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Supplement to the Desert Project Guidebook, with emphasis on soil micromorphology

L. H. Gile[1], J. W. Hawley[2], R. B. Grossman[3], H. C. Monger[4], C. E. Montoya[5], and G. H. Mack[6]

[1]Natural Resources Conservation Service, USDA, Las Cruces, NM 88001;
[2]New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801;
[3]Natural Resources Conservation Service, USDA, Lincoln, NE 68508;
[4]Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003;
[5]Natural Resources Conservation Service, USDA, Las Vegas, NM 87701;
[6]Department of Geological Sciences, New Mexico State University, Las Cruces, NM 88003

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Preface

The Desert Soil-Geomorphology Project (informally termed the Desert Project), a 400-square mile study of soil and landscape evolution astride the Rio Grande Valley, was conducted from 1957 to 1972 by Soil Survey Investigations, SCS-USDA. Objectives and additional background of the study are given in the preface to the Desert Project Guidebook (Gile et al., 1981), hereafter referred to as the Guidebook.

The 31/2-day study tour presented in the Guidebook gives information for 22 of the Desert Project study sites, which are designated *study areas* in the Guidebook. Supplements, to be prepared as needed and to be used with the Guidebook, were envisioned as a way of presenting additional information. This supplement, the first, was prepared partly for a 2-day field trip for the 1988 International Working Meeting on Soil Micromorphology in San Antonio, Texas, and partly to present additional study areas for use in future field study sessions. Objectives of the study areas are to illustrate soil-geomorphic relationships, to present features significant to soil genesis and classification, to show how and why these features change from one soil to another, and, where possible, to show on the landscape where such changes are likely to take place.

Although numerous Desert Project study tours have been held since 1957, the study tour on July 17 and 18, 1988, was the first one for micromorphologists. Because very little material on micromorphology is in the Guidebook, micromorphological information and photomicrographs are presented for a number of study areas in this Supplement.

ACKNOWLEDGMENTS: We are grateful to Sara Cox Hopkins and Dale Hopkins for their permission to use the Soledad Canyon study area. This continues the long-term cooperation and assistance given to our work by the Cox family, beginning with the late A. B. Cox, who in 1957 gave us permission to study the soils and landscapes on the Cox Ranch. We thank Jeff Isaacks for his permission to conduct soil-geomorphic investigations on his land; the Isaacks' radiocarbon site was named after Jeff. Alan Pumphrey kindly gave us permission to excavate the lower La Mesa site at new study area 26. We express our appreciation to Mike Medley for arranging permanent preservation of the well known airport site (study area 6) on upper La Mesa. This classic site is the type location of the Cruces series, named after the City of Las Cruces. We greatly appreciate the support of Ray Margo, Oran Bailey, Joe Batson, and Lou Gomez in permanently fencing and preserving five study areas at the Gardner Spring radiocarbon site. Four of the five contain soils with laboratory analyses; a fifth contains buried charcoal that has been dated, as do two of the other four. We thank Tommie Parham for his support and Leroy Hacker for assistance in soil correlation. We are indebted to LeRoy Daugherty and Bob Ahrens for reviewing the manuscript. Thanks also go to Nancy Gilson for editorial assistance and to Yvonne Flores for typing the manuscript.

L. H. Gile
Soil Scientist (retired)
Natural Resources Conservation Service, USDA
Las Cruces, NM 88001

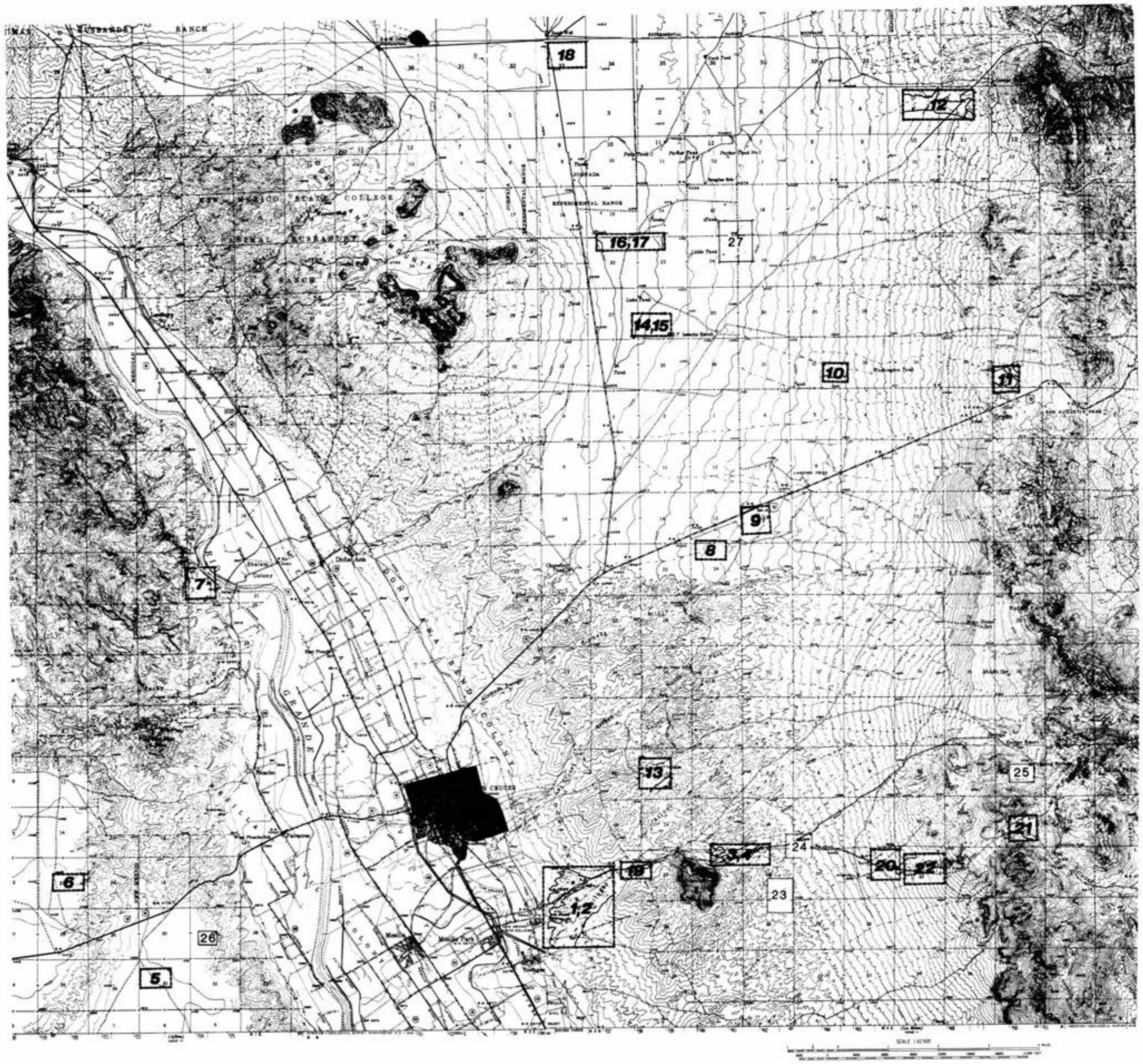
J. W. Hawley
Senior Environmental Geologist
New Mexico Bureau of Mines and Mineral Resources
Socorro, NM 87801

R. B. Grossman
Soil Scientist
Natural Resources Conservation Service, USDA
Lincoln, NE 68508

H. C. Monger
Assistant Professor
Department of Agronomy and Horticulture
New Mexico State University
Las Cruces, NM 88003

C. E. Montoya Soil Scientist
Natural Resources
Conservation Service, USDA
Las Vegas, NM 87701

G. H. Mack
Professor
Department of Geological Sciences
New Mexico State University
Las Cruces, NM 88003



FRONTISPIECE—The Desert Project area, showing selected study areas that are near roads to expedite access. Areas 1–22 were presented in the Desert Project Guidebook; additional information for most of them is in this Supplement. New study areas 23–27 (this Supplement) are outlined with thinner lines and numbers to distinguish them from areas 1–22.

Contents

This Supplement is organized by study area in the Desert Project Guidebook (Frontispiece; Gile et al., 1981). Only study areas having supplementary material are listed in this Supplement. New study areas 23-27 are inserted in numerical order at the end. Cross references to the Desert Project Guidebook are indicated in italics.

Tables

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Abstract

This Supplement to the Desert Project Guidebook presents new study areas 23-27, and additional information for other study areas and thin section studies. New study area 23 is near pipeline and power line roads that cross terraces and soils ranging in age from late Holocene to late middle Pleistocene. In area 23, morphology of the laminar, plugged, and adjacent horizons of an Argic Petrocalcid was related to the radiocarbon chronology of their carbonate. This pedon was the first so studied in the Desert Project and the first to be reported in the world literature on genesis of carbonate horizons.

Study area 24 illustrates a complex of Typic Haplocalcids and Argic Petrocalcids on a dissected landscape with ridge remnants of late middle Pleistocene age and the transition to a broad stable landscape of the same age dominated by Argic Petrocalcids. Area 24 illustrates a facies change from low-gravel to high-gravel materials and profound changes in carbonate morphology (stage III to IV) and soil classification (Typic Haplocalcid to Typic Petrocalcid) that accompany the facies change. Thin sections show evidence of dissolution of primary grains in the calcic horizon of the Haplocalcid.

Study area 25, in Ice Canyon of the Organ Mountains, illustrates a bedrock-defended ancient fan and an Argic Ustic Petrocalcid dating from middle to early Pleistocene. This soil has a red, clay Bt horizon with a subhorizon that has more than 70% clay, and illustrates stage IV of carbonate accumulation in soils of the mountain canyons. Thin sections show argillans on sand grains but not on ped faces. Prominent striae of oriented clay occur within peds and may represent former argillans.

Study area 26 is along and near the scarp of a middle Pleistocene relict basin floor that borders the Rio Grande valley. At area 26, the deep petrocalcic horizon of a Typic Petroargid illustrates stage IV of carbonate accumulation in low-gravel materials. Thin sections show evidence of dissolution of primary grains in the petrocalcic horizon and accumulation of silica below it. Electron microscopy, soil column and culture studies indicate that soil microorganisms are involved in precipitation of fine-grained calcite in horizons of carbonate accumulation. Microscopic and chemical evidence indicates that palygorskite was neoformed in the petrocalcic horizon.

Study area 27 is in a distinctive scarplet terrain in which the scarplets cut fan-piedmont sediments derived largely from sedimentary rocks such as limestone. The scarplets expose a Holocene Haplocalcid and the Bt horizon of an underlying Calciargid of late Pleistocene age. An argillic horizon has not formed in high-carbonate parent materials of late or middle Holocene age, but has formed in the underlying soil of late Pleistocene age. This suggests that moister climates of Pleistocene pluvials may have been involved in leaching the bulk of the carbonates so that the argillic horizon could form. Thin sections of the buried argillic horizon show both prominent argillans and some limestone grains. This shows that not all of the primary carbonate must be leached from the parent materials for an argillic horizon to form. Argillans were not found on limestone grains.

Photomicrographs illustrate illuvial clay and carbonate in soils that range in age from late Holocene to middle to early Pleistocene. Coatings of oriented clay on sand grains and pebbles (grain argillans) are characteristic of the Bt horizons. Grain argillans of many Bt horizons have been partly to completely obliterated by carbonate. Calcified root hairs, calcite filaments, and framework grain coatings (calcitans) are the youngest forms of carbonate accumulation. They are currently forming and are the major morphological expression of carbonate in late Holocene soils. Progressively older carbonate forms increase in density and hardness with increasing carbonate content. Thin sections show evidence of dissolution of primary grains in soils of late middle Pleistocene age and older.

Introduction

When the Desert Project began in August, 1957, one of the problems for study concerned the origin of horizons of silicate clay accumulation. At the time, the prevailing opinion was that horizons of clay accumulation in desert soils formed by weathering in place; desert soils "are not subject to leaching and do not develop either eluvial or illuvial horizons" (Nikiforoff, 1937, p. 124). This view was still common well into the 1960s when a joint 1964 publication of Agricultural Experiment Stations and the Soil Conservation Service had this statement about desert soils (1964, p. 13): "Generally, the quantity of moisture is insufficient to illuviate clay; and Bt horizons when present are due largely to weathering in place."

Thin section studies are one way of learning more about the origin of these horizons. In August, 1960, a visit by Dr. Roy Brewer provided an additional stimulus for thin section work. During the visit we showed Dr. Brewer several reddish-brown and red B horizons with ped faces that had smooth, reflective surfaces suggestive of clay skins (now commonly termed argillans, Brewer, 1964; Bullock et al., 1985). At each site, when questioned about the possibility of clay skins, Dr. Brewer's answer was the same: "I should like to see this in thin section."

Thin sections showed that nearly all ped surfaces and pores lacked clay skins in the arid part of the study area, pipes being the only exception (see cover). Instead, coatings of oriented clay on sand grains and pebbles were found to be characteristic of the Bt horizons. Field studies, laboratory analyses and thin sections all indicate that the red to brown horizons of silicate clay accumulation in the Desert Project area contain illuvial clay. A summary of Bt horizons and evidence for illuviation is presented in the Guidebook (pp. 71-75).

Laboratory analyses for study areas 4a, 11c, and 26 were done by Curtis Monger, except for organic carbon at area 11c, which was done by the Soil, Water, and Plant Testing Laboratory at New Mexico State University. All other laboratory analyses were made by the National Soil Survey Laboratory at Lincoln, Nebraska. Thin sections illustrated at sites 8, 16, 17, 19, 20, and 25 were made using the method of Gile (1967). The other thin sections were prepared with clear epoxy as the impregnating medium. The photomicrograph on the cover was taken in 1965 by Gile with an American Optical microscope and a Crown Graphic camera. Photomicrographs for the plates were taken in 1989 by Monger with a Nikon microscope and Minolta 35mm camera.

Horizon terminology

Some of the data and description sheets used in this Supplement are from the Desert Project Soil Monograph (Gile and Grossman, 1979). Since the Monograph was published, changes have been made (Soil Survey Division Staff, 1993) in the long-standing horizon designations used in the 1951 Soil Survey Manual (Soil Survey Staff, 1951) and its 1962 Supplement. Table 1 gives approximate equivalents of horizon designations used in the Monograph and in the revised Soil Survey Manual (Soil Survey Division Staff, 1993). However, the K horizon nomenclature (Gile et al., 1965) continues to be used in Desert Project and other publications because, as noted by Birkeland (1984), "most pedologists and geologists working in arid lands find it a very useful term."

Soil taxonomy

Major changes have been made in classification of the Aridisols (Soil Survey Staff, 1994), which formerly consisted of two suborders, Orthids and Argids. Now there are seven suborders—Cryids, Salids, Durids, Gypsids, Argids, Calcids, and Cambids. Of these, three occur in the Desert Project—the Argids, Calcids and Cambids. The main changes involve the suborder, great group and subgroup. Table 2 gives the classification of soils discussed in this Supplement, and compares classification of both the old and new systems at the subgroup level. The new classifications have been entered in all affected data and description sheets.

In the Guidebook, the young sediments of arroyo channels were designated Entisols. These materials are termed Streamwash in this supplement. This term designates unstabilized areas of sandy and gravelly materials that are flooded and reworked by streams so frequently that they have no pedogenic horizons and little or no vegetation. Streamwash is similar to Riverwash (Soil Survey Staff, 1993), and is used here instead of Riverwash because the streams of this study are not rivers. Arroyo channels and associated Streamwash commonly show as light-colored, narrow, linear patterns on aerial photographs.

TABLE 1—Approximate equivalents of horizon designations in the Desert Project Soil Monograph (Gile and Grossman, 1979) and in the revised Soil Survey Manual (Soil Survey Division Staff, 1993).

Horizon designations, Monograph		Horizon designations revised Soil Survey Manual	
Without vertical subdivision	With vertical subdivision	Without vertical subdivision	With vertical subdivision
A1	A11 A12	A	A1 A2
A2	A21 A22	E	E1 E2
A3		AB or EB	
B1t	B11t B12t	BAt	BAt1 BAt2
B2t	B21t B22t	Bt	Bt1 Bt2
B3t	B31t B32t B32tca	BCt	BCt1 BCt2 BCtk
C	C1 C2	C	C1 C2
	If a K horizon is present		
K1	K11 K12	Bk	Bk1 Bk2
K2	K21 K22		Bk3 Bk4
K3	K31 K32		Bk5 Bk6 Bk7

Field study sessions

Five new study areas and detailed soil maps have been added. Location of all study areas is shown on the frontispiece. The new study areas and other features (e.g., exposures of soils) are located on the soil maps. Micromorphological information available for the pedon at the time of Monograph publication is on the pedon description page. Table 3, an updated version of table 8 in the Guidebook, gives estimated ages of the geomorphic surfaces and their associated sediments and soils.

Study area 3—Haplocambids of the Fillmore surface; Calciargids and Petrocalcids of the Picacho surface

Refer to pages 104-108, Guidebook, for discussion of study area 3 as a whole.

Area 3a—Typic Haplocambid (Tugas) in Fillmore alluvium

Figures 1 and 2 show the Typic Haplocambid at site 3a. Clay contents of the E and Bt horizons are 7.2 and 8.7 percent respectively (data from the National Soil Survey Laboratory, Lincoln, Nebraska). The clay increase from E to B is too slight for an argillic horizon, but the Bt horizon is fine enough and thick enough for a cambic horizon. Sands and pebbles in the Bt horizon have the thin coatings of oriented clay (grain argillans, Plate 1) that are typical of Bt horizons in this and other desert areas.

