rocks (Seager et al., 1987). The most prominent sources of sedimentary rocks, however, are the San Andres and Robledo Mountains (Fig. 1), which are composed mainly of marine carbonates with interbedded clastic rocks with some intrusive igneous bodies (Seager et al., 1987).

Parent materials evaluated for clay mineralogy were grouped into six categories: (1) monzonite alluvium, (2) monzonite residuum, (3) rhyolite alluvium, (4) alluvium from sedimentary and igneous rocks, (5) ancestral Rio Grande alluvium, and (6) alluvium from mixed igneous rocks (Part B only). The ancestral Rio Grande alluvium constitutes the fluvial facies of the Camp Rice Formation and is composed of rounded gravels of mixed lithology that grade down into sand with interbedded silt and clay (Hawley and Kottlowski, 1969). The La Mesa surface is the constructional top of the Camp Rice fluvial facies. The La Mesa surface west of Las Cruces is subdivided into lower and upper La Mesa at the east Robledo fault (Fig. 4). Upper La Mesa is older than lower La Mesa (Machette, 1985) because it was uplifted and isolated from sedimentation from the ancestral Rio Grande (Gile et al., 1981).

The relative proportions of clay minerals in soils of different parent material, grouped by age, are given in Figure 5. The age of a geomorphic surface (Table 1) and its soils is considered to be the same (Gile et al., 1981).

<u>Soils of Organ age (Fig. 5a)</u>

The most obvious difference among the parent materials of Organ Age is the association of a mixed-layer clay mineral with alluvium from sedimentary and igneous rocks (Fig. 5a). Soils of Organ age have relatively constant amounts of kaolinite and mica, except in a few horizons (Fig. 5a). Smectite amounts are relatively

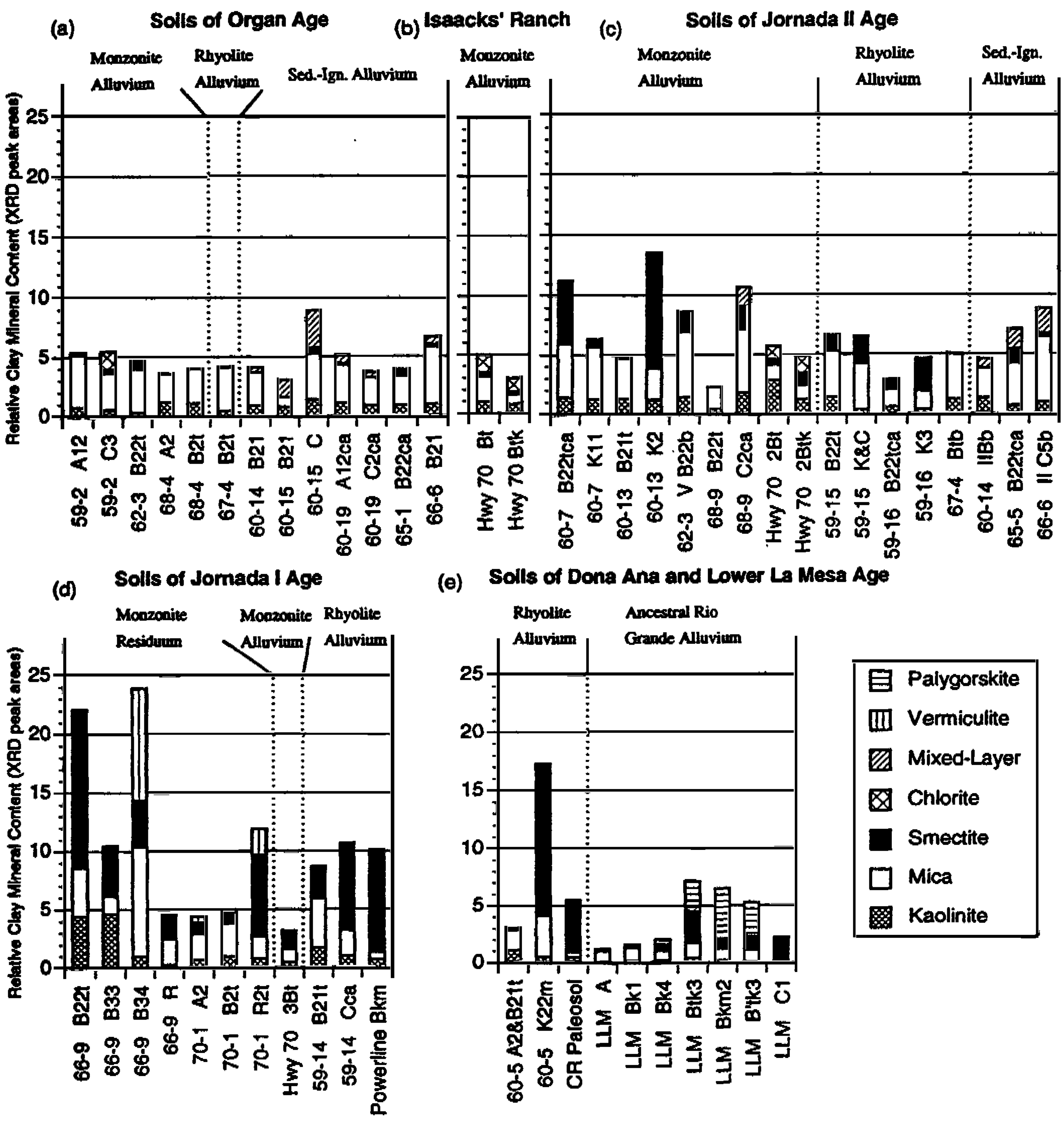


Figure 5. The relative proportions of clay minerals based on XRD peak areas in soils of different parent materials grouped by age. Peak areas are in arbitrary units which are the same for all graphs in this report.

minor. Small amounts of chlorite occur in monzonite alluvium but are absent in the other parent materials.

Soils of Isaacks' Ranch age (Fig. 5b)

The two samples in Isaacks' Ranch monzonite alluvium are similar to monzonite soils of Organ age in their relative amounts of kaolinite, mica, and smectite. However, both Isaacks' Ranch samples contain chlorite, unlike the monzonite soils of Organ age where only one horizon contains chlorite.

Soils of Jornada II age (Fig. 5c)

The mixed-layer mineral also occurs in alluvium from sedimentary-igneous rocks of Jornada II age, and is absent in other parent materials except for one sample in monzonite alluvium (Fig. 5c). Kaolinite is slightly more concentrated in monzonite than other parent materials and is somewhat more abundant than in soils of Organ and Isaacks Ranch age. Mica concentration varies noticeably, but is roughly the same for all parent materials, and is similar to mica concentrations in younger soils. Most striking, is that the amount of smectite increases in soils of Jornada II age (Fig. 5c) and is most abundant in soils from monzonite alluvium. Small amounts of chlorite occur in the Hwy 70 soils formed in monzonite alluvium. One sample from a soil formed in monzonite alluvium (68-9 C2ca) contains a minor portion of mixed-layer clay.

Soils of Jornada I age (Fig. 5d)

Smectite in soils of Jornada I age is much more abundant than in younger soils and is slightly more abundant in rhyolite alluvium than in monzonite alluvium. Vermiculite occurs in the soils formed in monzonite residuum (pedons 66-9 and 70-1) (Fig. 5d) but not in alluvial soils. Except for the relatively abundant kaolinite in the upper solum of pedon 66-9, suggesting neoformation, kaolinite varies little among parent materials and is similar in content to soils of Organ and Jornada II age. Mica concentration varies among the horizons and parent materials, and, except in sample 66-9 B34, is roughly the same as in younger soils.

Soils of Dona Ana and lower La Mesa age (Fig. 5e)

Kaolinite and mica in soils formed in rhyolite alluvium of Dona Ana age is similar to that in younger soils; smectite content is high. Relatively minor amounts of kaolinite and mica occur in the lower La Mesa soil formed in ancestral Rio Grande alluvium (Fig. 5e). The dominant mineralogic feature of the lower La Mesa soil is the occurrence of palygorskite.

Clay mineralogy versus age

Clay mineral distribution with age for the three dominant parent materials is illustrated in Figures 6, 7, and 8. Pedons within an age group are arranged in the sequence they were sampled, rather than being arranged chronologically. For example, pedon 59-2 in monzonite alluvium of Organ age is not necessarily younger than pedon 62-3 (Fig. 6).

Monzonite alluvium and residuum (Fig. 6)

Vermiculite concentration is higher in soils of Jornada I age, although its occurrence may be more of a function of its neoformation as a transitional mineral in soils formed in residuum (see descriptive clay information of pedon 70-1 in this report). An increase in kaolinite in the same pedon may also be the result of its neoformation. Otherwise, kaolinite and mica remain relatively constant in soils of different ages. Smectite abundance increases in older monzonitic soils.

Rhyolite alluvium (Fig. 7)

The three main clay components of soils formed in rhyolite alluvium are mica, kaolinite, and smectite. Of the three, smectite displays the most noticeable change with age, being highest in the older soils of Jornada I and Dona Ana age (Fig. 7).

Sedimentary-igneous alluvium (Fig. 8)

The studied soils formed in sedimentary-igneous alluvium are almost entirely of Organ age. The mixed layer appears slightly less abundant in the older Jornada II soils, which suggests an inherited origin. Kaolinite remains constant, while mica and smectite increase very slightly.

Clay mineralogy versus depth

Kaolinite-mica-smectite distribution with depth

The normalized proportions of kaolinite, mica, and smectite in surface and subsurface horizons are plotted in Figures 9 and 10. The A and C horizons are plotted in Figure 9 and the B and K horizons are plotted in Figure 10. The B and K horizons were grouped together because they represent the illuvial zones of clay accumulation.

Most Desert Project soils, regardless of age or parent material, tend to have A and C horizons that contain more mica than kaolinite or smectite (Fig. 9). The exception is the high smectite content in Cca horizon of pedon 59-14 which formed in rhyolite alluvium of Jornada I age.