The 5YR hue of the Bt horizon contrasts with the 10YR hue of the B horizon of the Torripsamment at study area 19 (Guidebook), which is thought to be about the same age. Development of the 5YR hues here and not at study area 19 is attributed to a difference in parent materials. The soil here at study area 3a has formed in dominantly rhyolite alluvium that contains ferromagnesian minerals such as biotite, that would be susceptible to weathering in an arid environment. Combination of extreme summer heat with the moist season is thought to promote enough weathering of these minerals in the E horizon to give the 5YR hues in the Bt. In contrast, the Torripsamment at study area 19 has formed in reworked river alluvium that is low in extractable iron. This reflects the scarcity of ferromagnesian minerals, and is apparently responsible for the lack of 5YR hues in the B horizon.

Areas 3b and 3c (see new study areas 4a, 4b)

Because of roadwork, study areas 3b and 3c are no longer suitable to illustrate soils of a stable Picacho surface (see new study areas 4a, 4b).

Area 3d—Argic Petrocalcid (Casito 60-1) in Picacho alluvium; the plugged horizon

Casito 60-1 at area 3d was selected to illustrate the stage III plugged horizon in the morphogenetic sequences of carbonate accumulation (Gile et al., 1966, pp. 349-351). Figure 3 shows the site as it appeared just before cleaning the exposure and sampling the pedon in 1960. Although the arroyo bank has eroded considerably since 1960, the site is still used for study tours because it illustrates so many features of soils of Picacho age (see Guide-

FIGURE 1—Landscape of the Typic Haplocambid at area 3a. The Tortugas surface is on the skyline. Scale is in feet. Photographed October 1981.

FIGURE 2—The Typic Haplocambid, Tugas, in Fillmore alluvium at area 3a. Vegetation consists of snakeweed and creosotebush Scale is in feet. Photographed October 1981.

TABLE 2—Classification of soils discussed in this report, according to the Soil Survey Staff, 1994. a = argillic horizon; c = calcic horizon; cam = cambic horizon; d = duripan; g = gypsic horizon; pc = petrocalcic horizon; pg = petrogypsic horizon; s = salic horizon; n = natric horizon. See Soil Survey Staff, 1994, for details of definitions. All soils are thermic and have mixed mineralogy unless otherwise stated.

Classification and study area	**Comparison of subgroup classification**	
Aridisols	**new system**	**old system**
Argids—have a or n, but no d, g, pc or within 100 cm		
Calciargids—have c within 150 cm		
Ustic	Ustic Calciargids	Ustollic Haplargids
fine-loamy		
Headquarters, 27		
fine		
Stellar, 17		
Typic	Typic Calciargids	Typic Haplargids
loamy-skeletal		
Pinaleno, 4a, 20b, 23, 24		
fine-loamy		
Berino, 6b, 8		
coarse-loamy		
Yucca, 10b		
fine-loamy		
Doña Ana, 27		
Haplargids—no c, d, g, pc, pg, or n within 150 cm		
Ustic	Ustic Haplargids	Ustollic Haplargids
loamy-skeletal		
Monza, near 11a		
Caralampi, 25		
clayey-skeletal		
Eloma, clayey substratum analog, 25		
coarse-loamy		
Summerford, 11c		
fine		
Eloma, fine analog, 25		
Lithic Ustic	Lithic Ustic Haplargids	Lithic Ustollic Haplargids
loamy-skeletal		
Lemitar, noncalcareous analog, 25		
Typic	Typic Haplargids	Typic Haplargids
loamy-skeletal		
Soledad, 23a, 24		
coarse-loamy		
Sonoita, 26		
fine-loamy		
Bucklebar, 9c		
Petroargids—have d, pc or pg between 100 and 150 cm		
Typic	Typic Petroargids	Typic Haplargids
coarse-loamy		
Rotura, 26		
Calcids—have c or pc within 100 cm; no a or n within 100 cm unless pc is within 100 cm		
Haplocalcids—c within 100 cm; no a, d, n, or pc within 100 cm		
Ustic	Ustic Haplocalcids	Ustollic Calciorthids
Fine-silty		
Reagan, 16, 27		
Reagan, buried soil analog, 27		
Typic	Typic Haplocalcids	Typic Calciorthids
coarse-loamy		
Algerita, 23, 24		
unnamed, 26		
coarse-loamy, carbonatic		
Jal, 26, 27		
fine-silty		
Reakor, 27		
Reakor, buried soil analog, 27		
Petrocalcids—have pc within 100 cm		
Argic—have a within 100 cm	Argic Petrocalcids	Petrocalcic Paleargids
loamy-skeletal, shallow		
Casito, 3d, 23, 24		
Hachita, 4b, 23b, 24		
loamy, shallow		
Cruces, 6a		
coarse-loamy		
Hueco, 26		

TABLE 2 (*continued*)

Classification and study area in Supplement	Comparison of subgroup classification	
Aridisols, continued	**New system**	**Old system**
Petrocalcids, continued		
Argic Ustic—have a within 100 cm	Argic Ustic Petrocalcids	Petrocalcic Ustollic Paleargids
clayey-skeletal		
Hayner, 25		
clayey--skeletal, shallow		
Terino, clayey-skeletal analog, 25		
clayey, shallow		
Terino, clayey analog, 25		
fine		
Hayner, fine analog, 25		
Typic	Typic Petrocalcids	Typic Paleorthids
loamy-skeletal, shallow		
Delnorte, 23, 24		
loamy-skeletal, shallow, carbonatic		
Tencee, 26		
coarse-loamy, shallow		
Simona, 26		
Cambids—have cam within 100 cm; no a, c, d, g, pc, pg, n, or s, within 100 cm		
Haplocambids—no d, pc, or pg within 150 cm		
Typic	Typic Haplocambids	Typic Camborthids
sandy-skeletal		
Tugas, 3a, 23, 24		
coarse-loamy		
Pajarito, 10a		
Ustic		
loamy-skeletal		
Gallegos, 25		

Classification and study area in Supplement	Classification and study area in Supplement
Entisols	**Mollisols**
Torrifluvents	Argiustolls
Ustic	Aridic
sandy-skeletal	clayey-skeletal
Minneosa, sandy-skeletal analog 25	Earp, clayey-skeletal analog, 25
fine-silty	Earp, clayey-skeletal, calcic analog, 25
Glendale, Ustic analog, 27	fine
Typic	Earp, fine analog, 25
fine-silty	Pachic
Glendale, 27	clayey-skeletal
	Limpia, 25
Torriorthents	
Ustic	Haplustolls
fine-silty	Cumulic
Lacita, buried soil analog, 27	loamy-skeletal
Lithic Ustic	Santo Tomas, Cumulic analog, 25
loamy-skeletal	Pachic
Coyanosa, 25	loamy-skeletal
Typic	Santo Tomas, 25
sandy-skeletal	
Kokan, 26	Paleustolls
Arizo, 23, 24	Petrocalcic
sandy	clayey-skeletal
Yturbide, 26	Hayner, mollic analog, 25
fine-silty	
Tome, buried soil analog, 27	
Torripsamments	
Typic	
Bluepoint, 26	
Bluepoint, thin analog, 26	
University, 19	

TABLE 3—Physiographic location and estimated age of geomorphic surfaces and their soils. The age of a geomorphic surface and its soils is considered to be the same. On a constructional surface, for example, all would date from the approximate time that sedimentation stopped and soil development started.

Geomorphic surface	Physiographic location and soil age (yrs. B.P. or epoch)
The valley border	
Arroyo channels	Historical (since 1850)
Coppice dunes[1]	Historical
Fillmore	100–7,000
Leasburg	Earliest Holocene-latest Pleistocene (8,000-15,000)
Fort Selden	(Fillmore and Leasburg—undifferentiated)
Picacho	Late Pleistocene (25,000–150,000)
Tortugas	Late to middle Pleistocene (150,000–250,000)
Jornada I[2]	Late middle Pleistocene (250,000–400,000)
Lower La Mesa[2]	Middle to early Pleistocene (500,000–900,000)
Upper La Mesa[2]	Late Pliocene (2,000,000–2,500,000)
Basin floor north of US–70	
Lake Tank	Present to Late Pleistocene
Petts Tank	Late Pleistocene (25,000–150,000)
Jornada I	Late middle Pleistocene (250,000–400,000)
La Mesa	Middle to early Pleistocene (500,000–900,000)
Jornada I–La Mesa	(Jornada I or La Mesa, undifferentiated)

Geomorphic surface	Physiographic location and soil age (yrs B.P. or epoch)
The piedmont slope	
Arroyo channels	Historical
Coppice dunes[1]	Historical
Whitebottom[3]	Historical
Organ	100–7,000
III	100(?)–1,100
II	1,100–2,100
I	2,200–7,000
Isaacks' Ranch	Earliest Holocene–latest Pleistocene (8,000–15,000)
Jornada II	Late Pleistocene (25,000–150,000)
Jornada I	Late middle Pleistocene (250,000–400,000)
Jornada	(Jornada I or Jornada II, undifferentiated)
Doña Ana	Middle to early Pleistocene (> 400,000)
Mountain slopes and summits (undifferentiated)	

[1]Coppice dunes have not been formally designated a geomorphic surface but are considered separately here because of the extent and significance to soils of the area.
[2]The Jornada I and La Mesa surfaces are not formally considered a part of the valley border. They are included here because they form part of a stepped sequence with the valley border surfaces.
[3]The Whitebottom surface is recognized in the silty, highly calcareous sediments northeast of Isaacks Lake Playa. Associated sediments are generally only a few cm thick.

book pp. 108). A feature not discussed in the Guidebook is the low-gravel horizon beneath the plugged horizon (Fig. 3; table 45, Guidebook). In places this low-gravel horizon, which has scattered carbonate nodules and occurs continuously across the exposure, has noncalcareous zones in the upper few cm. These noncalcareous zones and the carbonate nodules beneath them are thought to have formed during pluvial times of deep leaching, because the low-gravel horizon is relatively close to the surface and must have been within reach of wetting during moist times. During drier times, and particularly after the K horizon formed, the marked change in particle size would have caused soil moisture to hang along the sedimentary contact, slowing the wetting fronts so that carbonate would tend to accumulate along or above the contact.

Study area 4—Calciargids and Petrocalcids of the Picacho and Jornada I surfaces

Refer to pages 109-111, Guidebook, for discussion of study area 4 as a whole. New study areas 4a and 4b (Figs. 4, 5) replace 3b and 3c. The Typic Petrocalcid of the Jornada I surface (study area 4 of the Guidebook, pp. 109, 110) is now designated study area 4c.

New areas 4a and 4b—Typic Calciargid (Pinaleno) and Argic Petrocalcid (Hachita) in Picacho alluvium

The Picacho surface occurs as a terrace inset against sediments of the Jornada I surface just south. Presence of a small arroyo between the Picacho and Jornada I surfaces shows that this Picacho remnant could not have been

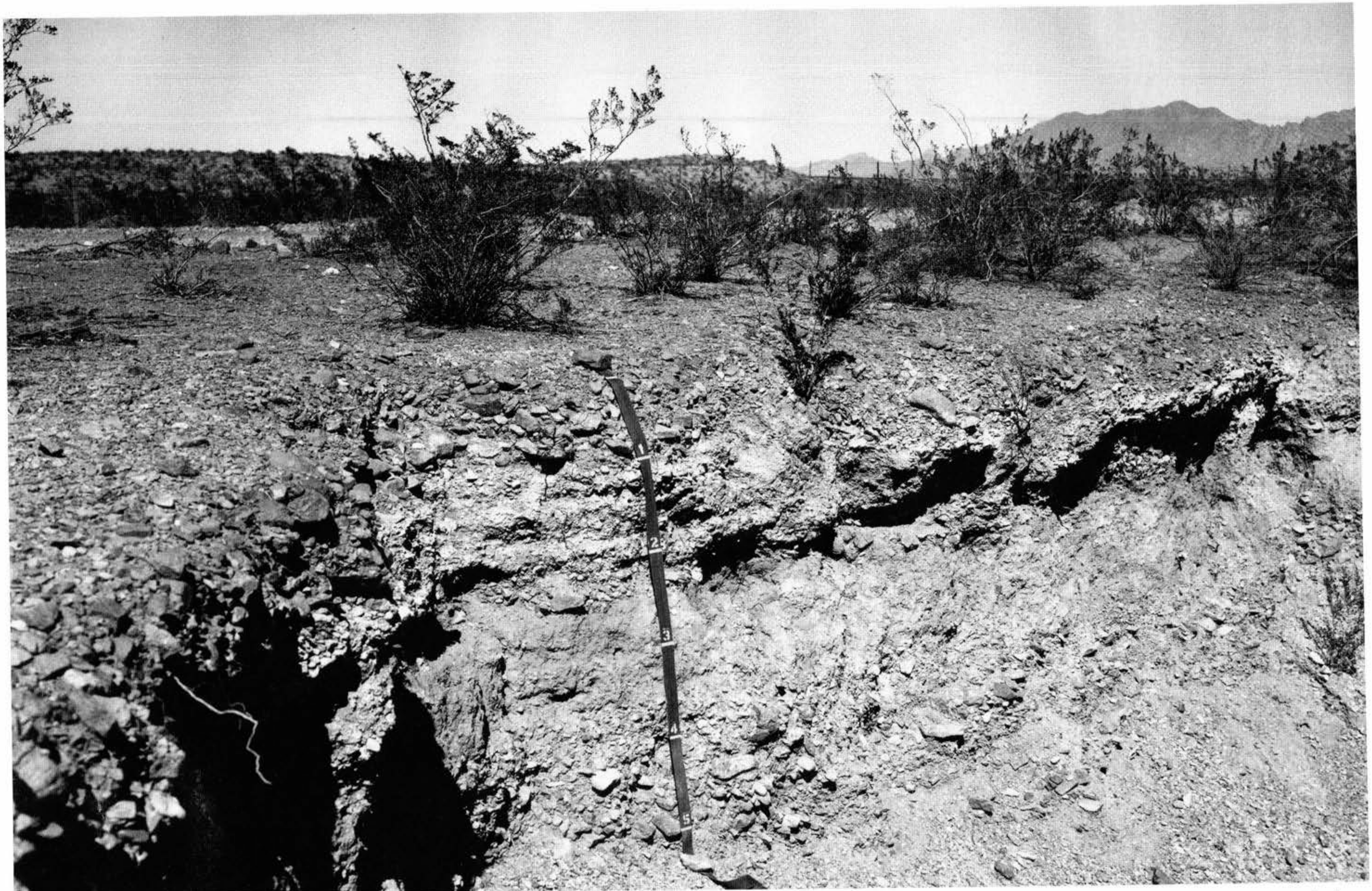

FIGURE 3—Landscape of the Argic Petrocalcid, Casito 60–1, on the Picacho surface at area 3d. This is the site selected to illustrate the stage III plugged horizon (see text). Note the low-gravel horizon with its upper boundary at a depth of about 2½ ft. The Organ Mountains are on the skyline. Scale is in feet. Photographed April 1960.

TABLE 4—Particle size distribution for upper horizons of the Argic Petrocalcid at study area 4b. $CaCO_3$ and organic carbon removed.

Horizon	Depth (cm)	Sand 2.0–0.05 mm	Silt 0.05–0.002 mm	Clay <0.002 mm	>2 mm (vol)
		percent			
E	0–5	69	24	7	30
BEt	5–12	66	21	13	55
Bt1	12–21	52	22	26	50
Bt2	21–34	60	22	19	55

affected by runoff from the Jornada I surface for a very long period of time. The surface is stable, and maximum penetration of soil moisture would be expected. The Bt horizon at this stable site has substantially more clay (Table 4) than at the less stable area 3d (table 45, Guidebook).

Micromorphology of the Bt horizon (Plate 2) differs markedly from that of the late Holocene Bt horizon at study area 3a. This is illustrated by a thin section from a Bt horizon near the west end of the trench (Plate 2). Argillans on the sands and pebbles are much thicker than at area 3a, and a clay-rich matrix occurs between the argillans.

The volume of rock fragments (>2mm material) in the soil prominently affects morphology of the accumulating carbonate and silicate clay (Guidebook, pp. 67, 72). This exposure of the Picacho alluvium and its soils illustrates initial and sporadic development of both the stage IV carbonate horizon and a petrocalcic horizon in skeletal material[1] of late Pleistocene age (Fig. 5). In the pedon just to the left (west) of the tape, carbonate cementation is not continuous enough for a petrocalcic horizon; this pedon is the Typic Calciargid Pinaleno. A petrocalcic horizon occurs at right (east) of the tape; this is the Argic Petrocalcid Hachita.

The volume of rock fragments is similar on both sides of the tape; thus, development of the petrocalcic instead of a calcic horizon cannot be attributed to the volume of rock fragments as it could be at areas 3b and 3c (see Guidebook, p. 107). Development of the petrocalcic horizon at

[1]A term used informally in this volume to designate materials of any texture and thickness that contain 35% or more, by volume, of rock fragments.

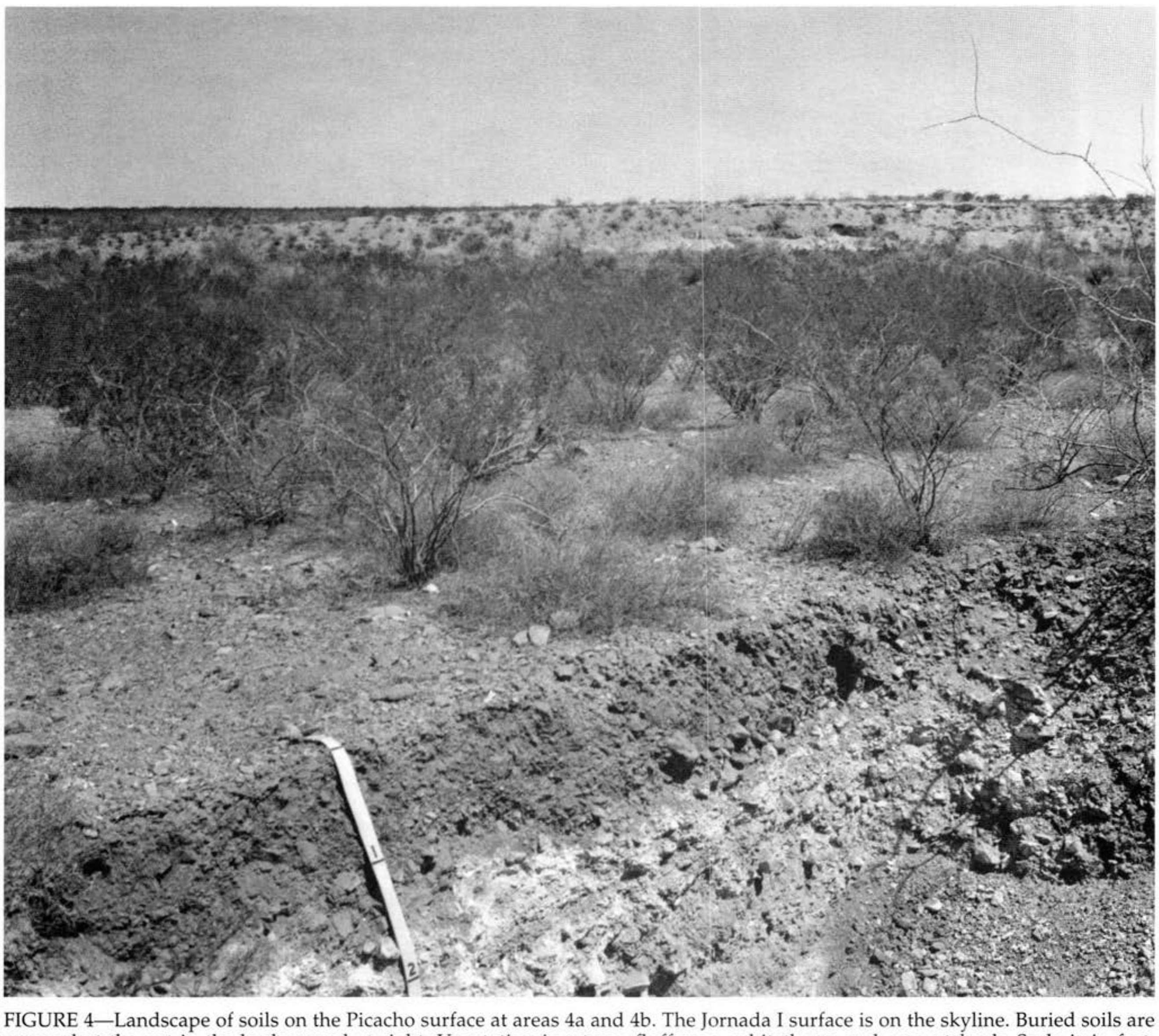

FIGURE 4—Landscape of soils on the Picacho surface at areas 4a and 4b. The Jornada I surface is on the skyline. Buried soils are exposed at the cut in the background at right. Vegetation is ratany, fluffgrass, whitethorn, and creosotebush. Scale is in feet. Photographed April 1988.

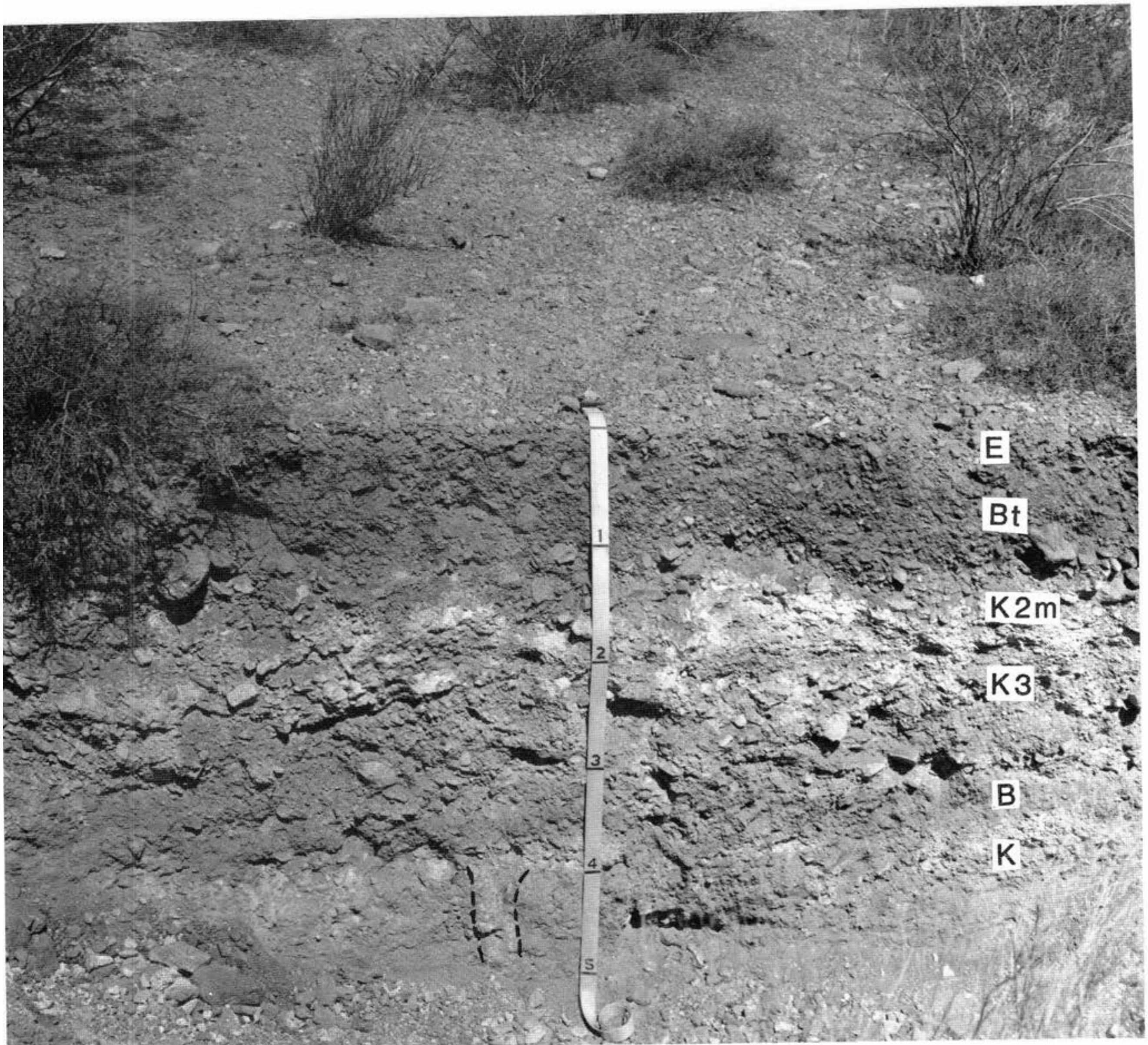

FIGURE 5—Picacho surface and soils at areas 4a and 4b. Profiles of the Typic Calciargid, Pinaleno, at left of the tape (4a) and the Argic Petrocalcid, Hachita, at right of the tape (4b). These soils of Picacho age illustrate isolated zones of K-fabric that are common in skeletal materials of Late-Pleistocene age. Such isolated zones of K-fabric are largely masked by later carbonate accumulations in the thick K horizons of pre-Picacho soils. Occasional tongues of carbonate nodules occur below a depth of about 4 ft (1.2 m); one of these is outlined at left of tape. Generalized horizon designations are shown for a pedon at right. Vegetation is ratany, fluffgrass, whitethorn, and creosotebush. Scale is in feet. Photographed April 1988.

the right of the tape may be related to the more gravelly zones at a depth of about 4 ft (1.2 m, Fig. 5), as compared to carbonate tongues, discussed later, in less gravelly materials at the left of the tape.

Soils of the Picacho surface are instructive in studying carbonate accumulation because they are less complex than older soils of Pleistocene age, in which more prominent carbonate horizons have largely masked patterns of carbonate accumulation that could be related to movement of soil water during soil development in the Pleistocene. Soils of the Picacho surface must have formed in part during pluvials of the late Pleistocene. During such times, moisture penetration would have been substantially deeper than now, and this could be responsible for the carbonate accumulation below a depth of about 4 ft (1.2 m, Fig. 5).

A number of workers have shown the effects of changes in particle size on water movement in soils, and their work suggests possible patterns of water movement and associated carbonate accumulation in deeper layers of these soils. Strata that differ markedly in particle size retard downward movement of the wetting front (Taylor, 1957; Miller and Gardner, 1962), and tend to increase the amount of water retained above the contact. Thus, early in soil history and before the petrocalcic horizon formed, at times of deeply penetrating moisture, the gravelly layer at about 4 ft (1.2 m) depth could cause soil water to "hang" along the sedimentary contact. As a result, carbonate could accumulate along the contact and such carbonate could have formed the zones of K-fabric in these materials (e. g., the zone designated K at the right side of Fig. 5).

When the soil above the contact becomes wet enough, water enters the soil beneath it in a few points and moves downward as in a drain (Taylor, 1957, p. 62). In these soils, such points of water entry may be marked by the downward-extending tongues of carbonate nodules outlined in Figure 5. In contrast to the carbonate tongues, some of the zones between them are noncalcareous or effervesce weakly. These zones may be similar in origin to the "by-pass zones" in stratified tuff at Kilbourne Hole (Gile, 1987), in that they represent material bypassed by tongues of deep moisture penetration.

In addition to roughly vertical movement of soil moisture, lateral movement of water above gravelly layers has been reported (Miller, 1963, 1973). Such lateral movement would also contribute moisture to the tongues of moisture penetration (Fig. 5).

During this period of early leaching, the deep B horizon (Fig. 5) would have been in cambic position, above the zone of carbonate accumulation (Soil Survey Staff, 1975, p. 36). But changes to drier climates would cause carbonate to accumulate at shallower depths. With continued carbonate accumulation above the deep B horizon, wetting fronts could not penetrate as deeply; the base of the gravelly layer just above the deep B horizon would tend to hold up these shallower wetting fronts, thus largely preserving the noncalcareous state. Similarly, abrupt changes in particle size could also be responsible for some of the remarkably abrupt boundaries between high-carbonate horizons and underlying noncalcareous horizons observed in other areas: the situation shown in Figure 5 would be an earlier stage of the phenomenon.

Study area 6—Calciargids and Petrocalcids of upper La Mesa surface

Work on the magnetostratigraphy by Mack et al. (1993) indicates that upper La Mesa dates from late Pliocene time. Age of its soils is tentatively estimated to be about 2.0-2.5 Ma (Table 3).

Refer to pages 118-124 of the Guidebook for discussion of study area 6, where the Petrocalcid Cruces 61-7 and the Calciargid Berino 68-8 were sampled in the well-known airport trench (Guidebook, fig. 37).

Area 6a—Argic Petrocalcid (Cruces 61-7) in upper Camp Rice sediments

Plate 3, a photomicrograph of the K21m horizon, shows a feldspar grain that has been partly dissolved and replaced by micrite (calcite crystals <4 pm, Bullock et al., 1985). See study areas 24a and 26 for additional evidence of dissolution of primary grains and replacement by micrite.

Area 6b—Typic Calciargid (Berino 68-8) in upper Camp Rice sediments

Upper horizons of a large pipe near Cruces 61-7 were sampled in 1968 (Guidebook, p. 121). The trench was deepened in 1987 and deeper horizons were sampled. A thick Btk horizon in the lower part of the pipe extends to 284 cm depth, where it overlies a deep Km horizon (App. Part 1). This thick Btk horizon and the Km horizon occur only beneath the pipe and clearly must have formed as a result of deep leaching by water that funneled into the pipe from the top of the adjacent petrocalcic horizon. Prisms in the Btk horizon are commonly coated with carbonate, but prism interiors are mostly noncalcareous (App. Part 1).

Thin sections of the deep Btk horizon show the thickest grain argillans found in the study area (Plate 4). The horizon also has common grain-to-grain contacts, which contrast with the "floating grains" of certain other Bt horizons (see study area 3a).

Prisms in the deep Btk horizon in the pipe are very and extremely hard (App. Part 1), do not soften noticeably when moistened, and do not slake in water. Lower subhorizons of the deep Btk horizon have very little clay and high ratios of 15-bar water to clay (App. Part 1). These characteristics are attributed to resistance of the materials to the dispersion pretreatment of mechanical analysis, as suggested by Flach et al. (1969) for materials cemented by silica. Thin sections of the lowest (Btk) subhorizon show part of a silica nodule (Plates 5, 6), and silica is thought to be largely responsible for hardness of the horizon, for its nonslaking property, and for cementation of the prisms. Tight packing, grain-to-grain contacts and well-developed grain argillans may be contributing factors.

Both margins and interiors of weatherable grains in the Btk horizon are sharp and lack evidence of weathering, even in this pipe which must have been quite moist at times in the past. This agrees with the abundance of weatherable minerals found in other Bt horizons and is further evidence that little of the clay in Bt horizons of the arid part of the Desert Project formed by weathering in place. As noted in the Guidebook (p. 118) for adjacent Cruces 61-7, "Despite the great age of this soil, the argillic horizon contains approximately 40 percent of weatherable minerals; little difference occurs with depth, indicating a lack of rigorous weathering during soil development."

Study area 8—Calciargids **of the Jornada II surface**

Refer to pages 134-139 of the Guidebook for discussion of study area 8.

Typic Calciargid (Berino 60-7) in jornada II alluvium

The photomicrograph (Plate 7) of the Bt horizon in Berino illustrates a ped face that is typical of fine-loamy argillic horizons of the area. Although hand specimens show smooth and reflective ped surfaces suggestive of argillans, thin sections show none to be present on ped faces. Instead, prominent argillans occur on sand grains in ped interiors. A clay-rich matrix occurs between the argillans.

Study area 9—Haplargid in Isaacks' Ranch alluvium

Refer to pages 139-145 of the Guidebook for discussion of study area 9, and page 144 for area 9c.

Area 9c—Typic Haplargid (Bucklebar 88-1) in Isaacks' Ranch alluvium

The Bucklebar pedon (Figs. 6, 7; App. Part 2) has formed in two different sedimentary environments and textures. The lower, coarser-textured materials represent a gully fill. The upper material contains less sand, more silt, and more clay, and reflects decreased energy of the Isaacks' Ranch streams as they spread out over the whole broad drainageway landscape instead of being confined to the gully.

No A or E horizon is present at the sampled pedon because of erosion along the gully. Silicate clay increases with depth in the Bt horizon (App. Part 2), and thin sections show the characteristic grain argillans in the argillic horizon (Plate 8). Some argillans have been obliterated by carbonate (Plate 9).

The pedon illustrates the typical stage II carbonate that is characteristic of Isaacks' Ranch soils. The Btk3 horizon contains barely enough carbonate (15%) for a calcic horizon, but does not meet the minimum thickness requirement (15 cm) of the calcic horizon. This pedon was one of a group of pedons in a study of pedogenic carbonate in soils of Isaacks' Ranch age (Gile, 1995). The study indicated that the amount of pedogenic carbonate in soils of

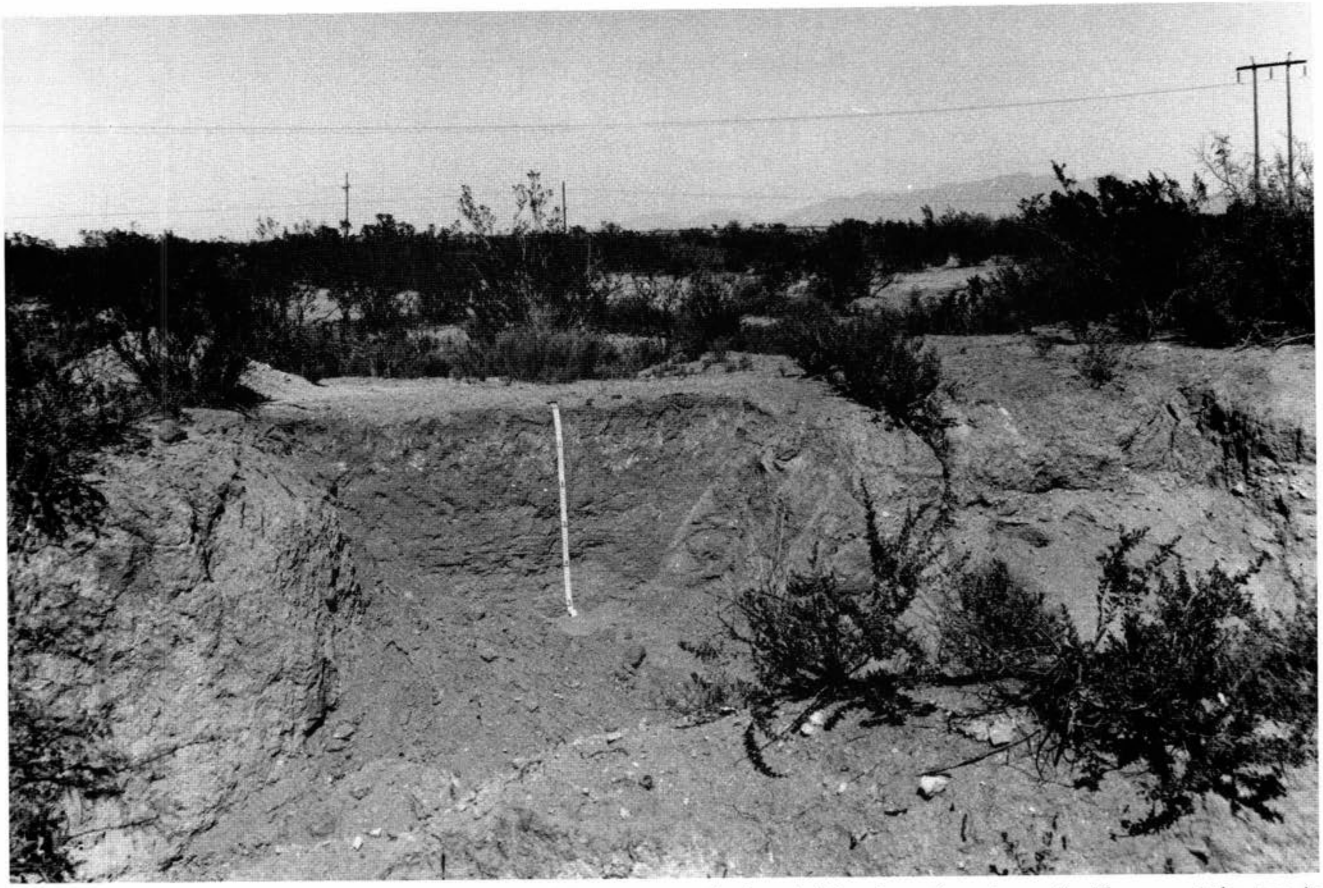

FIGURE 6—Landscape of the Typic Haplargid, Bucklebar 88–1, on the Isaacks' Ranch surface at area 9c. The area at the tape is barren. Pole lines along U.S. Highway 70 may be seen in the background. Scale is in feet. Photographed November 1981.