The B and K horizons are much more scattered with respect to the content of kaolinite, mica, and smectite (Fig. 10). Soils of

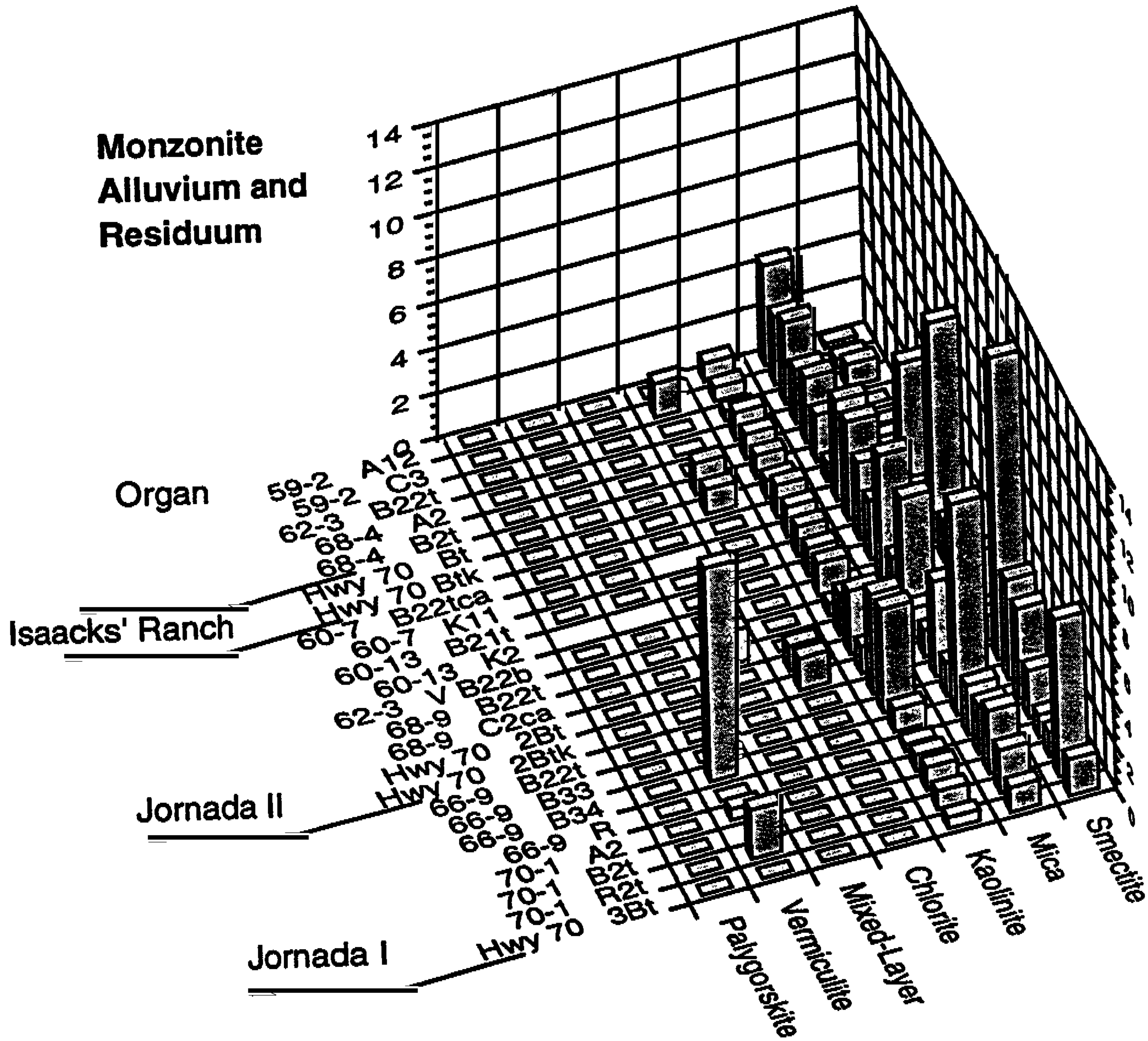


Figure 6. Clay mineral distribution with age for soils formed in monzonite alluvium and residuum. The geomorphic surface of Pedon 66-9 is Jornada undifferentiated.

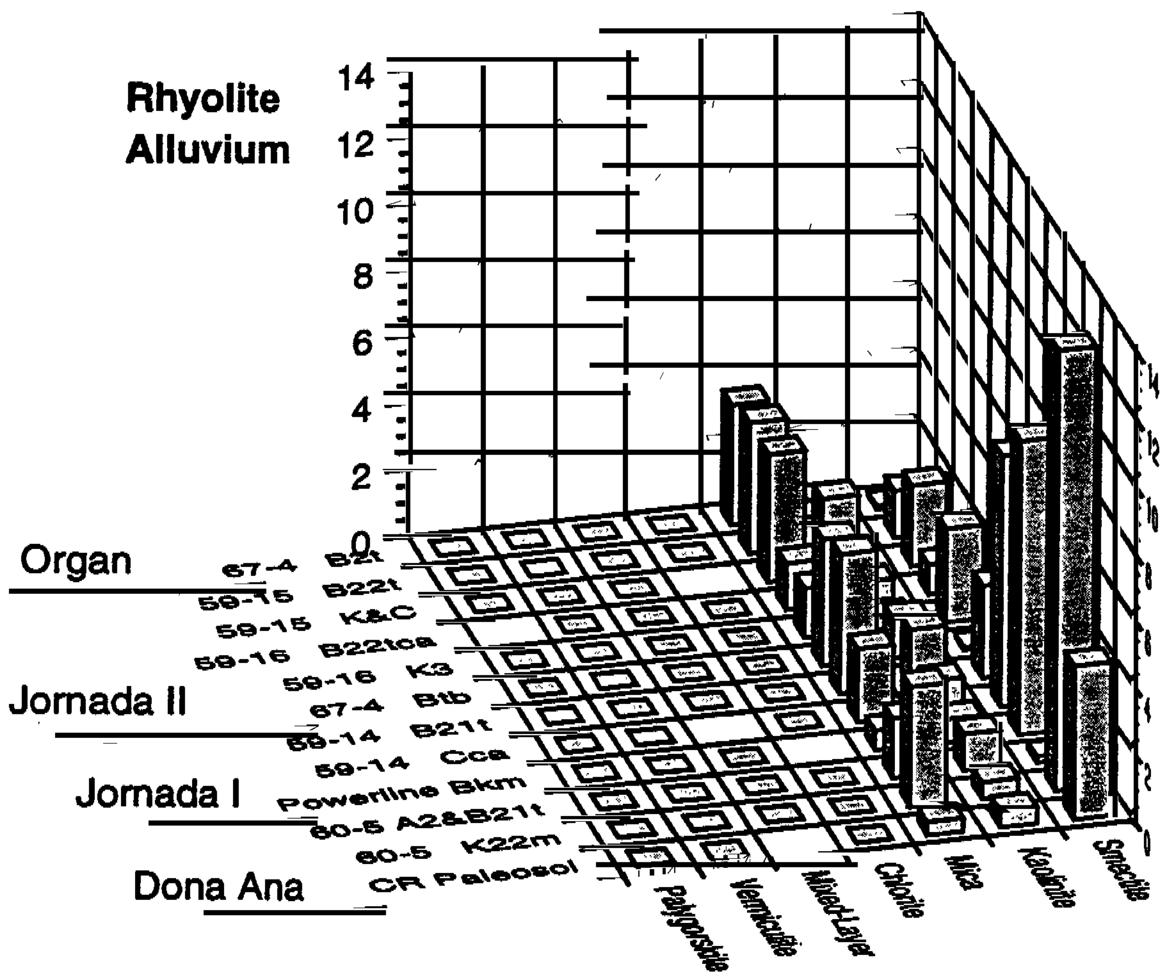


Figure 7. Clay mineral distribution with age for soils formed in rhyolite alluvium.

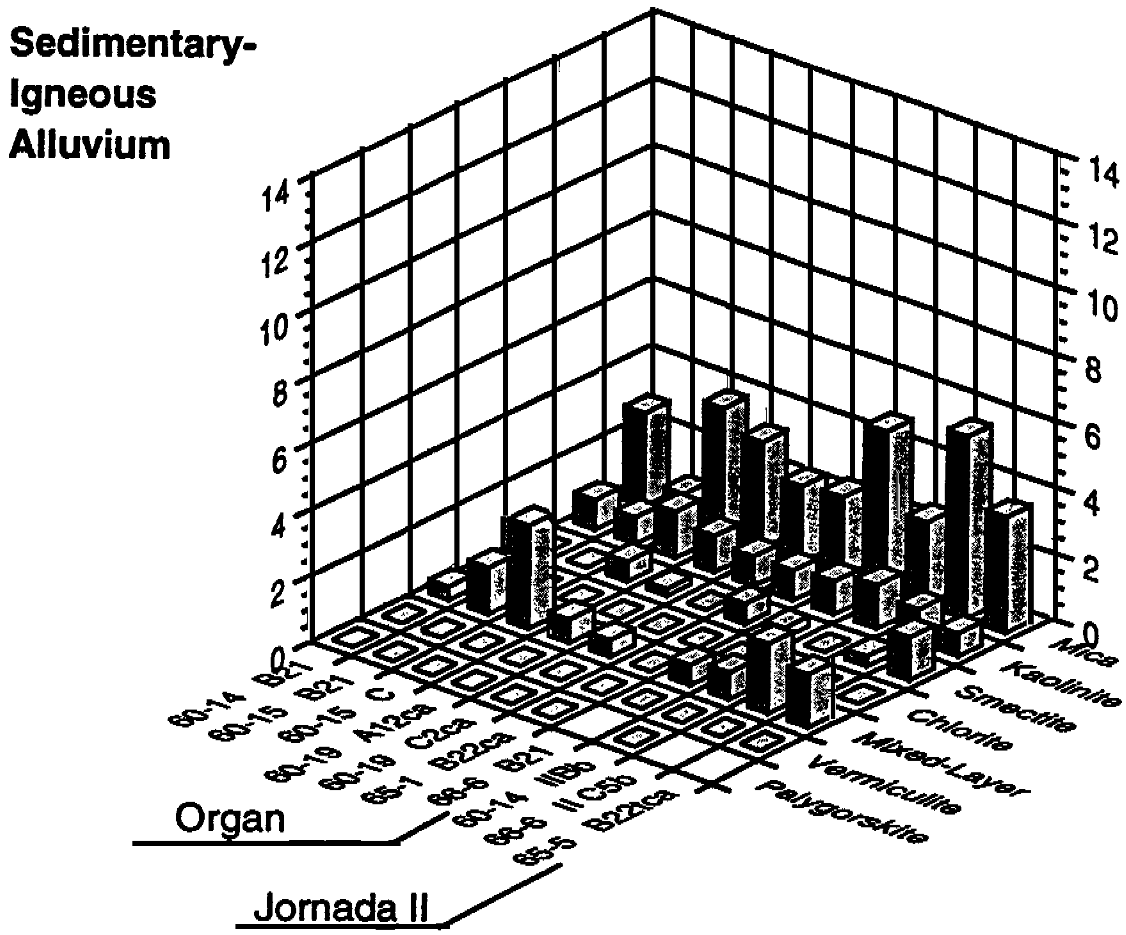


Figure 8. Clay mineral distribution with age for soils formed in alluvium derived from sedimentary and igneous rocks.