Isaacks' Ranch age may range up to five-fold, that landscape position is an important factor in this range, and that texture of the parent materials can have a major effect on the amount of carbonate in soils of a given age regardless of landscape position.

The range in age of Isaacks' Ranch surface and the associated alluvium and soils is from 8,000 to 15,000 yr B.P. (Table 3). Harden and Taylor (1983, page 346) believe the Isaacks' Ranch deposits to be about 20,000 yrs old; however, there is evidence for an age of about 11,000 yr for the bulk of this alluvium (Gile, 1987, p. 755; Gile, 1995).

Study area 10—Haplocambids of the Organ surface; Calciargids of the Late Jornada II surface; the Isaacks' radiocarbon site

Refer to pages 144-149 of the Guidebook for a discussion of study area 10.

Area 10a—Typic Haplocambid (Pajarito 67-3) in Organ alluvium

The north bank of the arroyo just south of Pajarito 67-3 (Guidebook, p. 147) has been used for area 10a instead of Pajarito 67-3 because the soils are very similar, because the same dated charcoal bed occurs in both soils, and because such use would help to preserve the original sample site. However, the arroyo bank site must be carefully filled each time that it is excavated because erosion of the bank has nearly penetrated to the sampled pedon.

Thin sections (Plate 10) show the Bt horizon at area 10a. Nearly all of the clay occurs as grain argillans. In the Ck horizon (Plate 11), thin carbonate coatings on sand grains and pebbles are termed grain calcitans (Douglas and Thompson, 1985).

Area 10b—Typic Calciargid (Yucca 88-2) in late Jornada II alluvium

The deposit and soil at study area 10b have been considered to be of earliest Isaacks' Ranch age (15,000 yr B.P.) or possibly slightly older (Guidebook, p. 149). Carbonate morphology and data (Table 5, App. Part 3) indicate that this soil is older than Isaacks' Ranch. Over the ridge crest as a whole, the horizon of carbonate accumulation commonly qualifies as a K horizon (as it does for the sampled pedon); this is not usual for soils of an Isaacks' Ranch ridge. Pedogenic carbonate totals 126 kg /m^2 (Table 5), which is intermediate between Isaacks' Ranch and Jornada II soils (Gile et al., 1981, table 27). On the basis of the foregoing evidence, the surface and soil at Yucca 88-2 are considered to be older than Isaacks' Ranch, and are designated late Jornada II.

Thin sections of the Bt horizon (Plate 12) show the grain argillans to be thicker than for the Haplocambid at area 10a. In addition, less void space is evident, and more clay—rich material occurs in the matrix between the grain argillans. Carbonate in the Btk horizon (Plate 13) is in the process of engulfing formerly continuous Bt material. As for many other soils of the area, the bulk of the carbonate in the underlying K horizon must have been emplaced before the accumulation of carbonate in the Btk horizon.

Study area il—Haplargids of a monzonite pediment and the Organ surface

Refer to pages 151-156 of the Guidebook for discussion of study area 11.

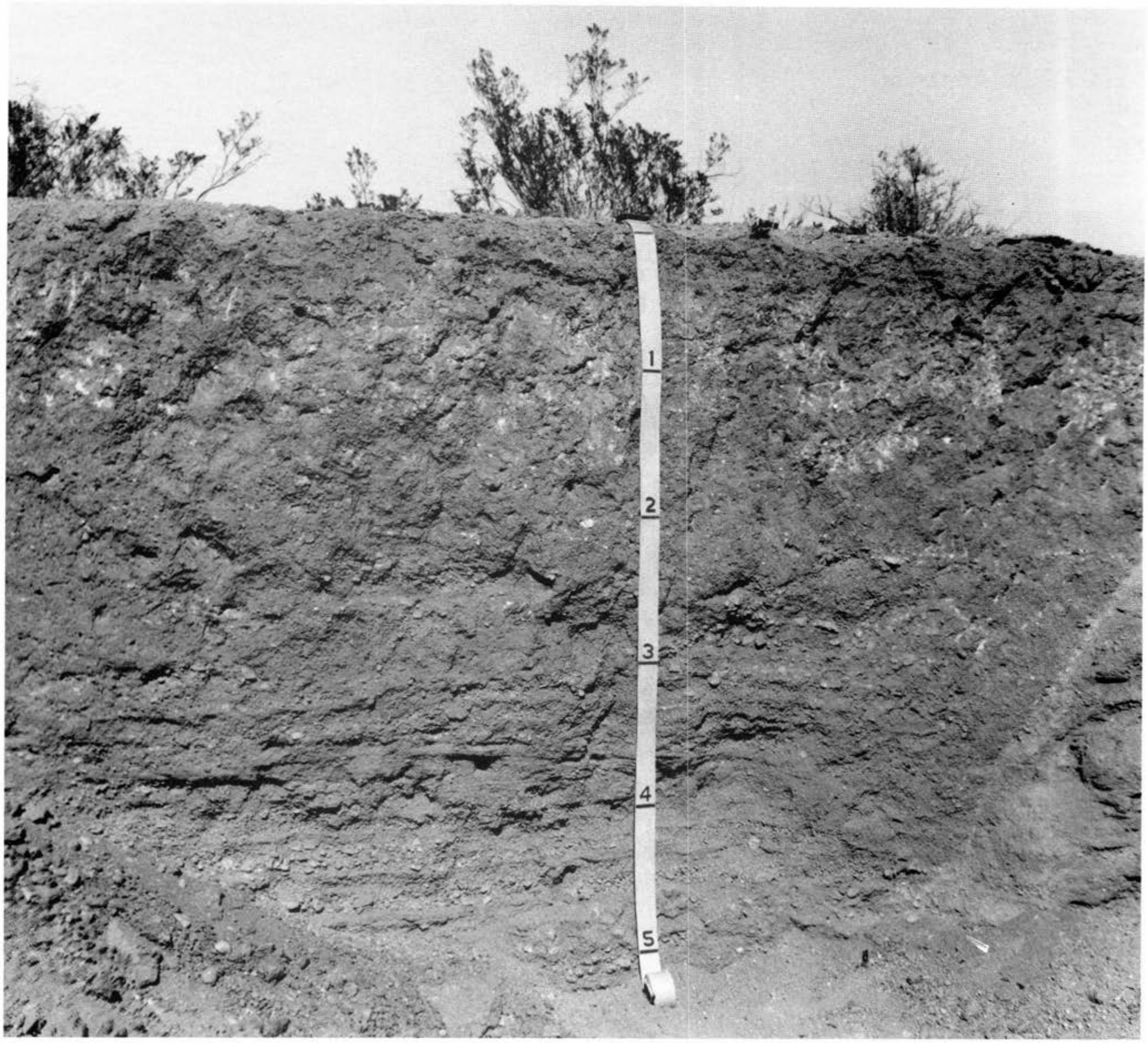

FIGURE 7—The Typic Haplargid, Bucklebar 88–1, in Isaacks' Ranch alluvium at area 9c. The stage II nodular carbonate is distinct. Scale is in feet.

Near area 11a—Ustic Haplargid in monzonite pediment

A thin section (Plate 14) of an Rt horizon from a pedon between Monza 70-1 (at study area 11a) and the road just west shows clay of two origins. Plate 13 shows *illuvial* clay in a grain fracture (at left) and clay formation by *weathering* from exfoliated biotite (at right).

Area llc—Ustic Haplargid (Summerford)

In the arid part of the Desert Project, Bt horizons in Holocene soils commonly are reddish brown. But in semiarid areas in and near the mountains, illuvial clay and Bt horizons can be masked by dark organic carbon, especially in younger soils with only slight clay accumulation. This is illustrated by the soil at study area 11c (Plate 15, Table 6). Clay increases enough from E to Bt, and the Bt horizon has grain argillans (Plate 15) that are typical of the argillic horizon in this area.

Although this soil is easily dark enough for a mollic epipedon (Table 6), organic carbon at 25 cm depth is too low (Table 6; the mollic epipedon must be at least 25 cm thick in these soils). Organic carbon is high enough for a mollic epipedon in some soils, however, especially mountainward, and these soils are Aridic Argiustolls if they have an argillic horizon. Pedon 59-1, formerly classified as a Haplustoll, illustrates (see table 62, Guidebook). Coatings **of** oriented clay have been found in the **B** position for Pedon 59-1, and silicate clay increases sufficiently from A to B for an argillic horizon.

Study area 12—Torrifluvents and Haplocalcids of the Organ surface; the Gardner Spring radiocarbon site

Refer to pages 157-164 in the Guidebook for discussion of study area 12.

Preservation of study areas

Attempts have been made to preserve many of the Desert Project study areas that are in the public domain (Gile and Grossman, 1979, p. 10). A number of them have already been lost due to rapid urban expansion; however, some study areas appear to have a good chance for

TABLE 5—Calculated total of pedogenic carbonate for Yucca 88–2 at study area 10b. Bulk densities estimated from previous work (Gile and Grossman, 1979), using soil texture, consistence, and carbonate content.

Horizon	Depth (cm)	$CaCO_3$ %	Pedogenic $CaCO_3$[1] kg/m²	Estimated bulk density g/cm³	>2 mm (vol.) %
E	0–5	TR			
Bt	5–18	TR			
Btk1	18–29	2	1.4	1.4	10
Btk2	29–43	5	6.3	1.4	20
Btk3	43–53	5	1.5	1.5	75
K1	53–60	23	20.9	1.7	20
K21	60–74	21	35.2	1.8	30
K22	74–88	13	22.7	1.8	25
Bk	88–99	5	5.6	1.6	20
K	99–110	10	12.5	1.8	30
C1	110–130	2	2.6	1.5	15
C2	130–143	3	3.3	1.5	15
Ck	143–153	12	14.0	1.5	15

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

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

where L is the thickness of the horizon in cm, Db is the bulk density of the fine-earth fabric, (1 – >2 mm 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.

TABLE 6—Characteristics of the soil at study area 11c. Organic carbon is 0.62% for the 0–5 cm zone.

Horizon	Depth (cm)	Sand 2.0–0.05 (mm)	Silt 0.05–0.002 (mm)	Clay < 0.002 (mm)	Organic C	Hue	Value/Chroma dry	Value/Chroma moist
		percent						
E	0–2	74.7	16.0	9.6	0.62	7.5YR	5/2.5	3/2
BAt1	2–5	74.1	14.7	11.2		7.5YR	4/2	2.5/2
Bat2	5–12	73.5	15.2	11.3	0.73	7.5YR	4/2	2/2
Bt1	12–20	73.2	14.9	11.9	0.55	7.5YR	4/2	2.5/2
Bt2	20–36	70.9	15.4	13.7	0.36	7.5YR	4.5/2	3/2
Bt3	36–52	75.0	12.0	13.0	0.33	7.5YR	4.5/2.5	3/2

preservation, and five of them are located at Gardner Spring. Thanks to a cooperative effort in 1980, these areas have been fenced for permanent protection. Study areas 12a and 12b (Guidebook) illustrate two of these protected areas.

Study area 16—Haplocalcids of the Petts Tank Surface: effects of parent material carbonate on micromorphology

Refer to pages 182-185 of the Guidebook for discussion of study area 16.

Area 16—Ustic Haplocalcid (Reagan 60-17) in Petts Tank sediments

The Ustic Haplocalcid Reagan 60-17 has formed in high-carbonate parent materials derived from the San Andres Mountains. Plate 16 is a photomicrograph of the Reagan Bk3 horizon. No grain argillans are present despite a considerable increase in clay from A to B. Carbonate in soil parent materials tends to flocculate silicate clay, reducing clay movement in the soil (Jenny, 1941, p. 71). Thus the oriented clay required for the argillic horizon cannot form in high-carbonate parent materials; however, not all of the primary carbonate in the parent materials must be removed for an argillic horizon to form (see study area 27).

Study area 17—Calciargids of the Jornada I surface

Refer to pages 185-189 of the Guidebook for discussion of study area 17.

Ustic **Calciargid (Stellar 60-21) in Jornada I alluvium**

In contrast to Reagan at study area 16, Stellar 60-21 has formed in low-carbonate parent materials derived primarily from monzonite, rhyolite, and andesite of the Dona Ana Mountains. Also in contrast to Reagan, the Bt horizon of Stellar 60-21 has prominent grain argillans (Plate 17).

Study area 19—Torripsamments of the Fort Selden surface

Refer to pages 192-197 of the Guidebook for a discussion of study area 19.

Typic Torripsamment (University 59-10) in Fort Selden colluvium

University 59-10 has formed in colluvium derived from upslope deposits of the ancestral Rio Grande. Thin sections (Plate 18) illustrate that coatings of oriented clay can also occur on sand grains in B horizons of Torripsamments.

Study **area 20—Argids of the Organ and Jornada II surfaces**

Refer to pages 197-205 of the Guidebook for discussion of study area 20.

Area 20b—Typic Calciargid (Pinaleno 59-15) in **Jornada II alluvium**

Pinaleno 59-15 has formed in Jornada **II** alluvial fan sediments derived from rhyolite. Prominent argillans occur on sand grains and pebbles (Plate 19), and a clay-rich matrix occurs between the argillans.

Study area 23—Haplargids and Haplocambids of the Fillmore surface; Petrocalcids of the Picacho and Jornada I surfaces

Summary of pedogenic features

Soils ranging in age from late Holocene to late middle Pleistocene; side-by-side occurrence of weak Haplargids and Haplocambids of late Holocene age, in high-gravel and low-gravel materials respectively; morphology and relative ages of carbonate as evidence for the developmental chronology of the stage IV carbonate horizon; obliteration of the argillic horizon and partial disintegration of the stage IV carbonate horizon in Jornada **I** soils due to landscape dissection and associated soil truncation; radiocarbon age of 19.7 kyr for carbonate coatings in the plugged horizon of a Petrocalcid as evidence of deep penetration of moisture in shallow petrocalcic horizons during pluvials.

Setting

The geomorphic map for study area 23 is in the Guidebook (fig. 25, southwest corner). With increasing elevation the geomorphic surfaces are arroyo channel-Fillmore-Picacho-Tortugas-Jornada **I.** Small areas of a post-Picacho surface (termed late Picacho) are also locally present. In the soil map (Fig. 8), stable areas of Fillmore and Picacho occur in map units A and B respectively. The Tortugas and Jornada I surfaces are strongly dissected in unit D and in the central and western parts of unit C. Dissection gradually decreases eastward, and quite stable Tortugas and Jornada I surfaces occur in the northeast delineation of unit B (Fig. 8). The soil parent materials consist of rhyolite alluvium derived from the Organ Mountains. Exposures of Fillmore, Picacho, and Jornada I alluviums are shown at areas 23a, b and c respectively. Additional exposures of alluviums and soils, including buried soils, can be seen at various places along the tour route; some of these are located in Figure 8.

Three roads along power lines and a pipeline cross the area nearly at right angles, providing a comprehensive view of this terrace landscape. Southward the tour route follows the west road; northward it follows the east road. Dashed lines (Fig. 8) locate routes to study areas 23a, b, and c. Because the roads are nearly north-south they illustrate vegetation of north and south aspects. Vegetation is generally somewhat denser and of greater variety (e.g., creosotebush, ratany, whitethorn, snakeweed; in places there are scattered clumps of fluffgrass and bush mutely) on north-facing than on south-facing slopes, which are dominated by creosotebush in many places.

Soil occurrence

The soil pattern (Fig. 8) is determined primarily by soil age, particle size and degree of soil truncation. In unit A, Torriorthents (primarily Arizo soils) and a few Haplocambids (Tugas soils) and weak Haplargids (Soledad soils) occur on the Fillmore surface. The Haplocambids and Haplargids occur only on the highest, stablest parts of the Fillmore, with the Haplargids occurring only in some of the very gravelly sediments.

Map unit B is dominated by the Argic Petrocalcid Hachita soils. Smaller areas of Typic Petrocalcids and Haplocalcids are also present, occurring mainly in or near drainageways, where the argillic horizon has been truncated and/or engulfed by carbonate accumulation. Minor areas of the Typic Calciargids, Pinaleno soils, occur where the carbonate horizon is not continuously cemented and a calcic instead of a petrocalcic horizon is present.

Many soils of map unit C have been strongly affected by dissection and former argillic horizons have now been obliterated. Unit C is dominated by Typic Petrocalcids (mostly Delnorte), Argic Petrocalcids (mostly Hachita), and Haplocalcids (mostly Algerita). The Argic Petrocalcids occur in stablest areas of the Jornada I and Tortugas ridge sides and ridge crests, and also are common on sides of drainageways that have penetrated below the petrocalcic and calcic horizons of the ridge-crest soils. Also in map unit C are small areas of the Argic Petrocalcid, Casito, which contains some macroscopic carbonate in all sub-horizons of the Bt horizon. The Haplocalcids occur in facies changes to low-gravel materials, so that a calcic horizon has formed instead of a petrocalcic horizon. Narrow areas of arroyo channels and the adjacent Fillmore surface are dominated by Streamwash and Torriorthents respectively.

The landscape of unit D has been so strongly dissected that only a very few Argids are present, and the unit is dominated by Typic Petrocalcids and Haplocalcids. The Typic Petrocalcids occur in the more gravelly areas where a petrocalcic horizon has formed, and the Haplocalcids occur in less gravelly areas. Buried soils, beveled by dissection, are common beneath colluvium on sides of ridges, and in places are at or very near the surface (see #1, Fig. 8).

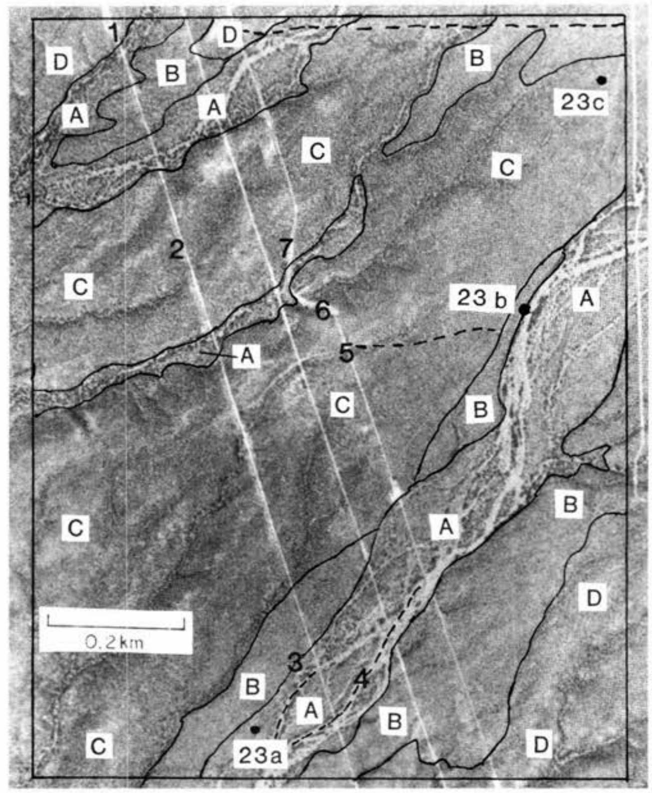

FIGURE 8—Map of soils in the vicinity of study area 23. A = Arizo–Streamwash complex (Fillmore and arroyo-channel surfaces); B = Hachita very gravelly sandy loam (dominantly Picacho surface, with minor areas of Tortugas and Jornada I); C = Delnorte–Hachita–Algerita complex (dominantly Jornada I and Tortugas surfaces, with minor areas of Picacho and Fillmore surfaces); D = Haplocalcids and Typic Petrocalcids (Jornada I and younger surfaces). Other features are 1 = exposure of buried soils in west track of road down the side of the Jornada I ridge; 2 = deep drainageway in Tortugas ridge (see text); 3 = exposures of Argic Petrocalcids of the Picacho surface, in north bank of arroyo; 4 = exposures of Bt horizons and stage I carbonate horizons in soils of Fillmore age, in arroyo banks; 5 = exposure of Jornada I K horizon, beveled by a drainageway that crosses the road; 6 = exposure of Petrocalcids in north-facing side of Jornada I ridge, on west side of road; 7 = exposure of the transition between Argic and Typic Petrocalcids on the margin of a Tortugas terrace, on west side of road. Aerial photograph taken in 1974.

A deep drainageway in a Tortugas ridge

The west road crosses a Tortugas ridge at #2 (Fig. 8). A deep drainageway in the margin of the ridge crest occurs west of the road. The floor of the drainageway appears to be quite stable, and although deep has no incised channel. Bt and Km horizons have formed in the drainageway. The Bt horizon is usually noncalcareous in the upper few cm and appears to be currently forming. The top of the Km (petrocalcic) horizon ranges from about 15 to 40 cm from the surface. Argic Petrocalcids dominate the floor and sides of the drainageway; there are minor areas of Haplocalcids and Typic Petrocalcids.

The drainageway forks in its northern part, with one fork heading east of the road and the other west of it. West of the road, the fork deeply cuts the Tortugas sediments to a depth of about 10 ft (3 m) at a point only about 60 ft (18 m) south of the south edge of the ridge crest.

Of considerable interest is the fact that in most places the floor of the deep drainageway is quite stable; in upper and middle reaches of the drainageway, a few centimeters of fine earth may have been removed but there is no rilling or obvious cut in the floor of the drainageway. Cycles of erosion and deposition associated with climatic changes to times of less effective moisture in the late Holocene (study areas 7,10, and 12, Guidebook) appear to have had little effect on the drainageway; however, downslope the drainageway is incised as it grades into a small arroyo at the foot of the slope.

The drainageway cuts the Tortugas surface and therefore must be younger than Tortugas. The Bt and Km horizons suggest that the drainageway may have formed in Picacho time.

The deep drainageways with Argic Petrocalcids differ from shallow drainageways that penetrate the thick carbonate horizon of the Tortugas or Jornada I soils. These soils are Haplocalcids or Typic Petrocalcids if the diagnostic calcic or petrocalcic horizon, respectively, has not been truncated. Effects of soil truncation by one of these shallow drainageways is shown at #5 in the soil map (Fig. 8).

Area 23a-Typic Haplargid (Soledad 66-16) in Fillmore alluvium

In this area the Fillmore surface extends headward as terraces along major arroyos. This soil has formed in alluvium associated with the Fillmore surface, which is about a meter higher than the arroyo channel to the south and is inset against the Picacho terrace to the north (Fig. 9). The site has a prominent facies change from very gravelly materials to sediments with little gravel (Fig. 9). Slope is 2 percent to the west. Vegetation consists mainly of creosotebush and ratany.

The Typic Haplargid Soledad 66-16 (App. Part 4) is at left in Figure 9 and illustrates typical late Holocene pedogenesis at a stable site in very gravelly parent materials with very little or no carbonate. The argillic horizon barely meets the requirements for the clay increase from the E to the B horizon (App. Part 4). Pebbles and sand grains in the argillic horizon have the thin coatings of oriented clay that are typical of the argillic horizon in this desert area (App. Part 4). The numerous pebbles in these very gravelly materials confine the soil solution to relatively small volumes so that clay illuviation proceeds faster than in materials with little gravel. The very gravelly surface is another factor favoring argillic horizon development in this soil; the numerous pebbles on the surface help to trap the dustfall and thus increase the amount of clay available for illuviation in the soil beneath.

The argillic horizon is underlain by a stage I carbonate horizon in which pebbles are thinly coated with carbonate. The percentage of carbonate is small (App. Part 4), as is typical for soils of late Holocene age in the Desert Project area.

The study trench illustrates the effect of a facies change from very gravelly alluvium to alluvium with little gravel and its significance to soil classification and genesis. In the alluvium with little gravel, the clay increase from E to B required for the argillic horizon is not met and the Haplargids grade to the Haplocambids (see p. 179 in Gile and Grossman, 1979, for an illustration).

The facies change in the study trench also illustrates the effect of rock fragment volume on the amount of organic carbon (Table 7). The zone with the greater volume of rock fragments also has the higher percentage of or

TABLE 7—Organic carbon for the 5 to 25 cm zone of two pedons differing in volume of rock fragments (>2mm material).

Pedon	Classification	> 2 mm Vol. %	Organic carbon Fine earth %	Organic carbon Total volume kg/m²
66–16	Typic Haplargid, loamy-skeletal	60	0.38	0.44
Nearby 66–16	Typic Haplocambid, coarse-loamy	10	0.16	0.38

ganic carbon in the fine earth. Concentration of the infiltrating water in the interstices between the numerous pebbles would tend to improve the moisture relationships and increase the abundance of plant roots; consequently the organic carbon would be raised. But because of the diluent effect of the coarse fragments, the amount of organic carbon on a volume basis is only slightly greater for the loam-skeletal pedon (Table 7). Enroute to study area 23b, the route passes by exposure of Fillmore alluvium in the north and south banks of the arroyo (at #4, Fig. 8). The soils have weak Bt horizons and stage I carbonate horizons. Commonly, the soils are overlain by a thin deposit of spoil associated with installation of the power lines.

At #5 along the east power line road (Fig. 8), a shallow drainageway crosses the road and bevels the thick stage III K horizon of Jornada I age. In parts of the road exposure there is a facies change to more gravelly materials that illustrate development of a stage IV carbonate horizon with plugged and laminar horizons (see study area 24a for a longer exposure of the stage III-IV transition).

Area 23b—Argic Petrocalcid (Hachita 59-16) in Picacho alluvium

This soil (Fig. 10; App. Part 5) has formed in alluvium of the Picacho surface, which here occurs as a narrow terrace inset against the Jornada I surface just north. The site is on the south edge of the Picacho terrace in the north bank of a large arroyo. Slope is 2 percent to the west. Vegetation consists of creosotebush, ratany, and whitethorn.

Hachita 59-16 has an argillic horizon and a petrocalcic horizon with a continuous laminar horizon. The site is considered to be significant because the carbonate morphology was studied in detail and related to its radiocarbon chronology; this pedon was the first so studied in the Desert Project (Gile et al., 1966), and the first to be reported in the world literature on genesis of carbonate horizons. In a study including the plugged horizon and the overlying laminar horizon, the oldest radiocarbon age was obtained from the plugged horizon, the next oldest from the lower part of the laminar horizon, and the youngest from the upper part of the laminar horizon. Absolute ages are questionable, but relative ages demonstrate that plugged horizon formed before the laminar horizon, and that lower laminae of the laminar horizon formed before the upper laminae. This agrees with extensive morphological observations that show the laminar horizon occurring only on plugged horizons or on bedrock, and that in its initial stage of development the laminar horizon is very thin, consisting of a single lamina. Refer to pp. 350-357 in Gile et al. (1966) for a detailed discussion of the morphology and radiocarbon chronology of this soil.

Enroute to study area 23c, a cut on the west side of the road exposes shallow Argic Petrocalcids (at #6, Fig. 8) on the north-facing side of the Jornada I ridge. The top of

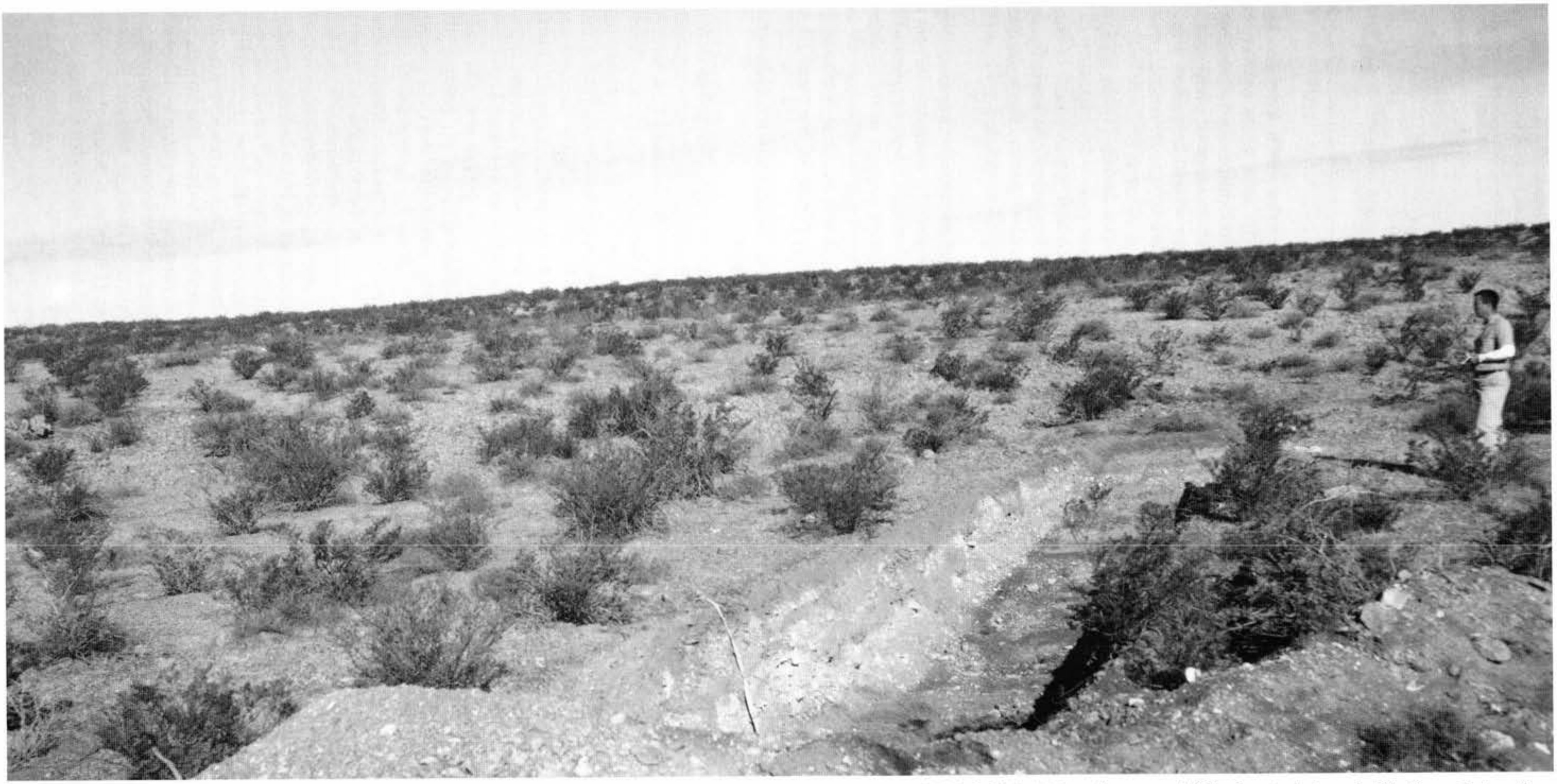

FIGURE 9—Landscape of Haplargids and Haplocambids on the Fillmore surface at area 23a. The Typic Haplargid Soledad 66–16 is at the tape at left in the study trench. The Jornada I surface is only the skyline, and a Picacho terrace is in the middle ground. Vegetation is creosotebush and ratany. Scale is in feet. The view is north. Photographed November 1966.

FIGURE 10—Picacho surface and Argic Petrocalcid at area 23b. Hachita 59–16 is at the tape. Vegetation consists of creosotebush, whitethorn, and ratany. Slope is 2 percent. Photographed May 1961.

the petrocalcic horizon is at depths ranging from about 27 to 33 cm along most of the exposure. A thin deposit of spoil is at the surface.

Further north along the road (at #7, Fig. 8) an exposure on the west side of the road illustrates the transition between Paleargids of a stable Tortugas terrace to Typic Petrocalcids on the margin of the terrace. The exposure illustrates the K horizons of Tortugas age, which are considerably thicker than most of Picacho age (see study areas 3d-e). Spoil is at the surface over much of the exposure.

Area 23c—Typic Petrocalcid (Delnorte 67-2) in Jornada I alluvium

This site (Figs. 11, 12) is on a Jornada I ridge. Slope is 2 percent to the west.

The soil at area 23c (Fig. 12; App. Part 6) is a Typic Petrocalcid with a cambic horizon and a petrocalcic horizon. Although no additional laboratory data are available for this soil, a radiocarbon date, discussed later, was obtained for inorganic carbon from the K22m horizon.

The cambic horizon is polygenetic, in the sense that it represents a former argillic horizon now engulfed by carbonate. Some pebble tops in the upper part of the Bk horizon have thin, reddish brown coatings of clay; however, the Bk horizon as a whole has so much carbonate that the amount of oriented clay required for the argillic horizon would not be present.

This soil also illustrates partial disintegration of the stage IV carbonate horizon and the upper part of the petrocalcic horizon. Two of the upper laminar horizons have been broken and the fragments mixed in varying degree with the fine earth (Fig. 12; App. Part 6) Fracture of these formerly continuous horizons is attributed to landscape dissection and associated soil truncation, as discussed for the Typic Petrocalcid at area 4. That soils in the vicinity of the study trench have been truncated to some degree is indicated by their occurrence on the ridge crest and by the presence of nearby drainageways that are tributary to the ridge crest, by the absence of the argillic horizon, and by the thicker B horizon that occurs at stable sites. See pp. 69 and 70 of the Guidebook for a discussion of the effect of truncation on soils with petrocalcic horizons.

The radiocarbon age of carbonate in the K22m horizon is 19.7 kyr. Laminar horizons form most rapidly during pluvials (Guidebook, p. 123), and fracture of the uppermost ones could have taken place during drier times of the Holocene. The zone now occupied by the K22m horizon would have been well within reach of wetting fronts during pluvials. Such wetting would cause younger C^{14} age (section 3.83, Guidebook).

Study area 24—Typic Petrocalcids, Haplocalcids and Argic Petrocalcids of the Jornada I surface

Summary of pedogenic features

Oldest soils in a chronosequence of soil development in the terraced terrain; the transition from Argic to Typic Petrocalcids as a result of dissection of Jornada I alluvium and soils; a facies change in Jornada I sediments, in which Typic Petrocalcids with stage IV carbonate horizons occur in very gravelly sediments and Haplocalcids with stage III horizons occur in sediments with little gravel; evidence for dissolution of primary grains in soils of Jornada I age; Jornada I Argic Petrocalcid at a stable site; anomalously low carbonate content for a Jornada I soil in very gravelly parent materials, when compared to nongravelly soils of the same age.

Setting

The geomorphic map for this area is in the Guidebook (fig. 88, northwest corner). With increasing elevation the surfaces are arroyo channel-Fillmore-Picacho-Tortugas-Jornada I. Small areas of the Isaacks' Ranch surface are also locally present. Stable surfaces of Jornada I, Tortugas, and Picacho age dominate the eastern part of the area shown in the soil map (map unit B, Fig. 13). In the western part of the area (map unit C, Fig. 13) erosional surfaces of Fort Selden age (Fillmore and Leasburg undifferentiated) and arroyo-channel surfaces are common in ridge-side and channel-floor positions, cut into Picacho and older alluviums. Soil parent materials are rhyolitic alluvium derived from the Organ Mountains. Exposures of Jornada I alluvium are shown at study areas 24a and 24b, and there are numerous exposures of Jornada I and younger alluviums along the new north-south road on which area 24a is located.