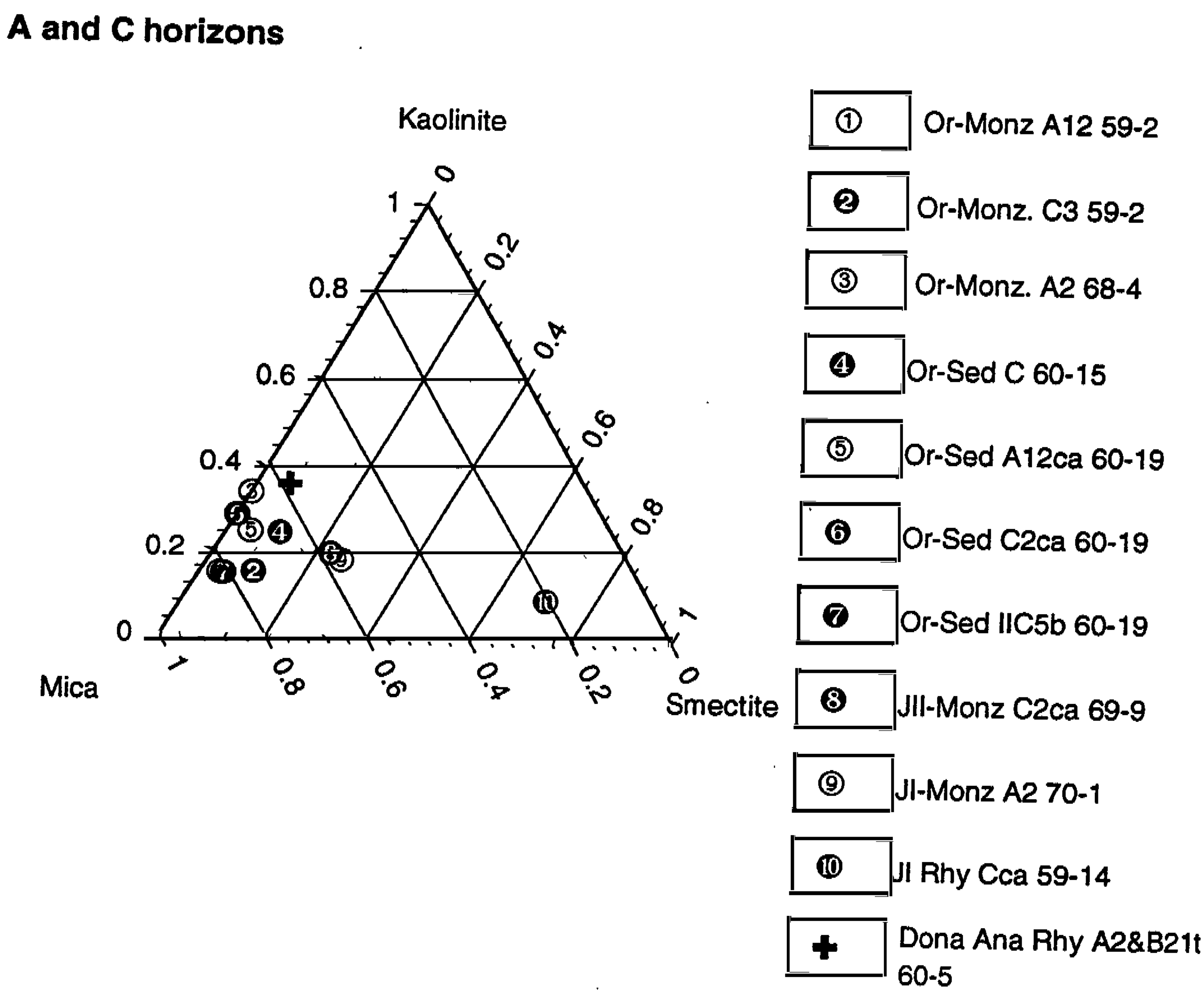


Figure 9.Relative proportions of kaolinite, mica, and smectite in A horizons (open circles) and C horizons (filled circles) identified by age and parent material as in Figure 5.

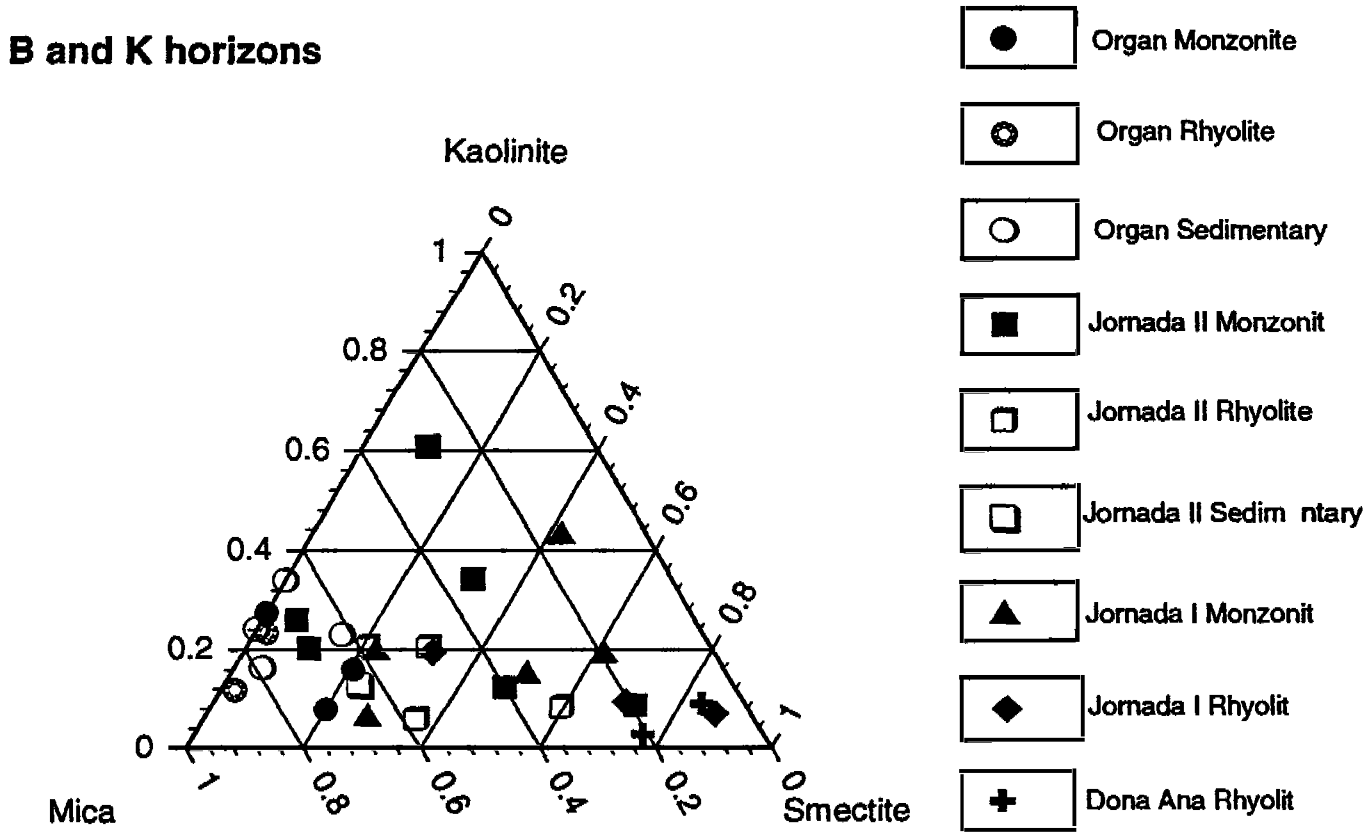


Figure 10. Relative proportions of kaolinite, mica, smectite in B and K horizons identified by age and parent material as in Figure 5.

Organ age show a fairly tight cluster similar to the A and C horizons of Figure 9. Soils older than Organ age, however, tend to contain relatively higher amounts of smectite. Some of the soils formed in monzonite alluvium older than Organ tend to contain relatively high kaolinite contents (Fig. 10).

Clay mineralogy versus depth for individual pedons

The distribution of clay minerals for individual pedons are plotted in Figures 11 through 16. Soils of Organ age (Fig. 11 and 12) are predominately composed of mica, kaolinite, and small amounts of smectite with relatively minor changes with depth.

Soils older than Organ, as indicated by W.C. Lynn (see p. 75, Gile et al., 1981), contain smectite that increases in abundance and crystallinity within and below the K horizon (Figs. 13 and 14). Figure 15 illustrates the rare occurrence of vermiculite (pedon 66-9), the occurrence of smectite in R horizons (pedons 66-9 and 70-1), and the progressive increase of smectite in older buried soils (Hwy 70-NMSU).

Figure 16 illustrates the occurrence of palygorskite in a soil associated with the lower La Mesa geomorphic surface (Fig. 2). Palygorskite is the dominant clay mineral in the Bkm horizon. Scanning electron microscopy indicates that palygorskite is neoformed in this soil (Monger and Daugherty, 1991).

Part B. Narrative clay mineralogy from the Desert Project Soil Monograph and other sources

Clay mineral data in Part B are grouped according to parent material and age as shown in Table 2. The six categories of parent materials are explained in Part A under the heading "Clay mineralogy and parent materials." Figure 2 show the location of sites in the Desert Project area.

Monzonite alluvium

Organ

Pedon 59-2 -- A12 (3-20 cm) and C3 (132-173 cm). Clays in the two horizons are similar: A moderate amount of mica and a small amount (10 percent) of kaolinite. There is an additional small component of mixed layer mica-montmorillonite. This component expands more in the A12 (more montmorillonitic) than in the C3. (See Monograph p. 763.) A13 (20-41 cm) contains abundant poorly organized montmorillonite-vermiculite, a small amount of mica, and 10 percent kaolinite.

Pedon 59-4 -- Clay mineralogy of the C1ca horizon (23-38 cm). A poorly organized montmorillonite-vermiculite intergrade is abundant; a small amount of mica and 15 percent kaolinite are present. (See Monograph p. 767.)

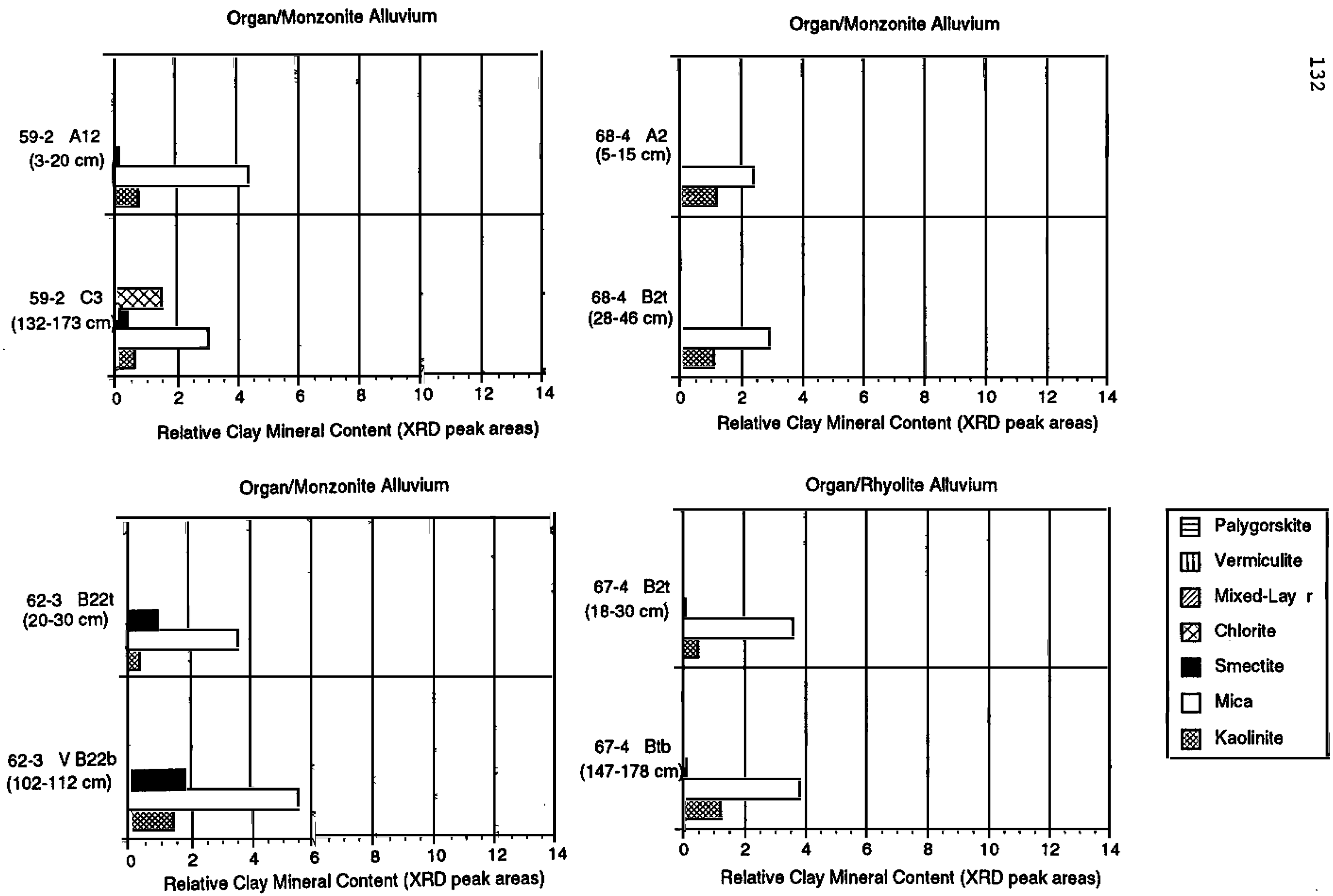


Figure 11. Clay mineral distribution with depth for soils of Organ age formed in monzonite and rhyolite alluvium.

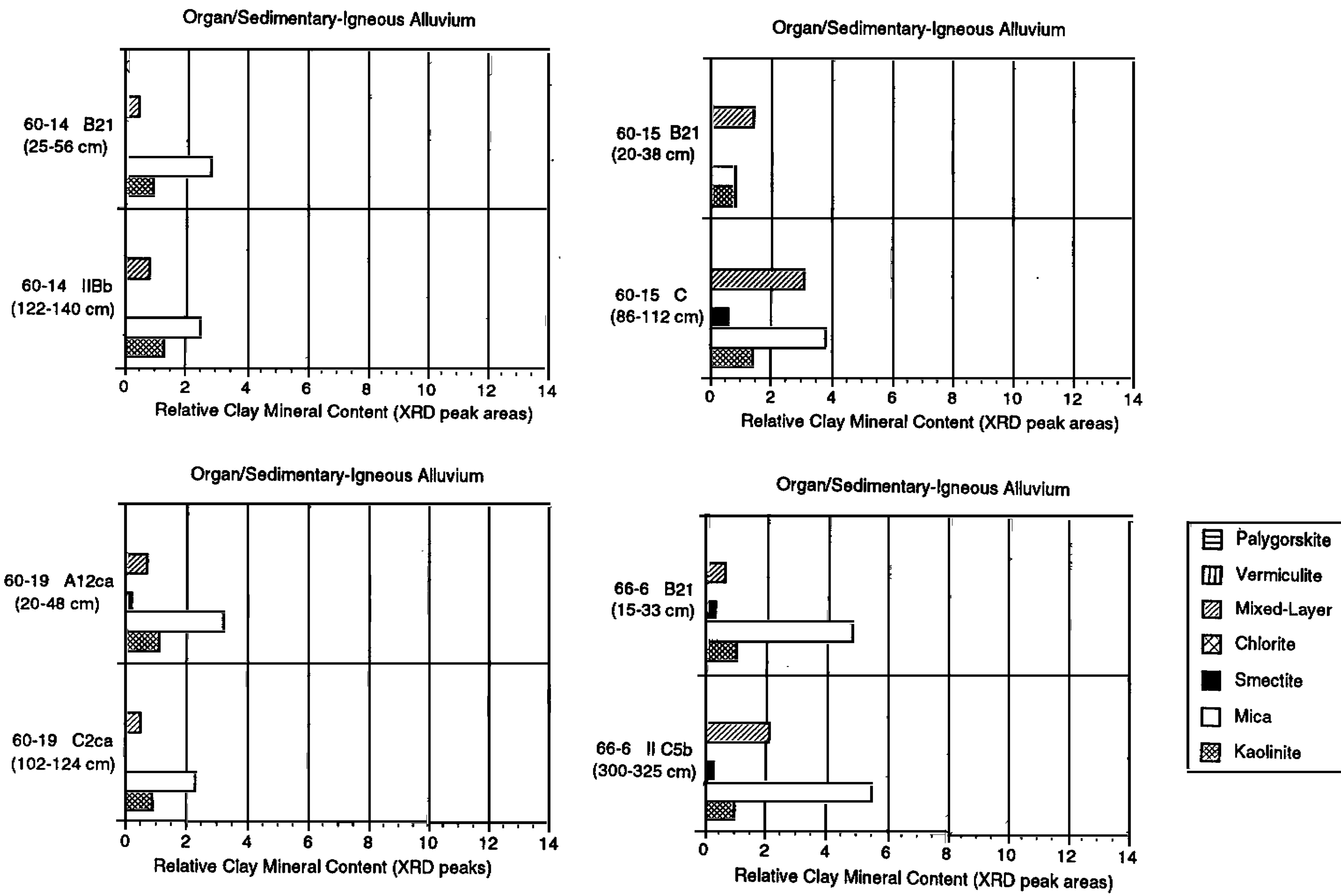


Figure 12. Clay mineral distribution with depth in soils of Organ age formed in alluvium derived from sedimentary and igneous rocks.

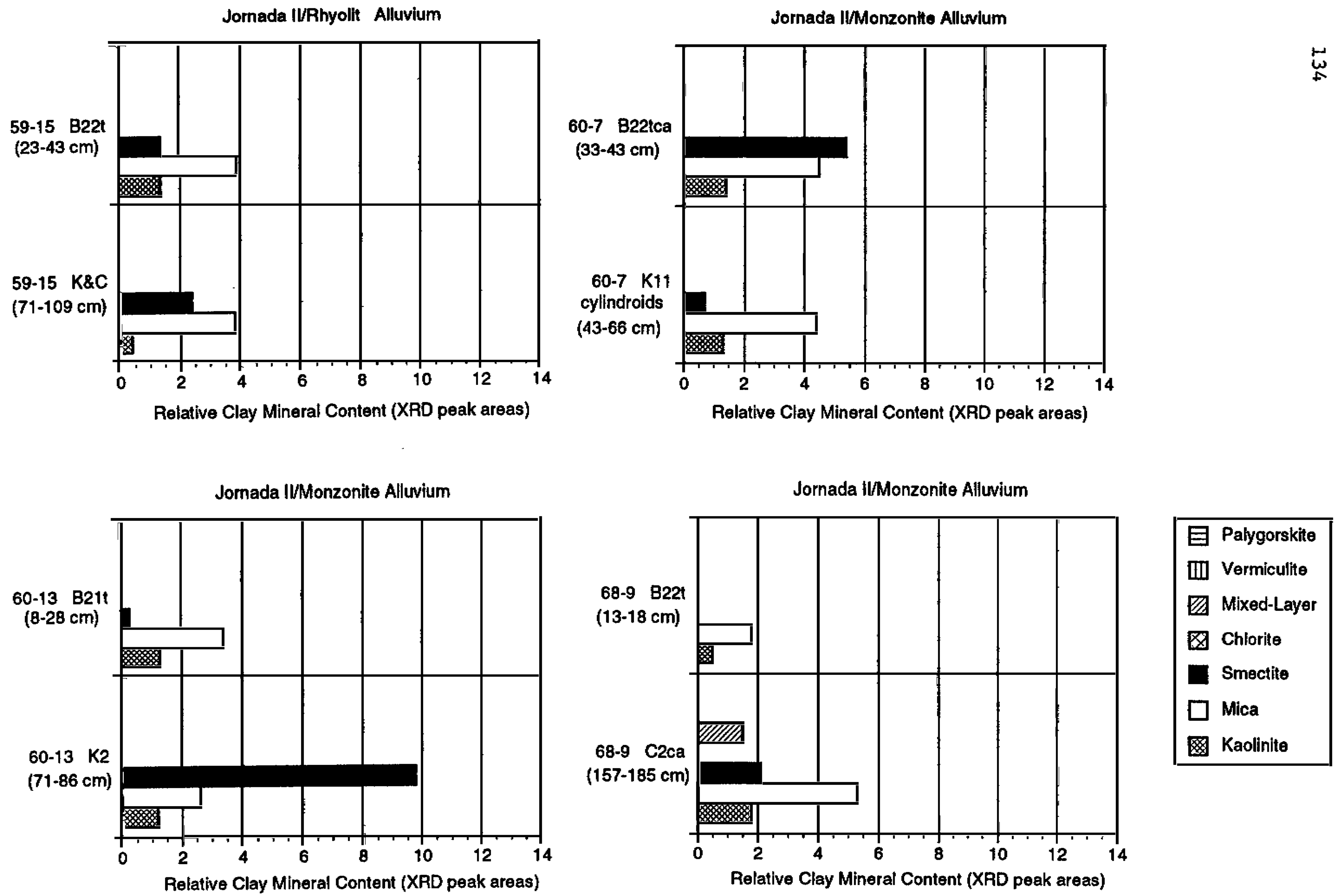


Figure 13. Clay mineral distribution with depth for soils of Jornada II age formed in monzonite and rhyolite alluvium.