Soil occurrence

The soil pattern is determined primarily by soil age, particle size and degree of soil truncation. Map unit A contains the Fillmore and arroyo-channel surfaces. In unit A, Torriorthents (primarily Arizo soils) and a few Haplocambids (Tugas soils) and weak Haplargids (Soledad soils) occur on the Fillmore surface. The Haplocambids and weak Haplargids occur only on the highest, stablest parts of the Fillmore, with Haplargids occurring only in some of the very gravelly sediments. Streamwash occurs in arroyo channels.

In map unit B, stable areas of the Picacho, Tortugas, and Jornada **I** surfaces are dominated by the Argic Petrocalcids, Hachita soils. Typic Calciargids, Pinaleno soils, occur in a few areas where the calcic horizon is not continuously cemented. Narrow areas of arroyo channels and the adjacent fillmore surface are dominated by Streamwash and Torriorthents respectively.

Map unit C is a soil complex dominated by the Typic Petrocalcids, Delnorte soils, and the Argic Petrocalcids, Hachita soils. Also in map unit C are small areas of the Pinaleno and Casito soils, which occur as isolated areas where the argillic horizon is still preserved. In Casito soils, all subhorizons of the argillic horizon contain some macroscopic carbonate. Typic Haplocalcids (Algerita soils) occur in facies changes to materials that have little or no gravel, so that a calcic horizon has formed instead of a petrocalcic horizon. Narrow areas of arroyo channels and the adjacent Fillmore surface are dominated by Stream-wash and Torriorthents respectively.

Area 24a-Typic Haplocalcid and Typic Petrocalcid in Jornada I alluvium

This is a Jornada I ridge side and roadcut exposure of Jornada I alluvium on the west side of the road. Slope is 5% to the south. Vegetation is mostly creosotebush, with a few ratany. The exposure illustrates the profound effect that content of rock fragments can have on carbonate morphology, cementation, and soil classification. The exposure shows the Typic Haplocalcid, Algerita, grading into the Typic Petrocalcid, Delnorte.

The roadcut exposes a facies change in the upper part

FIGURE 11—Landscape of the Typic Petrocalcid Delnorte 67–2 on the Jornada I surface at study area 23c. Vegetation consists of creosotebush, ratany, and a few pricklypear. Photographed June 1967.

FIGURE 12—Upper horizons of the Typic Petrocalcid, Delnorte 67–2, in Jornada I alluvium at study area 23c. Platy, light-colored fragments above the continuous surface of the Km horizon (at 1 ft depth) once were part of continuously cemented laminar horizons. The fragments occur just above the Km horizon (particularly at the right) and extend upward about half way to the soil surface. Scale is in feet. Photographed June 1967.

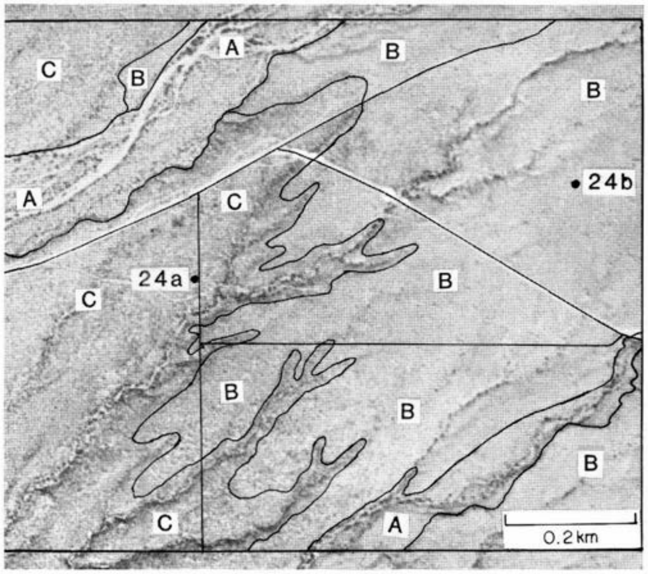

FIGURE 13—Map of soils in the vicinity of study area 24. A = Arizo–Streamwash complex (Fillmore and arroyo-channel surfaces); B = Hachita very gravelly sandy loam (Jornada I, Tortugas, and Picacho surfaces); C = Delnorte–Hachita complex (Jornada I, Tortugas, and Picacho surfaces). Aerial photograph taken in 1936.

of the K horizon. The change is from very gravelly sediments to sediments with relatively little gravel, and is accompanied by changes in stage of carbonate accumulation, from IV to III; in diagnostic horizons, from petrocalcic to calcic; and in soil classification, from Petrocalcid to Haplocalcid. The stage III carbonate horizon is typical in carbonate horizons of Jornada I age that have formed in sediments with little gravel. Development of the stage IV carbonate horizon in materials with little gravel is shown by the older soils of lower La Mesa, of middle Pleistocene age (see study areas 5 and 26).

The K horizon contains fewer rock fragments than horizons above, and the zone from 55-65 cm depth was sampled for thin section study. The samples were taken to compare with the next older soils of lower La Mesa, in which the petrocalcic horizon shows evidence of dissolution of primary grains, and which also contains few rock fragments. The thin section of the upper part of the K horizon of the Jornada **I** soil also shows evidence of dissolution (Plate 20); some grains appear to have been completely dissolved.

Area 24b-Argic Petrocalcid (Hachita 70-8) in Camp Rice alluvium

In this area the Jornada I surface widens to a broad stable landscape that has been little affected by dissection. A somewhat greater variety of vegetation occurs in this area, which is part of a broad transition zone from drier areas westward and moister areas mountainward. Vegetation consists of ratany, fluffgrass, scattered clumps of three-awn, and a few zinnia, Mormon tea, snakeweed and creosotebush. Slope is 3% to the west.

The Argic Petrocalcid, Hachita 70-8 (Fig. 14; App. Part 7) has prominent argillic and petrocalcic horizons. Soil and geomorphic tracing from the Jornada I Typic Petrocalcid at study areas 4 and 23 demonstrates that prominent Argic Petrocalcids do occur on stable areas of the Jornada I surface, and illustrates the significance of long-continued dis section on the formation and classification of Haplocalcids and Petrocalcids in these terrains.

These soils contain abundant gravel throughout, and this can affect the amount of carbonate retained within the soil. In pluvials and before the soil becomes plugged with carbonate, a substantial amount of carbonate presumably would move lower than the sampled horizons in very gravelly soils of Pleistocene age. That such deeper movement does in fact occur is indicated by low carbonate values and deeper horizons of carbonate accumulation in soils of the mountain canyons where precipitation is higher (see study area 21, Guidebook). Carbonate lost to deeper horizons is critical in age determinations using amounts of pedogenic carbonate (see Guidebook, pp. 70, 71). Thus the very gravelly pedons of Jornada I age were excluded from age calculations using pedogenic carbonate because of carbonate values that are anomalously low when compared to low-gravel soils of the same age.

Study area 25—Argic Ustic Petrocalcids of the Doña Ana surface

May 21, 1958, was a memorable day in the Desert Project soil survey, for on that day the distinctive soil of the Doña Ana surface in Ice Canyon (Fig. 15) was first encountered. This soil has much more clay and carbonate than any other soil with the same parent materials (rhyolite alluvium) and landscape position (level-transversely part of an alluvial fan along the front of the Organ Mountains).

Summary of pedogenic features

Remnants of thick, relict E horizons; some Bt horizons have more than 70 percent clay, and gypsum in their lower parts; formation of plugged and laminar horizons, and completion of the carbonate sequence in gravelly materials in the mountain canyons, which illustrates long-term effect of calcareous dustfall in soils of the mountains; evidence for more weathering in the soil than in the arid parts of the Desert Project.

Setting

The general pattern of geomorphic surfaces in this area is shown by a map in the back pocket of the Guidebook. The high ridge (in which the pit at study area 25 occurs, Fig. 15) is a remnant of the oldest (Doña Ana) alluvial-fan surface in the Desert Project area. The remnant has been preserved by bedrock defenders to the north and south. The area just east of the Doña Ana remnant, now dominated by Organ sediments, represents an area beheaded by post-Doña Ana streams that formed the large fan to the northwest. Ridge sides of Jornada age occur below the Doña Ana ridge crest. Small areas of Jornada and post-Jornada sediments also occur in the southwest part of the area. A dissected bedrock terrain, mountain slopes and summits undifferentiated, occurs in the northwest part of the area.

Soil occurrence

The soil pattern is determined primarily by differences in soil age, slope position and aspect. Map unit A is dominated by the Pachic Haplustolls Santo Tomas soils. The Santo Tomas soils have formed in very and extremely gravelly sediments on the Organ surface, have very thick mollic epipedons, and are noncalcareous throughout. Some soils have an irregular decrease in organic carbon; these are the Cumulic Haplustolls Santo Tomas, cumulic

FIGURE 14—Jornada I surface and Argic Petrocalcid at area 24. Landscape of the Argic Petrocalcid Hachita 70–8. Vegetation consists of fluffgrass, ratany, three-awn, Mormon tea, snakeweed, zinnia, and creosotebush. Slope is 3 percent. Photographed May 1970.

analog, and the Ustic Torrifluvents Minneosa, sandy-skeletal analog. Streamwash occurs in arroyos.

Map unit B includes the soils that are dominantly on the Jornada ridge sides of the Dona Ana ridge crest of map unit C. To the south these soils also occur on the narrow Doñ[a] Ana ridge crest as well as on the Jornada ridge sides. These soils also occur on two smaller delineations to the south and west of the terrace remnant. Many of the soils have extremely fragmental surfaces that help to protect the soil from wind and water erosion. The Ustic Haplargids Eloma, clayey substratum analog, are dominant. These soils have prominent argillic horizons and appear quite stable despite being on slopes as high as 65 percent. In the extreme southwest corner of figure 34, a pedon of Eloma, clayey substratum analog on a north-facing slope of 46% has a light-colored BEt horizon about 40 cm thick. This thick BEt horizon contrasts with the much thinner and discontinuous E horizon of Hayner, on a narrow ridge crest as discussed in the next section. The Petrocalcic Paleustolls Hayner, mollic analog; the Aridic Argiustolls Earp, fine analog, Earp, clayey-skeletal analog; Earp, clayey-skeletal, calcic analog; and the Ustic Haplargid, Eloma, fine analog, occur mostly on northern exposures. Pachic Argiustolls (Limpia soils) occur in places on lower sides of the remnant. Argic Ustic Petrocalcids (Hayner soils) occur in scattered places near the ridge crest. Small areas of rock outcrop also occur.

Soils of map unit C occur on the top of a terrace remnant of the Dona Ana surface. The Argic Ustic Petrocalcids, Hayner soils, dominate map unit C. Also present are smaller areas of the Argic Ustic Petrocalcids Hayner, fine analog; Terino, clayey-skeletal analog; and Terino, clayey analog. The latter two soils occur mostly on shoulders of the ridge remnant.

Map unit D is dominated by the Ustic Haplargids, Caralampi soils, on the Jornada surface. Smaller areas of the Ustic Haplocambids, Gallegos soils, occur on the more erosional areas near drainageways where the argillic horizon was either truncated or never had the opportunity to develop. Streamwash also occurs in drainageways.

The dominant component of map unit E is Rock outcrop, which occurs as a barren or nearly barren (less than 10 cm of soil material) areas of rhyolite. Lithic Ustic Torriorthents (Coyanosa soils) are dominant soils, occurring on ridge crests and benches. Very small areas of Lithic Ustic Haplargids (Lemitar, noncalcareous analog) occur on small benches. Streamwash occurs in drainageways at the bottom of small canyons. All soils in this unit are noncalcareous throughout.

Argic Ustic Petrocalcid (Hayner 60-5) in Camp Rice alluvium

This Doña Ana ridge crest is the topographic high in this general area. Slope is 9 percent to the west. Vegetation consists of black grama, sideoats grama, mesquite, snakeweed and cholla.

Hayner 60-5 has a relatively deep (20 to 23 cm) E horizon (App. Part 8) which has not been found elsewhere on the ridge crest. The E horizon is thought to be a remnant that elsewhere has been obliterated by prominent accumulations of silicate clay (see discussion of map unit B, previous section, for a thicker and deeper E horizon). This soil also has prominent argillic and petrocalcic horizons (App. Part 8; see Gile and Grossman, 1979, pp. 632 and 633, for photographs of this distinctive soil and its landscape).

Part of the Bt horizon has 74% clay, much more than is found in younger soils in this area. Gypsum occurs in the lower part of the Bt horizon, and more soluble salts occur in the petrocalcic horizon. Presence of gypsum and soluble salts is attributed to a very long period of dust-fall additions to the soil, and to the petrocalcic horizon, which would trap these components in the dust-fall and prevent their movement to deeper horizons. In the mountain canyons, petrocalcic horizons occur only in soils of the Dona Ana surface; soils of the next younger Jornada I surface have only stage I carbonate horizons (Guidebook, p. 206).

This soil was studied in detail by McKim, 1969 (App. Part 8). McKim found very fine sand in the Bt horizon to be higher in quartz than in the underlying carbonate horizon. He also found that the percentage of biotite in the

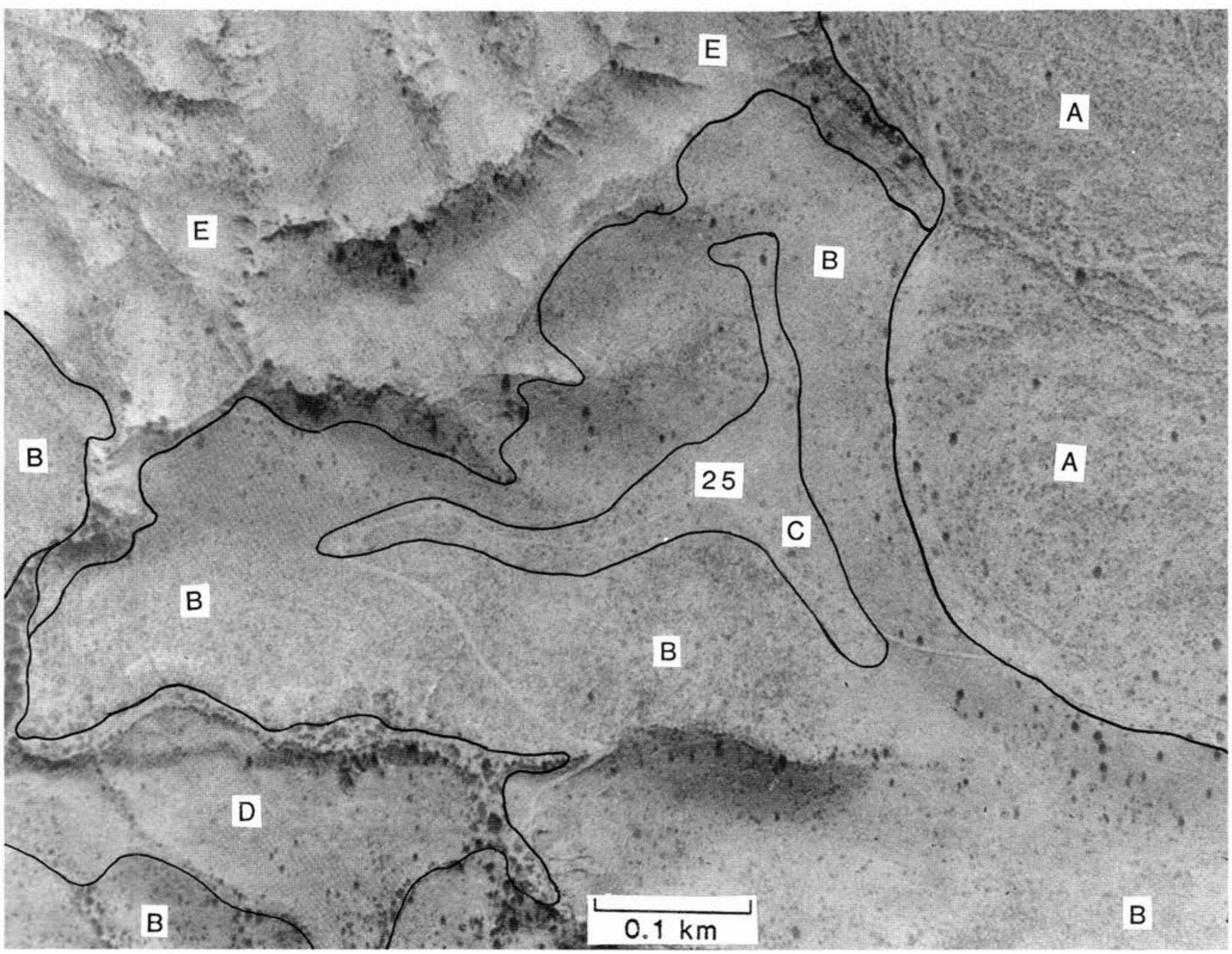

FIGURE 15—Map of soils in the vicinity of study area 25. A = Santo Tomas complex (Organ and arroyo-channel surfaces); B = Eloma analog (Jornada surface); C = Hayner Soils (Doña Ana surface); D = Caralampi very gravelly sandy loam (Jornada surface); E = Rock outcrop, Lithic Torriorthents and Lithic Haplargids (mountain slopes and summits undifferentiated). Aerial photograph taken in 1974.

coarse silt fraction increased considerably with depth. He attributed both of these to weathering in the Bt horizon, and thought that lack of weathering in the carbonate horizon was due to carbonate accumulation.

Thin sections (Plate 21) show argillans on grains, but none on the ped faces. The prominent striae of oriented clay may represent former argillans now within peds.

Study area 26—Typic Petroargids of lower La Mesa surface: The Curtis Monger study site

Soils at this site were studied and discussed by Monger (1990).