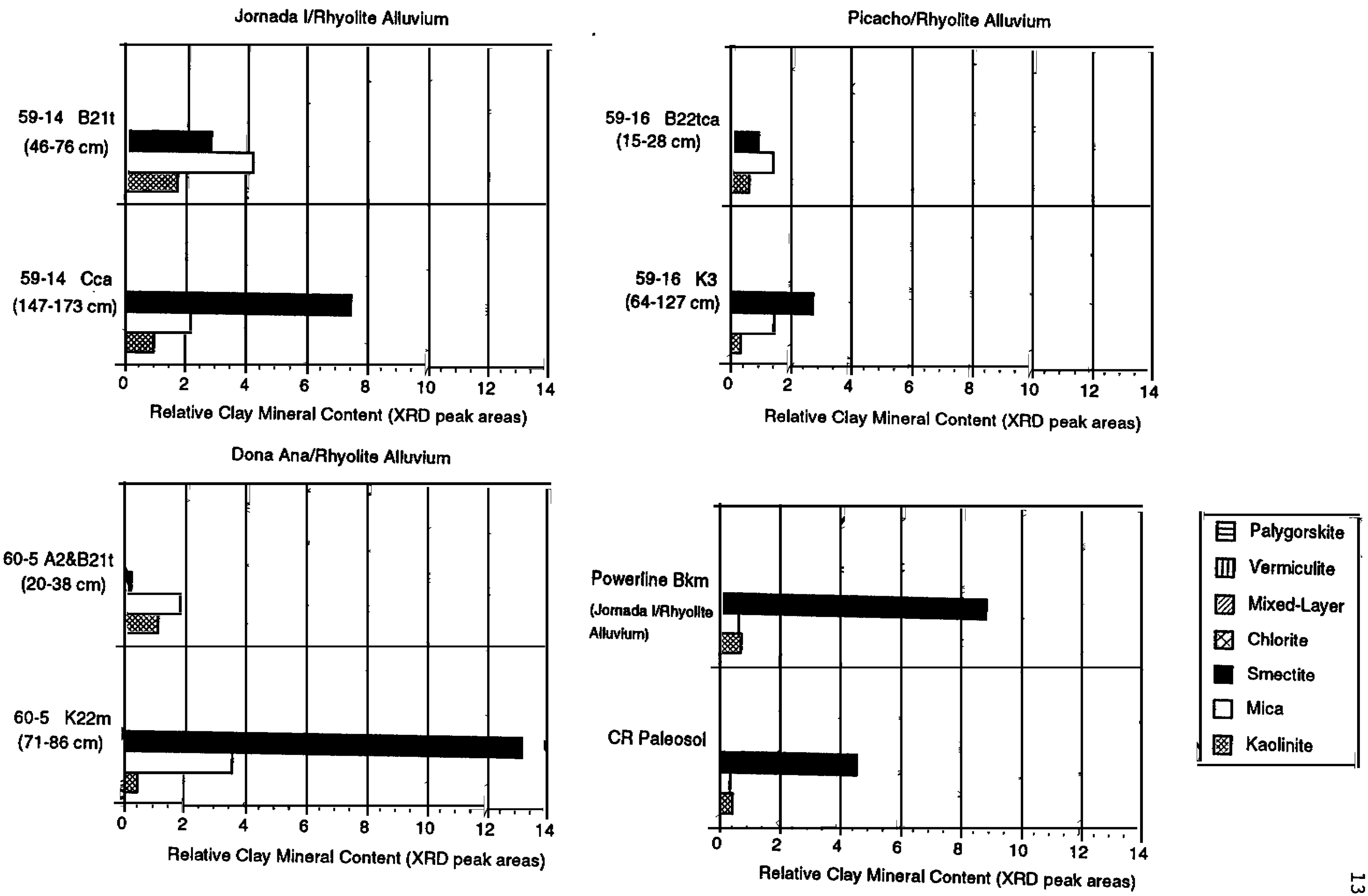


Figure 14. Clay mineral distribution with depth for soils on Picacho, Jornada I, and Dona Ana age formed mainly in rhyolite alluvium.

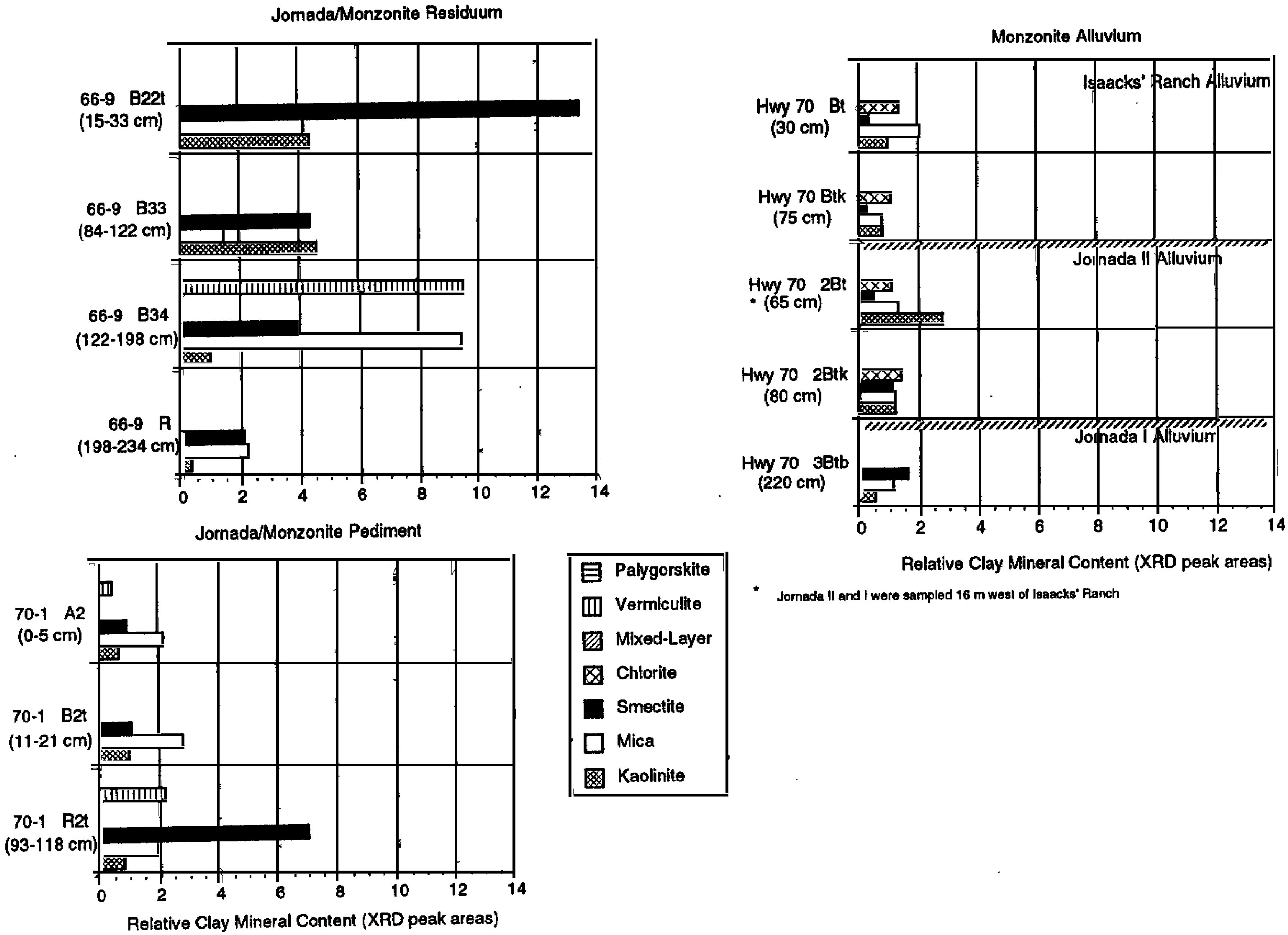


Figure 15. Clay mineral distribution with depth for soils formed in monzonite parent material.

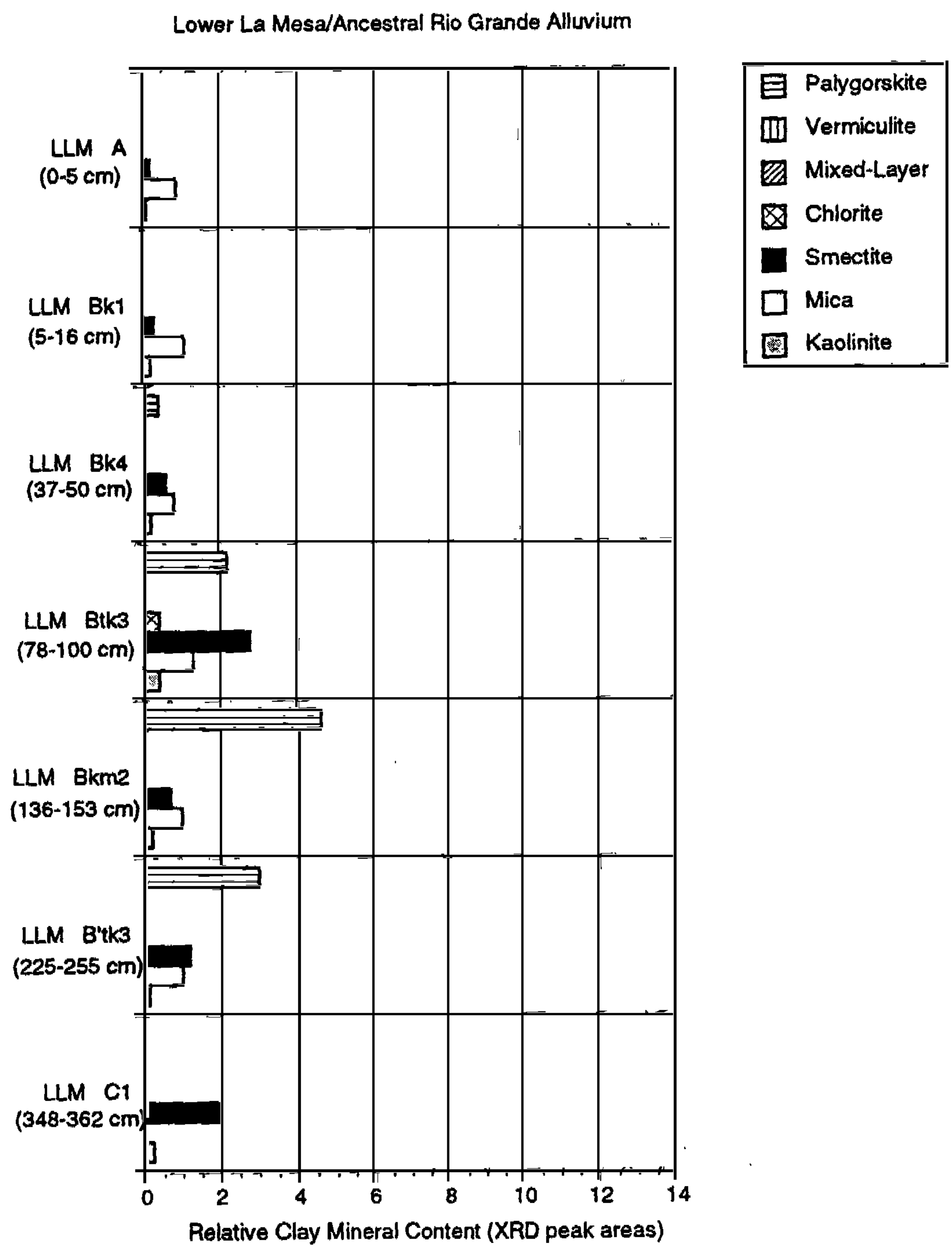


Figure 16. Clay mineral distribution for a soil formed in ancestral Rio Grande alluvium of lower La Mesa age.

Pedon 59-8 -- The B22t horizon (28-46 cm). A poorly ordered vermiculite-montmorillonite intergrade is abundant; a small amount of mica and 15 percent kaolinite is present. (See Monograph p. 775.)

Pedon 60-8 -- B21t (8-23 cm) and IICca (81-102 cm). Clay mineral suites are similar in the two horizons: moderate amount of poorly ordered montmorillonite, a small to moderate amount of mica and a small amount of kaolinite. There is a trace of chlorite in the B21t. Montmorillonite is somewhat better ordered in the IICca. (See Monograph p. 813.)

Pedon 62-3 -- The B22t horizon (20-30 cm) contains small amounts of mica, kaolinite, and montmorillonite. The montmorillonite is poorly ordered and contains some interlayer material. The IIIC2ca (43-61 cm) is similar with small amounts of mica, kaolinite, and poorly ordered montmorillonite. The VB22b (Buried Jornada II; 102-112 cm) contains a moderate amount of mica, small to moderate amounts of kaolinite and montmorillonite. The montmorillonite is somewhat poorly ordered but has little, if any, interlayer material. (See Monograph p. 869.)

Pedon 68-4 -- A2 (5-15 cm) and B2t (28-46 cm). Clays are similar in the two horizons -- small amounts of mica and trace to small amounts of kaolinite and an expandable 2:1 layer silicate component. The mica and kaolinite are well ordered. (See Monograph p. 935.)

Isaacks' Ranch

Pedon 59-6 -- B21tca (13-30 cm) This horizon has abundant poorly organized montmorillonite-vermiculite, a trace amount of mica, and 15 percent kaolinite. B2tb (Buried Jornada II; 71-91 cm). This horizon has abundant poorly organized montmorillonite-vermiculite, a trace amount of mica, and 15 percent kaolinite. The B2tb2 (Buried Jornada I; 168-201 cm) horizon has abundant poorly organized montmorillonite-vermiculite, a trace amount of mica, and 15 percent kaolinite.(Unpublished Desert Project data. For field description and laboratory data, see Monograph p. 770.)

Pedon 59-7 -- The B22tca horizon (38-58 cm) contains a moderate amount of montmorillonite, a small amount of illite, and 15 percent kaolinite. (See Monograph p. 773.)

Jornada II

Pedon 60-6 -- The clay from the B22tca (41-51 cm) contains a poorly organized montmorillonite-vermiculite intergrade in abundance, 15 percent kaolinite, and a trace of mica. (See Monograph p. 807.)

Pedon 60-7 -- Clays of the B22tca horizon (33-43 cm) contain moderate amounts of montmorillonite, mica, and kaolinite. The montmorillonite is moderately well ordered and contains little interlayer material. Clay of the IIIK32b horizon (246-267 cm) contain small to moderate amounts of montmorillonite and mica, small amounts of calcite and kaolinite.

Clay from carbonate cylindroids in the K11 horizon contains an abundant amount of an interlayered montmorillonite mineral plus small amounts of mica and kaolinite. The montmorillonite mineral resists expansion with glycerol and collapse upon heat treatment. (See Monograph p. 811.)

Pedon 68-9 -- B22t (13-28 cm), Bca (61-84 cm), and C2ca (157-185 cm). Clay mineral suites are similar throughout -- small amounts of mica and kaolinite plus a small component of poorly ordered montmorillonite. Treatment of the B22t sample with 0.1N NaOH had little effect on the crystalline clays. Buffer treatment of the Bca and C2ca samples increased apparent crystalline quality of clays -- probably because of carbonate removal. (See Monograph p. 945.)

Jornada (undifferentiated)

Pedon 60-9 -- Clay mineralogy of B22t (28-84 cm). Montmorillonite is abundant; a trace of mica and 15 percent kaolinite are present. (See Monograph p. 815.)

Monzonite residuum

Mountain slopes and summits (undifferentiated)

Pedon 66-9 -- Clay in the B22t horizon (15-33 cm) contains moderate to abundant, well-ordered montmorillonite and a small amount (15 percent) of very well-ordered kaolinite. The montmorillonite contains some interlayer material. Clay from the B33 horizon (84-122 cm) is very similar, perhaps a little less interlayering in the montmorillonite. Clay from the B34 horizon (122-198 cm) contains a moderate amount of mica, small amounts of montmorillonite and kaolinite, plus moderate to abundant amounts of regularly alternating mica-montmorillonite. Clay from the R horizon contains moderate amounts of montmorillonite and mica. Kaolinite is absent. (See Monograph p. 901.)

Pedon 66-10 -- X-ray traces of the clay from the B22t horizon (13-25 cm) show a strong peak from a well-ordered kaolinite with a small amount of montmorillonite present. The montmorillonite has interlayer components. Clay from the R2 horizon (132-178 cm) contains discrete components of montmorillonite and vermiculite and an additional component of interstratified mica-montmorillonite. The three components are present in about equal amounts. (See Monograph p. 903.)

Pedon 66-15 -- Clays from IIB2t&A horizon (41-58 cm) contain a small amount of fairly well-ordered kaolinite and a moderate amount of a 2:1 layer silicate complex. The complex includes discrete components of mica and vermiculite and a trace of poorly ordered montmorillonite. Interlayer components are suggested. The R2 horizon (201-244 cm) contains a moderate amount of a similar 2:1 layer silicate complex. The proportion of discrete montmorillonite is higher than in the IIB2t&A horizon and the mica appears to have an interstratified component that expands upon solvation. Kaolinite is absent. (See Monograph p. 912.)

Jornada pediment

Pedon 70-1 -- The A2 (0-5 cm) contains small amounts of mica, kaolinite, and montmorillonite. The B1t (5-11 cm) contains small amounts of mica, kaolinite and montmorillonite. The B2t (11-21 cm) contains a small to moderate amount of mica, and small amounts of kaolinite and montmorillonite. The B3tca (21-52 cm) contains a moderate amount of montmorillonite, and small amounts of mica and kaolinite. The R1tca (52-93 cm) contains a moderate to abundant amount of montmorillonite, small amounts of mica and kaolinite, and a trace of vermiculite. The R2t (93-118 cm) contains a moderate amount of montmorillonite and mica, a moderate amount of vermiculite (or vermiculite-chlorite) a small amount of kaolinite and possibly some calcite.

Mica flakes were hand picked from crushed rock fragments of the R2t horizon. Mica and quartz were identified by X-ray diffraction. The mica flakes were then heated in a H_2O_2 solution and the flakes decanted. Mica dominates. A moderate amount of 1.4 nm mineral is present. The mineral expands partially upon solvation with glycerol. A broad 2.4 nm peak is present which indicates regularly alternating 1.4 and 1.0 nm minerals (mica and chlorite, vermiculite, or montmorillonite). (See Monograph p. 951.) Lincoln Lab correspondence (7/27/73): The weathering sequence is principally from biotite to degraded montmorillonite. Vermiculite is transitory at best.

Rhyolite alluvium

Organ

Pedon 60-4 -- A moderate amount of poorly organized montmorillonite-vermiculite in the B22 (25-43 cm) with small amounts of montmorillonite and mica, and 15 percent kaolinite. (See Monograph p. 801.)

Pedon 67-4 -- Clay from the B2t horizon (18-30 cm) contains a small amount of poorly ordered montmorillonite, a small to moderate amount of mica and a small amount of kaolinite. The clay mineral suite of the C2ca horizon (71-94 cm) is similar. The montmorillonite component expands less than in the B2t. Chlorite interlayer material is suggested. Clay from the Btb horizon (Buried Jornada II; 147-178 cm) contains small to moderate amounts of kaolinite and mica plus a small amount of montmorillonite. The montmorillonite expands to give a series of spacings as in the upper horizons. However, collapse to a 1.0 nm spacing is more distinct than in upper horizons, and suggests fewer chlorite interlayers. (See Monograph p. 923.)

Picacho

Pedon 59-13 -- Montmorillonite dominant in the K2 (13-18 cm) with detectable illite and 15 percent kaolinite. (See Monograph p. 785.)

Pedon 59-16 -- The B22tca (15-28 cm) contains small amounts of montmorillonite, mica and kaolinite. The montmorillonite is very poorly ordered. The K3 horizon (64-127 cm) contains moderate to abundant montmorillonite with small amounts of mica and kaolinite. The montmorillonite is fairly well ordered. (See Monograph p. 791.) The K21m (C1cam 28-30 cm) contains a moderate amount of montmorillonite, small amount of poorly organized montmorillonite-vermiculite, a trace of mica, and 15 percent kaolinite.

Pedon 60-2 -- Clay mineralogy for the K1 horizon (23-36 cm) contains a poorly organized montmorillonite-vermiculite intergrade which occurs abundantly, with a trace of mica and 10 percent kaolinite. (See Monograph p. 797.)

Jornada II

Pedon 59-15 -- The clay of the B22t (23-43 cm) contains small to moderate amount of very poorly ordered montmorillonite, and small amounts of well-ordered mica and kaolinite. The clay of the K&C (71-109 cm) contains a moderate amount of mica and a small amount of kaolinite, a moderate amount of interstratified mica (or chlorite?) mineral and a trace of discrete chlorite. The interstratified mineral does not expand to any extent upon solvation. (See Monograph p. 789.)

Jornada I

Pedon 59-14 -- The B21t (46-76 cm) contains a moderate amount of mica, a small amount of kaolinite, a small to moderate amount of very poorly ordered 2:1 layer silicates (montmorillonite-like). The Cca horizon (147-173 cm) contains abundant montmorillonite that is somewhat poorly ordered, a moderate amount of mica, and a small amount of kaolinite. (See Monograph p. 787.) This pedon is very near the Cady site (below).

Cady Site, 1958 --

Clay mineralogy was determined for the < 2μm fractions of samples of a profile sampled at the wall of Soledad Canyon, New Mexico by John Cady in 1958, Beltsville Soil Survey Lab (Table 3).

Table 3. Clay mineralogy for a pedon in Soledad Canyon analyzed by John Cady in 1958.

Horizon		Mont.	Interstrat. Mica-Mont.	Mica	Kaol.
		Mineral			
A1	0-9"	-	x	xx	x
B1	9-15"	-	xx	xx	x
B21	15-22"	-	xx	xx	x
B22	22-31"	-	xx	xx	x
B23	31-40"	xx	x	xx	x
B24	40-50"	xxx	-	xx	x
C	50-82"	xxx	-	xx	x
Cca	>82"	xxx	-	x	tr

KEY: xxxx = dominant
xxx = abundant
xx = moderate
x = small
tr = trace or detected

Dona Ana

Pedon 60-5 -- Horizons above the K1 contain small to moderate amounts of kaolinite and mica plus traces of interlayer montmorillonite, chlorite, and quartz. Clays in the K1 horizon and beneath contain a moderate amount of mica-montmorillonite complex, small amounts of mica and kaolinite, and traces of chlorite and quartz. The proportion of montmorillonite below the K1 increases somewhat with depth. In the fine clay (<0.2 μm), mica predominates above the K1 horizon and a mica-montmorillonite complex predominates below. (See Monograph p. 805.)

Sedimentary-igneous alluvium

Organ

Pedon 60-14 -- B21 horizon (28-56 cm, Lincoln). Clay contains small amounts of vermiculite, mica, and kaolinite, plus additional components of interlayer mineral, involving vermiculite, mica, and chlorite. Small to moderate amount of calcite is present. B22 horizon (56-76 cm, Beltsville). A moderate amount of a poorly ordered montmorillonite-vermiculite mineral is present, plus small amount of vermiculite and kaolinite (10 percent kaolinite). IIBb horizon (Buried Jornada II; 122-140 cm, Lincoln). Small amounts of vermiculite and mica are present, plus a trace of kaolinite and an additional component of interlayer mineral, involving vermiculite, mica, and chlorite. A small amount of calcite is present. (See Monograph p. 825.)

Pedon 60-15 -- B21 (20-38 cm) and C (86-112 cm) horizons. Clay mineral suites are the same in the two horizons. The clays contain small amounts of vermiculite, mica, and kaolinite, plus and interlayer mineral component, probably a vermiculite-mica. A small to moderate amount of calcite is present. A chlorite-like mineral remains stable at 300° C, but collapses partially at 500° C. (See Monograph p. 827.)

Pedon 60-19 -- A12ca horizon (20-48 cm). Clay contains small amounts of mica and kaolinite, plus traces of vermiculite and montmorillonite. A small amount of calcite is present. A chlorite-like mineral (small amount) remains stable at 300° C, and partially at 500° C. A13ca (48-76 cm). The clay contains a moderate amount of a poorly ordered montmorillonite-vermiculite, and small amounts of montmorillonite, mica, and kaolinite (10 percent kaolinite). C2ca (102-124 cm). Clay contains a small to moderate amount of mica, small amount of kaolinite, trace to small amount of poorly ordered montmorillonite. A small amount of calcite is present. A chlorite-like mineral (small amount) remains stable at 300° C, collapses partially at 500° C. (See Monograph p. 835.)