Summary of pedogenic features

See Guidebook, p. 112, for general pedogenic features of lower La Mesa soils. In addition to those features, at study area 26, there is evidence for the corrosion of primary grains, for the formation of palygorskite in the petrocalcic horizon, and for the precipitation of calcite by microorganisms. Study area 26 also illustrates how dissection and associated soil truncation along the lower La Mesa scarp has changed soils from Petroargids to Argic Petrocalcids, and finally to Typic Petrocalcids and Haplocalcids.

Setting

See Guidebook, p. 112, for the general setting of lower La Mesa and for a discussion at study area 5, also on lower La Mesa and southwest of new study area 26 (frontispiece). Study area 26 illustrates soils of lower La Mesa along a prominent scarp at the top of the steep valley-border slopes leading to the Rio Grande flood plain below.

Additional information is now available on the chronology of lower La Mesa as the result of work on the magnetostratigraphy by Vanderhill (1986) and Mack et al. (1993). Vanderhill (1986) studied three lower La Mesa soils in an area about 25 to 35 mi (40 to 56 km) south of the Desert Project. He found that the sediments in which one of the soils had formed to have normal polarity and to be of Brunhes age, and by stratigraphic tracing concluded that the other two soils had also formed in Brunhes sediments. Thus, valley incision must have started after 0.78 Ma in that area.

North of the Dona Ana Mountains, lower La Mesa appears to be older because Mack et al. (1993) found lower La Mesa soils to have formed in sediments deposited between the Matuyama-Brunhes boundary and the Jaramillo subchron, or between 0.78 and 0.9 Ma. In addition Mack et al. (1993) found the Lava Creek B volcanic ash at Selden Canyon (0.62 Ma, Hawley et al., 1969; Seager and Clemmons, 1975; Izett and Wilcox, 1982) to be of Brunhes age, and interpreted the section to be inset against lower La Mesa in that area. On the other hand, elevation of the Lava Creek B ash at Selden Canyon is 4270 ft (1302 m, Hawley et al., 1969), and lower La Mesa at study area 26 is 4200 ft (1280 m). Thus, river sediments beneath the ash at Selden Canyon could have been graded to a level approximating that of lower La Mesa at study area 26, where valley entrenchment could have begun after 0.62 Ma. Machette (1985) postulates that valley entrenchment at lower La Mesa began about 0.5 Ma. Pending further information, the soils of lower La Mesa in the Desert Project area are estimated to range from 0.5 to 0.9 Ma (Table 3).

Soil occurrence

The soil pattern (Fig. 16) is determined primarily by soil age, landscape position, eolian deposition, and soil truncation as controlled by the lower La Mesa scarp. Map unit A is dominated by Typic Petroargids (Rotura soils) that occur in complex pattern with Typic Torripsamments (Bluepoint soils and Bluepoint, thin analog, in which buried soils occur at depths ranging from 50 to 100 cm) of coppice dunes. There are also very small areas of Typic Haplargids (Sonoita soils) in pipes, and unnamed Typic Haplocalcids in which the Bt material of Rotura has been obliterated, possibly by rodents. These Haplocalcids have been observed in only one area, a portion of the west end of the study trench at study area 26.

Soils of map unit B occur in a depression in lower La Mesa surface. The unit consists primarily of Sonoita soils, with smaller areas of Rotura soils, Bluepoint soils, and Blue-point, thin analog, in dunes. Rotura soils occur in places at outer parts of the depression; the petrocalcic horizon deepens and then disappears towards lower parts of the depression, where Sonoita soils have a filamentary stage I carbonate horizon. The range of depth to the petrocalcic horizon in Rotura soils is 40 to 60 in (100 to 150 cm). Soils with petrocalcic horizons deeper than 60 in (150 cm) are included in Sonoita as it is used in this map unit. In some pedons carbonate and clay decrease, then increase with depth, and auger samples indicate a buried soil that is younger than Rotura. These soils warrant further study, because the evidence suggests at least one cycle of pre-coppice dune, post-lower La Mesa sedimentation in the depression.

Soils of map unit C occupy a transitional zone between the stable soils of lower La Mesa and the eastern edge of the K horizon remnants of the lower La Mesa soils. With increasing soil truncation and decreasing elevation along the scarp, characteristic soils are Argic Petrocalcids (first the Hueco soils, and then with increasing truncation the shallow Cruces soils); Typic Petrocalcids (Tencee and Simona soils and their eroded analog, in which the petrocalcic horizon is at the surface); and Typic Haplocalcids soils, eroded, in which the remains of the lower La Mesa K horizon is a calcic instead of a petrocalcic horizon).

Map unit D is dominated by Typic Torripsamments, Bluepoint soils. Weak B horizons and stage I carbonate horizons are common. These Bluepoint soils have formed in eolian sands that occur in discontinuous deposits in the lee of the scarp and northeast of structural benches. This landscape position shows that the dominant wind direction was from the southwest. The sand may represent periods of aridity during the Holocene. Bluepoint soils also occur in the younger, stratified sands of coppice dunes, and consist largely or wholly of stratified C horizon material. Also included are small areas of Typic Torriorthents, tentatively called Yturbide soils (see Guidebook, page 62 for discussion of these soils), in which content of rock fragments in the control section averages between 15 and 35 percent.

Map unit E occurs on the strongly sloping Fort Selden surface, which connects the lower La Mesa surface to the Rio Grande flood plain. The Fort Selden surface has beveled gravel, sand, and buried soils of the Camp Rice fluvial facies. Map unit E is dominated by the Typic Torriorthents Kokan (sandy-skeletal) and Yturbide (sandy). Minor inclusions of Torripsamments and exhumed, once-buried Haplargids are also present. Streamwash occurs in arroyo channels. Map unit F consists of Streamwash in arroyo channels.

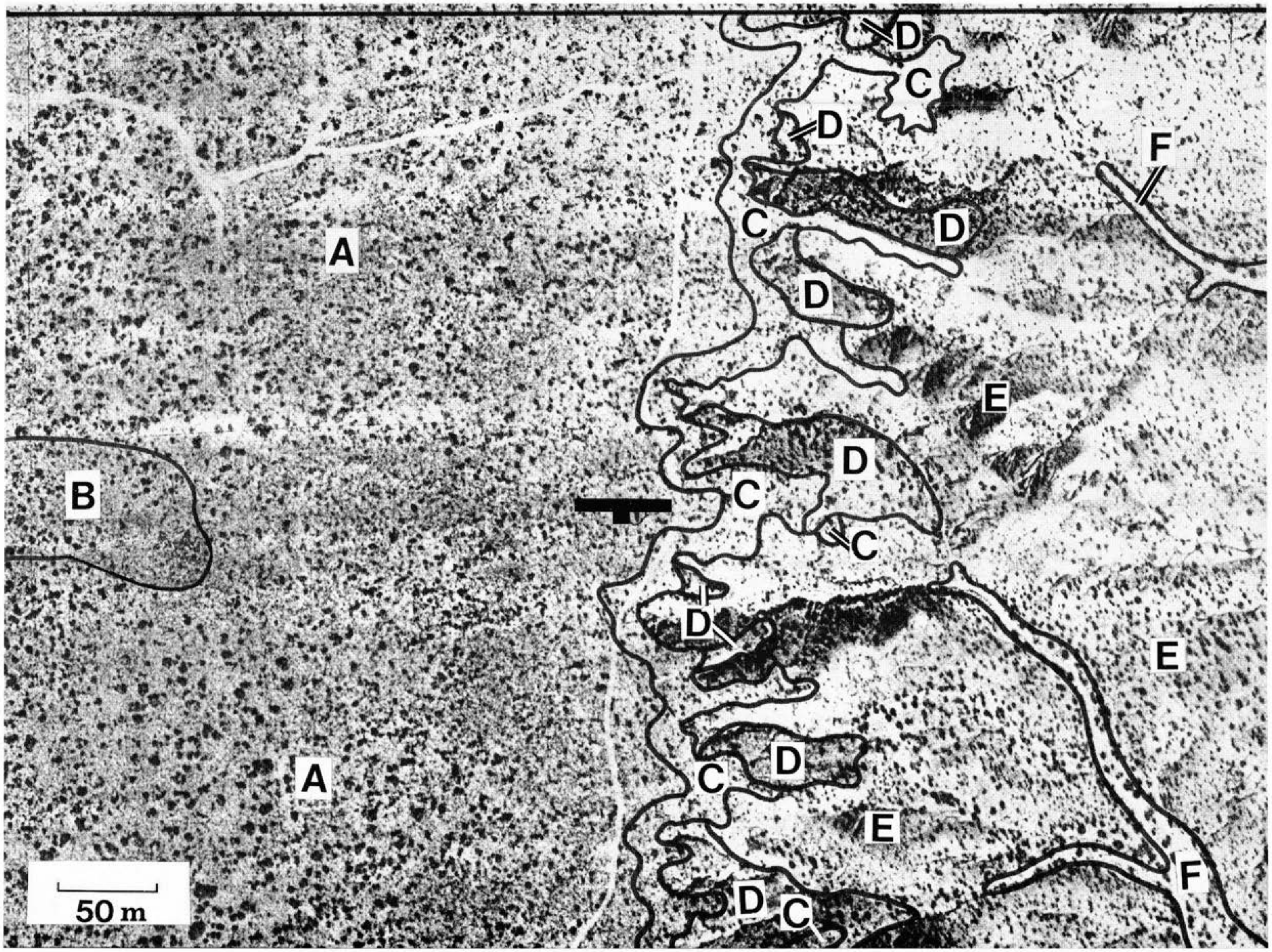

FIGURE 16—Map of soils in the vicinity of study area 26. A = Rotura-Bluepoint complex (lower La Mesa surface and dunes); B = Sonoita, overwash phase (depression on lower La Mesa); C = Hueco–Tencee–Jal complex (lower La Mesa surface along scarp); D = Typic Torripsamments (Fort Selden surface); E = Kokan–Yturbide complex (Fort Selden and arroyo-channel surfaces); F = Streamwash (arroyo-channel surface). Modified from Monger (1990, fig. 4).

Typic Petroargid (Rotura) in the upper Camp Rice **Formation (fluvial facies)**

The studied pedon (Table 8) is near the eastern margin of lower La Mesa. The pedon has an argillic horizon and a petrocalcic horizon that is deep enough to be diagnostic for the Petroargids (between 100 and 150 cm; Table 8, Fig. 17). The area is level. Vegetation consists of scattered snakeweed, mesquite, creosotebush, and fourwing salt-bush.

Some of the soil mineral transformations that have occurred in the Rotura pedon are as follows (Monger, 1990). First, sand and silt grains (i. e., silicate grains because they are mainly quartz and feldspars) in the petrocalcic horizon are more corroded than silicate grains in other soil horizons. The silicate grain corrosion appears to be the result of pressure exerted on the grains by crystallizing calcite. As calcite crystals grow, contact, and push against sand and silt grains, the Gibbs free energy of the grains increases, and thus, silica solubility increases, resulting in dissolution of the grains (Plate 22).

Second, palygorskite, a Mg-rich fibrous clay mineral, is the dominant clay mineral in the petrocalcic horizon. Petrographic and soil chemical evidence indicates that palygorskite was neoformed in the petrocalcic horizon. Possibly the Si and Al released by the dissolving sand and silt grains has contributed to the formation of palygorskite by combining with Mg supplied by atmospheric additions. The degradation of smectite and other clay minerals in the petrocalcic horizon may also be a source of palygorskite neoformation. Some of the Si may also have moved to lower horizons because opal has been found there (Plate 23).

Third, the formation of calcic and petrocalcic horizons is not a purely inorganic process. Soil microorganisms are involved in the precipitation of the fine-grained calcite crystals within these horizons. Three lines of evidence indicate that soil microorganisms are involved in calcite precipitation: (1) electron microscopy reveals fossilized communities of calcified fungi in the petrocalcic horizon; (2) soil microorganisms precipitate calcite when cultured on Ca-rich media; and (3) in a soil column experiment, sterile soil columns irrigated with Ca-rich solutions did not form calcite, but in similar soil columns inoculated with soil microorganisms, calcite did form. Soil microorganisms appear to be involved in calcite precipitation by excreting Ca onto their external surfaces as a detoxification mechanism, and by producing bicarbonate as the result of their metabolic activity.

Study area 27—Haplocalcids of the Organ surface; exhumed Calciargids and Haplocalcids

Summary of pedogenic features

These soils have formed in high-carbonate parent materials; fine-silty soils of late to middle Holocene age lack argillic horizons but have structural B horizons and, in places, stage I calcic horizons; extensive scarplet erosion of the Holocene soils has exhumed once-buried soils of late Pleistocene age that commonly have an argillic horizon and a thick calcic horizon; below scarplets the argillic horizon has been eroded and/or carbonate engulfed in many places and in others an argillic horizon may never have formed, so that many of these soils are Haplocalcids; presence of occasional limestone pebbles and sand grains in the argillic horizon show that not all carbonates must be leached out to form the argillic horizon.

Setting

The general pattern of geomorphic surfaces in area 27 (see frontispiece) is shown by a map in the back pocket of the Guidebook. The landscape is marked by scarplets ranging from a few centimeters to more than a meter in height. Fine-grained Organ alluvium is exposed in the scarplets. Thickness of the Organ deposits ranges from a few centimeters to more than 11/2 m. Coarser-textured Jornada II alluvium occurs beneath the Organ alluvium and is commonly at or very near the surface downslope of the scarps. Soil parent materials consist of alluvium derived from limestone, calcareous sandstone, shale, and mixed igneous rocks of the San Andres Mountains.

Soil occurrence

The soil pattern (Fig. 18) is determined by differences in soil age, texture, erosion, and density of grass vegetation. Soils of map unit A occur along scarplets that cut the fine-silty Organ alluvium and its soils. Erosion is active along the scarplet and vertical or near-vertical headcuts are slowly eroding upslope. The fine-silty Organ alluvium and its soils are gradually being eroded, exhuming the underlying Jornada II soil. Upper horizons of the Jornada II soil (which is more resistant to erosion because it has more fine gravel, more sand, and more strongly developed soil horizons than Organ alluvium) have also been eroded in places by small streams, and a lag gravel occurs in places on the surface. In other places the lag gravel is derived in part from basal Organ alluvium. Because of the highly variable amount of material that has been eroded along the scarplet, the area is a complicated pattern of exhumed soils of Jornada II age (mostly the Haplocalcids, Jal soils, and the Calciargids, Doña Ana soils) and eroded remnants of Organ alluvium and its soils.

Map units B, C, and D all occur above scarplets that are about a meter or more in height, and illustrate initial development of the calcic horizon in high-carbonate, fine-silty parent materials. The calcic horizon has stage I carbonate filaments, as illustrated by the Reagan soils and pedon 60-14, discussed later. Units B, C, and D differ in degree of erosion. Soils of unit B have a good cover of grass in most places. Ustic Haplocalcids, Reagan soils, and Ustic Torrifluvents, Glendale analog, are dominant, with minor areas of the Typic Haplocalcids, Reakor soils, and the Typic Torrifluvents, Glendale soils, occurring in areas with little or no grass vegetation. Soils of unit C are moderately eroded and lack the common grassy cover of unit B. Reakor and Glendale soils are dominant and there are small areas of Jal and Doña Ana soils in drainageways. Soils of unit D are severely eroded and also have thin deposits of eolian sand in places; Reakor and Glendale soils are dominant, with minor areas of Doña Ana and Jal soils in drainageways.

Soils of map units E and F are similar in having deposits of the distinctive fine-silty Organ alluvium that are mostly 50 to 100 cm thick over buried Haplocalcids or Calciargids, with smaller areas being thicker or thinner than this range. There is the same discontinuous development of the calcic horizon and the Haplocalcids as in the areas of thicker Organ alluvium (Units B, C, and D). These soils with 50 to 100 cm of Organ alluvium over buried soils are designated "buried soil analog" to indicate the presence of buried soils at relatively shallow depths.

Soils of map unit E are severely eroded, lack the grass concentrations that are common in unit F, and consist of Typic subgroups. Buried soil analogs of Reakor and the

TABLE 8—Particle–size distribution (carbonate free basis), pH, $CaCO_3$ equivalents, and zones of carbonate morphology for the Typic Petroargid on the lower La Mesa geomorphic surface (Monger, 1990, table A1, p. 119).