Pedon 65-1 -- A (0-13 cm), B22ca (38-66 cm), Btcab (Buried Jornada II; 132-150 cm), and IIK31b (Buried Jornada II; 173-190 cm). Clay mineral suite similar in the four horizons studied: Trace to small amounts of kaolinite, and small amounts of mica and interlayer complex involving montmorillonite, mica, and chloritic interlayers. Minerals are poorly ordered. Amounts and degree of crystallinity increases slightly with depth. (See Monograph p. 871.)

Pedon 66-6 -- Clays from the B21 (15-33 cm), B22cab (Buried Jornada II; 81-114 cm), IIC5b (Buried Jornada II; 300-325 cm), and IIIK22b2 (Buried Jornada I; 373-396 cm) were examined. Carbonate-free clays were also examined. Clay mineral suites are similar throughout with a moderate amount of calcite, small to moderate amounts of kaolinite, mica, and chlorite present. Minerals rather well-ordered. Trace to small amounts of montmorillonite and talc present. (See Monograph p. 894.)

Pedon 66-7 -- Clay from the B21ca horizon (18-30 cm) contains a moderate amount of calcite and small amounts of mica, kaolinite, montmorillonite, and chlorite. Clays are poorly ordered. By inference there is a considerable amorphous component. Clay from the IIIB2cab (Buried Jornada II; 51-61 cm) contains a moderate amount of calcite, small amounts of mica, kaolinite, and montmorillonite and a trace of chlorite. Clay from the IIIC1cab (Buried Jornada II; 89-112 cm) contains a moderate amount of montmorillonite, small to moderate amounts of mica and kaolinite, and small amounts of chlorite and calcite. Clay from the IVC3cab (Buried Jornada II; 140-175 cm) contains a moderate to abundant amount of montmorillonite, and moderate amounts of mica, kaolinite, and calcite. Some interlayer chlorite is present in the montmorillonite.

Crystalline order of the montmorillonite and its abundance increase with depth. A noticeable increase occurs in the IV C3cab horizon. (See Monograph p. 896.)

The unpublished Lincoln lab report by Warren Lynn, 7/27/73, for pedon 66 N. Mex-7-7 states further: The pattern is similar to that in rhyolite and some monzonite pedons where amount and crystallinity of montmorillonite is greater in and below the K horizon. The trend does not agree with other limestone-derived pedons (66-6, 65-1, 65-5, 60-15, 60-14, or 60-18). Interpretation of results for 66-7 are confounded because increased montmorillonite is in buried soils and beneath lithologic breaks. These problems are not present in 60-13 (monzonite) or rhyolite (59-14, 59-15) pedons with well-ordered montmorillonite in lower horizons.

Lake Tank

Pedon 60-16 -- C1 (23-48 cm) A moderate amount of poorly organized montmorillonite-vermiculite intergrade is present, as is also a trace of mica and 10 percent kaolinite. (See Monograph p. 829.)

Picacho

Pedon 66-5 -- B22ca horizon (8-20 cm). The clay contains a small to moderate amount of poorly ordered montmorillonite, plus traces of mica and kaolinite. A small amount of calcite is present. (See Monograph p. 893.)

Petts Tank

Pedon 60-17 -- B22 horizon (20-43 cm). This horizon contained abundant montmorillonite, a trace of mica, and 10 percent kaolinite. (See Monograph p. 831.)

Jornada II

Pedon 60-18 -- B2tca horizon (23-33 cm, Beltsville). A moderate amount of poorly organized montmorillonite-vermiculite is present, as is also a trace of mica and 15 percent kaolinite. (See Monograph p. 833.)

Lincoln lab report, written by Warren Lynn, 7/27/73

S60(65) N. Mex-7-18 (13229-13233, 20824-20825)
Mineralogy (Method 7A2C) B2tca (13231), K22 (13233), and IICca (20825) horizons.
(13231) Clay from the B2tca horizon contains a moderate amount of calcite, and small amounts of montmorillonite, mica, and kaolinite. Montmorillonite is poorly ordered.
(13233) Clay from the K22 contains moderate amounts of mica and kaolinite, and small to moderate amounts of montmorillonite and chlorite. Peaks are sharp.
(20825) Clay from the IICca contains moderate amounts of montmorillonite and mica, a small amount of kaolinite, and a trace of chlorite. Montmorillonite is poorly ordered.
Note: I am concerned about a sample mix-up between 13233 and 20825. Sample 13233 as reported has different mineralogy than the other two, and would be easier to explain if located deeper in pedon. Carbonate clay between XRD and manometer do not agree.

Pedon 65-5 -- B22tca (25-41 cm) and K22 (89-114 cm). Clay mineral suites are similar in the two horizons. Small amounts of mica, kaolinite, and a 2:1 layer silicate complex involving montmorillonite and mica with chloritic interlayers. (See Monograph p. 879.)

Jornada (undifferentiated)

Pedon 60-20 -- K22m (C3cam, 28-46 cm). This horizon contains a moderate amount of poorly organized montmorillonite-vermiculite, a small amount of vermiculite, and 5 percent kaolinite. (Unpublished Desert Project data. For field description and laboratory data, see Monograph p. 836.)

Anc stral Rio Grande alluvium

Tortugas

Pedon 59-11 -- C3ca horizon (28-48 cm) contains an abundance of montmorillonite, a trace of mica, and 10 percent kaolinite. (See Monograph p. 781.)

Jornada-La Mesa

Pedon 61-1 -- (Jornada and La Mesa surfaces) Whitish nodules in K horizon were analyzed for sepiolite-palygorskite. Samples were sent to Vanden Heuvel, Beltsville Soil Survey Laboratory. He wrote: "I have not been able as yet to identify the cementing material in the abundant aggregates in these samples.

Montmorillonite is the major crystalline component and sample 14933 (K31, 112-132 cm) contains fluorite both in the clay and in the coarser separates. The clay extracted from sample 14933 (buffer treated) is pink and that from 149334 (K32) is white, corresponding to the color of the aggregates. Total analysis of both clays shows no major difference in composition. Both are high in MgO (14.4, 12.6 percent). Extraction in 0.5N NaOH yields only about 3 percent SiO_2 in both cases."(See Monograph p. 845.)

Upper La Mesa (see Fig. 4 for location)

Pedon 61-7 -- Sepiolite and palygorskite (attapulgite) occur in this pedon. See Table 4 and Monograph p. 859 for details. From Vanden Heuvel, R.C. 1966. *The occurrence of sepiolite and attapulgite in the calcareous zone of a soil near Las Cruces, New Mexico.* Clays and Clay Minerals, 13th Conf., Pergamon Press.

Table 4. Clay mineralogy for Pedon 61-7 on upper La Mesa surface.

Horizon	Clay Minerals§				
	Mont.	Mica	Kaol.	Sep.	Att.
A	xx	xx	x		
B1t	xx	xx	x		
B21t	xx	xx	x		
B22tca	xx	xx	x		
K21m laminar	xx	d?	x		xx
K21m nonlaminar	xx		x		xxx
K22m	x		x		xxxx
K23m	x	d?	x	xxx	xx
K31	x		d	xxxx	x
K32	x		d	xxxx	x
C1ca	xx		x		x
C2	xxx		xx		x

§ Clay extracted without prior carbonate removal and then treated for one hour with pH 5 NH_4OAc at room temperature. xxxx = dominant, xxx = abundant, xx = moderate, x = small, d = detected.

Pedon 68-8 -- B1t horizon (5-30 cm). The clay contains moderate amounts of montmorillonite and mica plus a small amount of kaolinite. The montmorillonite is poorly ordered. K&B horizon (114-157 cm). The clay contains a moderate amount of montmorillonite, plus small amounts of mica, kaolinite, and a chlorite-like mineral that resists collapse at 300° C, but does collapse at 500° C. Sepiolite was not identified in either horizon. (See Monograph p. 943.)

La Mesa

Pedon 65-7 -- (La Mesa basin floor). B22tca (18-33 cm), K12 (61-79 cm), K22m (137-168 cm), and K33 (274-307 cm). The clay mineralogy changes little with depth. The minerals are rather poorly ordered. Small amounts of mica, kaolinite and a vermiculite mineral are present. Additional 2:1 layer silicates are indicated, probably interlayer mica and vermiculite species. There is a suggestion of chlorite interlayer minerals. A trace of montmorillonite is suggested in the upper two horizons. (See Monograph p. 882.)

Mixed igneous alluvium

<u>Tortugas</u>

<u>Pedon 59-9</u> -- IIB22cab (71-135 cm) This sample contained abundant montmorillonite with 10 percent kaolinite. (See Monograph p. 777.)

<u>Jornada I</u>

<u>Pedon 60-21</u> -- B21t (25-51 cm) and K22 (130-155 cm). The clay from the B21t contains a moderate amount of mica(or illite) and a small amount of kaolinite, both well ordered, plus a small amount of a very poorly ordered montmorillonite and a trace of calcite. The clay mineralogy is mixed. The clay from the K22 contains a small amount of mica and a small amount of kaolinite and trace amounts of chlorite and montmorillonite. Additional 2:1 layer silicates are present, most likely an interlayer mineral involving the mica and chlorite. The mica and chlorite are fairly well ordered. No indication of sepiolite. The clay mineralogy is mixed. (See Monograph p. 839.)

<u>Pedon 61-3</u> -- (Jornada basin-fill alluvium). The B21t and B23t horizons (8-18, 36-48 cm) contain small to moderate amounts of mica, small amounts of kaolinite and small amounts of a poorly ordered smectite-like mineral that contains considerable interlayering. (See Monograph p. 849.)

Rincon geomorphic surface study area

The Rincon geomorphic surface study area contains a number geomorphic components as listed in Table 5.

Lincoln lab report, 1965

Two Grab Samples were taken at the Rincon Surface.

<u>LSL</u>

20857 - Rincon Surface Cap Rock - near edge of surface remnant.

20858 - Rincon Surface, 20 feet below surface and 8 feet above white zone.

The purpose was to check for sepiolite. A very small amount of sepiolite may be present in 20857. In general, the results are negative. Clays separated from carbonate-free material (treated with NaOAc, pH 5.0) yielded no discernible crystalline minerals except for the possibility of a small bit of sepiolite in 20857. The fine earth (< 2 mm) fraction of each sample was analyzed by X-ray diffraction. Quartz was dominant or abundant in all samples.

Table 5. Estimated age, landscape position and lithology of soils with clay mineralogy data, Rincon study area.

Estimated age	Pedon no.	Depth(cm)	Landscape	Lithology
Mostly late Pleistocene, minor amount Holocene	69-1	0-194	Playa	Mixed sedimentary and igneous
Late Pleistocene	69-2	0-224	Playa	"
	69-3	0-144	Playa	"
Mostly late Pleistocene, minor amount middle or early Pleistocene	69-6	0-106	Depression	Mixed igneous
Late or middle Pleistocene	69-1	194-325	Playa	Mixed sedimentary and igneous
	69-2	224-289	Playa	
	69-3	144-197	Playa	
Middle or early Pleistocene	69-1	325-351	Playa	"
	69-2	289-356	Playa	"
Late Pliocene or older(Rincon surface)	Grab samples from K horizon		Basin floor	Low-carbonate sandy sediments of Camp Rice Fm. (fluvial facies)

The Lincoln lab report by Warren Lynn, 7/20/73, for the Rincon samples states the following:

Pedon 69-1 (S69N.Mex-7-1) -- Dalby

Mineralogy (Method 7A2C).

Clays from the Bw2 (16-31 cm) and BC (110-159 cm) horizons contain a moderate amount of montmorillonite, small to moderate amounts of mica and calcite and a small amount of kaolinite. Clay from the combined Btk3b and Btk4b horizons (278-325 cm) contain a moderate amount of montmorillonite, a small to moderate amount of mica and a small amount of kaolinite. Clay from the Btkb2 (325-337 cm) horizon contains abundant montmorillonite, a small to moderate amount of mica and a small amount of kaolinite. The montmorillonite is progressively more abundant and better ordered as the age of the sequum increases. Clay mineralogy is montmorillonitic.

Pedon 69-2 (S69N.Mex-7-2) -- Ratliff

Mineralogy (Method 7A2C)

Clay from the upper Bw1 (4-15 cm) horizon contains small amounts of montmorillonite, mica, and calcite, and a trace of kaolinite. By inference, there is a considerable amorphous component. Clay for the Bw3 (38-60 cm) horizon contains a moderate amount of montmorillonite and small amounts of mica, calcite, and kaolinite. Clay from the Bk2 (122-168 cm) horizon contains moderate to abundant montmorillonite, small to moderate amounts of mica and calcite and a small amount of kaolinite. Clay from the Btk2b2 (305-318 cm) horizon contains dominant montmorillonite, a small to moderate amount of mica and a small amount of kaolinite. The amount of montmorillonite and its degree of ordering increase with depth. Clay mineralogy is montmorillonitic, bordering on mixed.

Pedon 69-3 (S69N.Mex-7-3) -- Ratliff

Mineralogy (Method 7A2C)

Clay from the Bw2 (38-61 cm) horizon contains small amounts of montmorillonite, mica, and kaolinite, and a small to moderate amount of calcite. Clay from the K2 (72-105 cm) horizon contains a moderate amount of montmorillonite and calcite, and small amounts of mica and kaolinite. Clay from the Btkb (157-173 cm) horizon contains abundant montmorillonite and small amounts of mica, kaolinite, and calcite. The amount and ordering of the montmorillonite increase with depth. Clay mineralogy is montmorillonitic.

Pedon 69-6 (S69N.Mex-7-6) -- Stellar, deep petrocalcic analog

Mineralogy (Method 7A2C)

Clay from the Bt2 (14-36 cm) horizon contains moderate amounts of montmorillonite and mica, a small amount of kaolinite, and a trace of calcite. Clay mineralogy is montmorillonitic, bordering on mixed.

General Comments:

1. Kaolinite and mica are distributed uniformly throughout the pedons - small or small to moderate amounts.
2. Montmorillonite increases in amount and in degree of crystalline ordering with depth in the pedon.
   Possible explanations:
   a. It is a function of depth from the present weathering surface and reflects increased degradation by the surficial weathering and pedogenic processes.
   b. Clays deposited in lower (deeper) sequa were better crystallized than those deposited in the upper sequa - an indication of deposition under a wetter climate.

(Note: Pedon S69N.Mex-7-2: Increase in montmorillonite in upper sequum, but also jump in amount and in crystallinity in the 305-318 cm horizon.

3. Carbonate Clay - calcite - is much less abundant in the lower sequa than in the upper sequum, even though total carbonate is sometimes considerably higher in the deeper sequa.
4. By inference, the upper horizons, particularly in S69N.Mex-7-2 have a considerable component of amorphous material.
5. I would place Pedons S69N.Mex-7-2 and 7-6 in a montmorillonitic family. Pedons S69N.Mex-7-2 and 7-3 are not in fine families.

Clay mineralogy of dust trap samples

Clay mineralogy was determined for dust in all 7 traps for the years 1965 and 1966. By X-ray diffraction, after buffer treatment to remove carbonates, the clays were very similar. The clay contains small amounts of mica and kaolinite (ratio of 2 to 1) and small amounts of poorly ordered montmorillonite. (See Monograph p. 80.)

The Lincoln lab report by Warren Lynn, 7/26/73, for the dust trap samples states further: The same clay mineralogy statement can be put to each of the dust trap samples examined, i.e. dust fall for 1965 and 1966 collections. There is not a smidgen of difference as far as I can ascertain from x-ray diffraction.

Mineralogy (Method 7A2C) (sample ident.)

The clay contains small amounts of mica and kaolinite (ratio of 2 to 1) and small amounts of poorly ordered montmorillonite.

1965 20542-20550
1966 66L542-66L550

Dust Trap Data

1. X-ray diffraction analysis partially completed on 1965 and 1966 clay separations--buffer treated samples. (Heat treatments yet to be done.)
   a. Qualitatively, clay mineral suites are similar in each sample: small amount of kaolinite, small to moderate amounts of mica and component (small amount?) of expandable 2:1 layer silicates.
   b. Clay mineralogy would be difficult to distinguish from clay mineralogy of upper horizons over the desert project as a whole (with exception of residual monzonite pedons). Haven't checked surface horizon.
   c. Traps 1 & 2 appear to have slightly smaller amounts of mica than other samples.
   d. Clays from traps 3 & 3a and traps 6 & 6a are virtually identical.
2. Consideration should be given to sampling surface horizons (at least) near dust trap sites for comparison.
3. Dust trap in area of residual monzonite soils might be good spot to check local vs. distant sources of deposition.

SUMMARY

Compiled in this report is clay mineral information for 154 samples taken from soils and dust traps of the Desert Project and the Rincon geomorphic surface study area. This information is in two parts. The first part presents clay mineral data based on measured XRD peak areas for 53 samples. The second part is composed of narrative information for 135 samples, both published and unpublished, that was produced by SCS personnel between 1958 and 1970.

Part A

Based on XRD peak areas, the following observations were made concerning the clay minerals in Desert Project soils:

1. Mica, kaolinite, and smectite are the dominant clay minerals. A mixed-layer clay, chlorite, vermiculite, and palygorskite are less common. Mica and kaolinite are ubiquitous in the soils of the Desert Project.

2. The amount of smectite, which is minor in Holocene soils, progressively increases in older soils, whereas the amount of kaolinite and mica remains relatively constant.

3. A mixed-layer clay mineral is common in soils formed in alluvium derived from Paleozoic sedimentary rocks, but is largely absent in soils formed in monzonitic and rhyolitic alluvium. The mixed-layer mineral appears to be a randomly interstratified chlorite-vermiculite or possibly a hydroxy-interlayer vermiculite. The association of the mixed-layer clay with the alluvium from Paleozoic sedimentary rocks suggests that the clay mineral is inherited rather than pedogenic.

4. Vermiculite occurs in soils formed in monzonite residuum and appears to be a transitory weathering product. In the same soils, the occurrence of well-ordered kaolinite, smectite and interstratified smectite minerals in the sola and weathered zones of R horizons indicates that chemical weathering and clay authigenesis is occurring.

5. Palygorskite is the dominant clay mineral in the petrocalcic horizon of a soil formed in ancestral Rio Grande alluvium on the lower La Mesa geomorphic surface (mid-Pleistocene age). Palygorskite is absent in the upper 16 cm (A and Bk1 horizons) and C horizons, where the clay mineralogy consists of kaolinite, mica, and smectite.

6. The clay mineralogy of A and C horizons, regardless of age and parent material, is dominated by mica with lesser amounts of kaolinite and relatively minor amounts of smectite. In contrast, the B and K horizons generally contain larger amounts of smectite,

especially in soils of Pleistocene age. The increase in smectite amount and crystallinity with age and depth implies that it is largely pedogenic.

Part B

Descriptive clay mineral information in this report was obtained mainly from lab characterization data for pedons contained in the Desert Project Soil Monograph (Gile and Grossman, 1979). Much of this information is summarized by W.C. Lynn (p.75 in Gile et al., 1981) and is given below:

"The clays from the dust samples contain small amounts of kaolinite, mica, and poorly ordered montmorillonite.

The residue from Paleozoic calcareous sedimentary rocks after carbonate removal consists of mica, with some kaolinite and a little chlorite; no montmorillonite or vermiculite were identified. Clays in soils developed in sediments derived from these rocks contain small amounts of kaolinite and mica and small to moderate amounts of poorly ordered montmorillonite. Clay mineralogy changes with depth are small.

In the semiarid zone, soils of Pleistocene age developed on high-biotite monzonite contain well-ordered kaolinite, mica, montmorillonite and, in some instances, regularly interstratified mica-montmorillonite. The biotite alters to montmorillonite even if the rocks are consolidated. Holocene soils in alluvium derived from this high-biotite monzonite contain small amounts of kaolinite and mica and small to moderate amounts of poorly ordered montmorillonite throughout the pedon.

The clays of soils of Pleistocene age derived from the low-biotite monzonite contain small amounts of kaolinite and mica throughout the pedon; montmorillonite is poorly ordered in upper horizons and more abundant and better ordered in and below the K horizon.

Turning to rhyolite alluvium, Holocene soils contain small amounts of poorly ordered montmorillonite. Soils of Pleistocene age have a similar distribution of kaolinite and mica; but, as with the soils of this age in monzonite alluvium, the montmorillonite increases in abundance and degree of ordering within and below the K horizon.

Greater amounts of montmorillonite in the K horizon and improved ordering with depth may be a regional pattern. Buol and Yesilsoy (1964) found an increase in montmorillonite in K horizon. For the particular pedon studied, however, the change may not have a pedogenic origin because there is evidence for a lithological change at the top of the K horizon. Frye and others (1974) report that crystallinity improves with depth through the upper part of caliche sections located in east-central New Mexico.

An explanation for the better-ordered montmorillonite within and below the K horizon is that it was largely emplaced in Pleistocene pluvials and during subsequent drier periods has not been subjected to appreciable pedogenesis. In shallower horizons, this weathering after the last Pleistocene pluvial has acted to reduce the crystalline quality of the montmorillonite".

In addition to characterization data contained in the Monograph, clay mineral analysis was conducted by Vanden Heuvel (1966) and Cady (1958, unpublished). Vanden Heuvel found palygorskite and sepiolite in the calcareous zones of a soil associated with the upper La Mesa geomorphic surface (Gile et al., 1981). Cady found small amounts of interstratified mica-montmorillonite in addition to montmorillonite, mica, and kaolinite in a soil formed in rhyolitic alluvium of Jornada I age.

Horizons overlying the calcretes in soils of the Rincon surface contain small to moderate amounts of kaolinite and mica uniformly distributed with depth, and montmorillonite that increased in amount and crystallinity with depth. Thus, the horizons above the calcretes in the Rincon soils are similar to clay suites in Desert Project soils. Clay mineralogy of stage V and VI calcretes of the Rincon surface was not analyzed. But based on comparison to the calcretes of the upper La Mesa, the Rincon calcretes probably also contain sepiolite and palygorskite.

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