Horizon[1]		Depth (cm)	PSD Sand %	PSD Silt %	PSD Clay %	pH 1:1	$CaCO_3$ %	Zones of Carbonate morphology: Zone no.	Carbonate morphology
A[2]	A	0–5	86.5	8.0	5.5	8.2	1.1		
Bk1	Bk1	5–16	89.0	4.9	6.1	8.1	1.9	1	Stage I filaments
Bk2	Bk2	16–28	87.1	5.7	7.2	8.0	3.7		
Bk3	Bk3	28–37	84.1	5.4	10.5	8.3	6.1		
Bk4	Bk4	37–50	80.2	6.6	13.2	8.0	8.8		
								2	Stage II nodules and pore hypo-coatings
Btk1	Btk1	50–61	81.6	3.9	14.5	7.8	8.4		
Btk2	Btk2	61–78	81.7	3.8	14.5	8.2	10.3		
K11t[3]	Btk3	78–100	83.4	4.6	12.0	8.6	9.5		
K12t	Btk4	100–113	84.4	6.1	9.5	8.4	10.0	3	Stage II and III nodules and internodular fillings
K13t	Btk5	113–120	85.0	9.3	5.7	8.3	24.0		
K21m	Bkm1	120–136	77.7	14.7	7.6	8.4	45.6 →	4	Stage IV laminar zone
K22m	Bkm2	136–153	75.4	14.2	10.4	8.5	41.1		
K23m	Bkm3	153–175	77.0	13.0	10.0	8.2	35.9	5	Stage IV plugged horizon
K31t[4]	B′tk1	175–203	84.3	8.8	6.9	8.6	24.3		
K32t	B′tk2	203–225	83.2	9.7	7.1	8.7	29.5		
K33t	B′tk3	225–255	86.6	9.7	3.7	8.6	22.5	6	Stage III massive and nodular
K34t	B′tk4	255–272	89.2	8.0	2.8	8.8	12.7		
K35t	B′tk5	272–294	92.4	6.3	1.3	8.8	9.8		
K36	B′k1	294–313	92.9	6.1	1.0	8.9	8.8		
K37	B′k2	313–330	94.2	4.9	0.9	9.0	9.2	7	Stage II massive and nodular
Ck[5]	Ck	330–348	96.8	2.7	0.5	9.4	3.1		
C1	C1	348–362	99.1	0.8	0.1	9.5	0.2		
C2	C2	362–382	99.0	0.9	0.1	9.6	0.4		
C′k	C′k	382–389	98.2	1.4	0.4	9.6	1.3	8	Stage I pebble coatings
C	C	389–430	99.2	0.7	0.1	9.6	0.0		
C″k	C″k	430–	98.6	1.2	0.2	9.6	1.0		

[1]Two sets of horizons are indicated for purposes of comparison. The first set contains the K horizon nomenclature of Gile et al. (1966), except that the letter t has been added to designate the presence of argillans. K2 and K2m horizons contain at least 90% K-fabric; the transitional K1 and K3 horizons contain at least 50% K-fabric. The second set of horizons is according to Guthrie and Witty (1982).
[2]The A horizon was sampled 3 m north of the profile because it was disturbed by excavation.
[3]Argillans in the K1t horizon occur as reddish-brown volumes, with little or no macroscopic carbonate, that are preserved between the volumes of K-fabric, in which carbonate occurs as an essentially continuous medium. The argillans consist of coatings of oriented clay on sand grains, which are typical of Bt horizons in the Desert Project area (Gile and Grossman, 1968).
[4]Argillans are sparse in the K3 horizons as a whole. Laterally, the K3t grades into K3 material without argillans and with 100% K–fabric.
[5]Some subhorizons of the C horizon have pedogenic calcite in the form of pebble coatings and vertical tubes. The C horizon is dominated by geologic structure consisting of sedimentary strata deposited by the ancestral Rio Grande.

Typic Torriorthent, Tome, are dominant, with minor areas of thicker (than 100 cm) Organ alluvium, and the Dona Ana and Jal soils in drainageways and other places where these soils are covered by less than 50 cm of Organ alluvium, or are at the surface.

Soils of map unit F have a distinctive pattern of alternating barren and grassy strips (Fig. 18). This prominent difference in vegetation is associated with major differences in infiltration and soil moisture, as discussed by Gile and Grossman (1979). Ustic subgroups, which are dominant, occur in grassy strips, and Typic subgroups occur in the barren strips. Thus, buried soil analogs of either the Reagan soils or the Ustic Torriorthents, Lacita soils, or both, dominate the grassy strips. Buried soil analogs of either the Reakor soils or the Tome soils, or both, dominate the barren strips. Minor areas of Reakor, Glendale, Reagan, Dona Ana, Headquarters, and the carbonatic Haplocalcids, Jal soils, also occur.

Soils of map unit G have been truncated to the point that much or all of the fine-silty material that once may have overlain the Jomada II soil has been eroded. This unit commonly occurs below the base of the scarplets of map unit A; drainageways that head in the scarp are common. The Typic Haplocalcids, Jal soils, and the Typic Calciargids, Doña Ana soils, are dominant. Small areas with a surficial lag gravel are common throughout this unit.

Ustic Haplocalcid (Reagan 60-14) in Organ alluvium

Reagan 60-14 (App. Part 9) was sampled at the prominent, digitating scarp that is oriented roughly north-south (Fig. 18; see Gile and Grossman, 1979, p. 519, for a photograph of the scarplet and soil). Slope is 1% to the west. Vegetation is dominantly burrograss, with some tobosa, scattered tarbush, creosotebush, holly, and a very few snakeweed.

Reagan 60-14 has a structural B horizon, a filamentary stage I carbonate horizon that qualifies as a calcic horizon, and a buried argillic horizon. Clay increases from A to B in the land-surface soil but the oriented clay required for the argillic horizon is not present (Plate 24). The buried Bt horizon of late Pleistocene age, however, does have enough oriented clay for the argillic horizon (Plate 25). The thin section is from the silicate clay maximum, a sandy clay loam that underlies the IIBb horizon (App. Part 9) and was not sampled.

As discussed at study area 16, carbonate in the parent materials tends to flocculate silicate clay and to prevent formation of oriented clay required for the argillic horizon. Evidence at area 27 shows that not all carbonate must

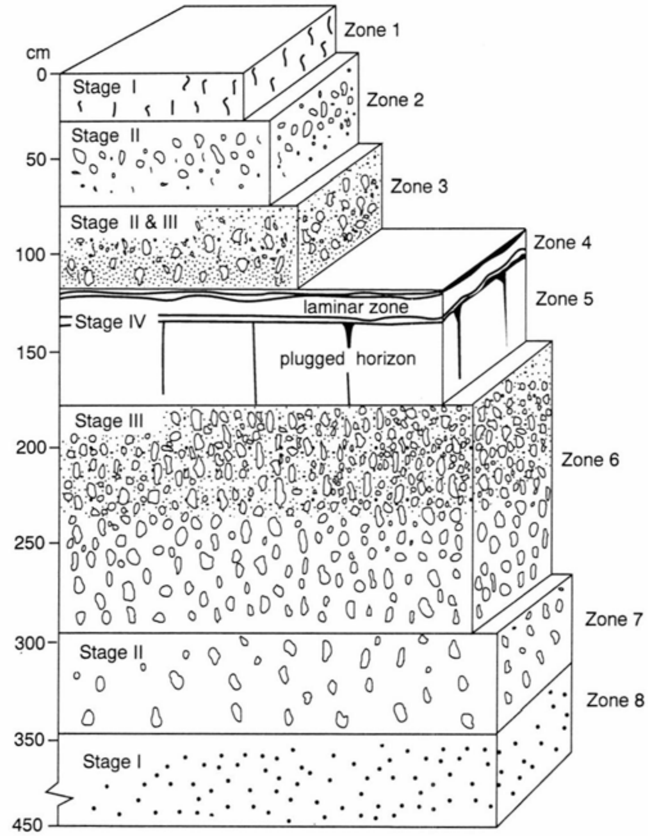

FIGURE 17—Block diagram of the Rotura pedon on lower La Mesa, showing the stages of carbonate accumulation (Gile et al., 1966) and the eight zones studied in thin section. From Monger (1990, fig. A2).

be removed for an argillic horizon to form, because some limestone pebbles and sand grains are still in it. Such pebbles are characteristic of argillic horizons in these materials as shown by an extensive lag gravel that accumulated below the scarplets as the buried soil was gradually exhumed by erosion of the overlying silty sediments. In addition, thin sections (Plate 25) show occasional smaller limestone grains still present in the argillic horizon. No argillans have formed on the limestone grains, and grains near it have no or very weak argillans, suggesting that limestone grains have a depressing effect on the development of argillans.

In other places the B horizon of the Jornada II soil has so much carbonate that the required 1% of oriented clay cannot be seen in thin section. The gradual obliteration of oriented clay and the resultant change from a Calciargid to a Haplocalcid are associated with increasing carbonate accumulation and changes in color, as follows. Noncalcareous Bt horizons in these materials are commonly colored 5YR 5/4 or 5YR 5/6, dry; oriented clay is abundant as grain argillans. As carbonate accumulates in the horizon it gradually becomes yellower, lighter-colored, and lower in chroma. In the first part of carbonate accumulation, some oriented clay is still preserved (Plate 25) although some of it has clearly been obliterated by carbonate. This Bt horizon has a dry color of 6YR 5.5/4. With continued carbonate accumulation, the gradual change in color and obliteration of oriented clay also continues. This is illustrated by thin sections from the B horizons of two Jal pedons just south of the road at #1 (Fig. 18). Enough carbonate has accumulated that virtually all of the oriented clay has been obliterated and the horizon no longer qualified as an argillic horizon. These horizons have a dry color of 7.5YR 6.5/3, and the soils are Haplocalcids.

Camp Rice Formation (Upper Santa Fe Group)

The Camp Rice Formation is composed of piedmont and axial-fluvial sediment and sedimentary rocks ranging from Pliocene to middle Pleistocene in age, during the most recent phase of extension of the southern Rio Grande rift (Seager, 1975; Hawley, 1981; Seager et al., 1984). Originally named by Strain (1966) for exposures in the Hueco Basin of west Texas, the Camp Rice Formation was subsequently applied as a map unit in the vicinity of Las Cruces, New Mexico (Seager et al., 1971, 1982, 1987; Seager and Hawley, 1973; Seager and Clemons, 1975). In southern New Mexico, the Camp Rice Formation was deposited in five separate basins, including (1) the Mesilla basin, which extends from east of the Robledo Mountains southward to the New Mexico-Mexico border, (2) the Corralitos basin, located west of the Robledo Mountains, (3) the Jornada basin, located west of the San Andres Mountains, (4) the Hatch-Rincon basin, centered around towns of the same name, and (5) the Tularosa basin, east of the Organ Mountains (Seager, 1981; Mack et al., 1993). North of the HatchRincon basin, between Garfield and Truth or Consequences, sediment equivalent in age and lithofacies to the Camp Rice Formation is referred to as the Palomas Formation (Lozinsky and Hawley, 1986a, b).

The Camp Rice Formation unconformably overlies rocks ranging in age from Eocene to late Miocene and has a maximum exposed thickness of 130 m along the northeastern flank of the Robledo Mountains. Although largely undeformed, the Camp Rice is locally offset by and tilted against both basin-bounding and intrabasinal faults (Seager et al., 1982, 1987). Deposition of the Camp Rice Formation ended when the ancestral Rio Grande and its tributaries began to entrench the basins. The preserved geomorphic surface representing the constructional top of the Camp Rice Formation is called the Jornada I surface, when developed upon piedmont lithofacies, and the La Mesa surface above fluvial facies. The roughly coeval surface at the top of the Palomas Formation is the Cuchillo surface (Lozinsky, 1986).

Camp Rice lithofacies

The Camp Rice Formation is generally divided into piedmont and axial-fluvial lithofacies. The piedmont lithofacies consists of interbedded conglomerate/gravel, sandstone/sand, and a minor amount of mudstone and was deposited on alluvial fans and alluvial flats. The relative abundance and grain size of conglomerate/gravel decreases rapidly basinward. Near basin-bounding faults, the piedmont lithofacies is composed of thick-bedded to massive beds of coarse conglomerate/gravel and was deposited by gravity flows and running water. In contrast, distal exposures of piedmont lithofacies consist of thinly interbedded fine conglomerate/gravel and sandstone/sand that was deposited primarily by sheetflood processes (Mack and Seager, 1990). The composition of gravel-sized clasts in the piedmont lithofacies is highly variable and reflects derivation from local bedrock uplifts. The piedmont lithofacies is locally well cemented by calcite, especially where Paleozoic carbonate clasts are abundant.

The ancestral Rio Grande was responsible for deposition of axial-fluvial lithofacies, which occupies a basin-

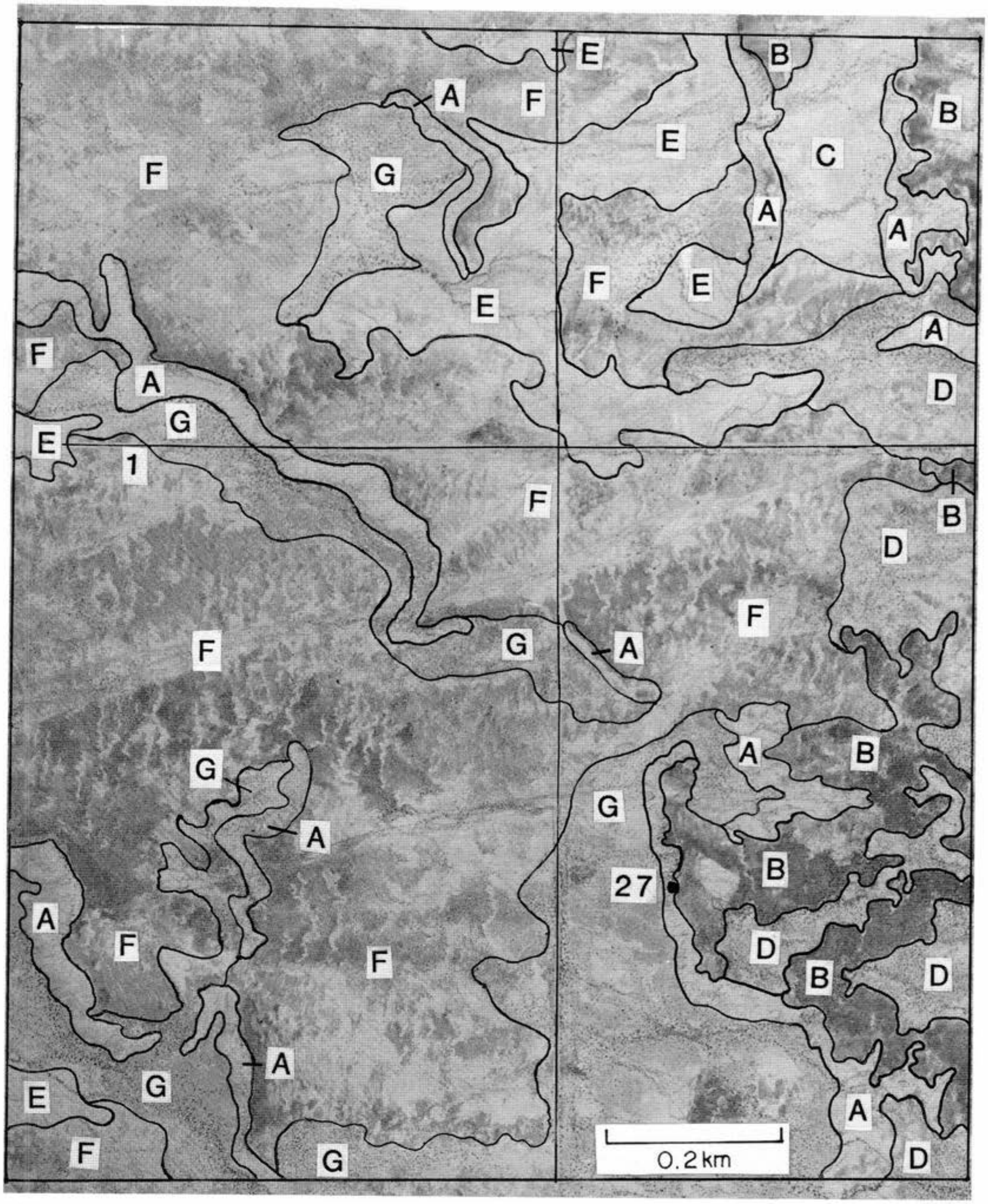

FIGURE 18—Map of soils in the vicinity of study area 27. A = Jal and Doña Ana soils, dissected (Jornada II and Organ surfaces); B = Reagan soils and Glendale Ustic analog (Organ surface); C = Reakor and Glendale soils, moderately eroded (Organ surface); D = Reakor and Glendale soils, severely eroded (Organ surface); E = buried soil analogs of Reakor and Glendale soils (Organ surface); F = buried soil analogs of Reakor and Lacita soils (Organ surface); G = Jal–Doña Ana complex, severely eroded (Jornada II and Organ surfaces). Number 1 at middle left locates two Jal pedons with B horizons studied in thin section (see text discussion).

axis position and interfingers with the piedmont lithofacies along basin margins. Also referred to as basin-floor lithofacies, the axial-fluvial lithofacies constitutes interbedded pebbly medium to coarse sandstone/sand deposited in fluvial channels, and floodplain fine sandstone/ sand, siltstone/silt, and mudstone (Mack and James, 1993). Channel beds are 2 to 18 m thick and are generally multistory in character, with individual stories displaying a variety of current structures, including trough and planar crossbeds, horizontal laminae, and ripple cross-laminae. Rip-up clasts of mudstone and carbonate are common along story boundaries. Although commonly unconsolidated, channel deposits are locally cemented by calcite or opal, the latter of which is present near faults. Individual beds of floodplain sediment range in thickness from a few centimeters to 4.5 m and are either traceable laterally for hundreds of meters to kilometers or are truncated within a few tens of meters by fluvial channels. Fine sandstone/sand and siltstone/silt display horizontal laminae and ripple cross-laminae and probably were deposited by overbank floods, although an eolian origin for some of the beds is possible. Red to brown mudstones are rarely more than a meter thick and vertically accreted on the floodplain farthest from the active channels (Mack and James, 1993). The ancestral Rio Grande is interpreted by Mack and James (1993) to have been a broad, low-sinuosity stream characterized by rapidly shifting channels. Low-stage modification of inter-channel bars and bedforms was a common process and may have been the result of seasonal discharge.

Calcic paleosols (buried soils) are present in both piedmont and axial-fluvial sediment of the Camp Rice Formation (Mack and James, 1992). The best developed paleosols have an argillic B horizon (Bt) underlain by a calcic B horizon (Bk) characterized by scattered nodules and tubules of low-magnesium micrite indicative of stage II morphology (Gile et al., 1966). Less commonly, K horizons consisting of massive carbonate (stage III morphology) or massive carbonate overlain by a laminar and pisolithic cap (stages IV, V morphology) are present beneath the Bt horizon (Mack et al., 1994a). "A" horizons are rarely preserved in Camp Rice paleosols due to pre-burial erosion, and in some cases the truncation surface is located within the Bk horizon. Stable oxygen and carbon isotopes of pedogenic carbonate provide information on changes in temperature and/or soil vegetation during deposition of the Camp Rice Formation (Mack et al., 1994b). An overall upsection decrease in isotopic values suggests that the paleoclimate became warmer, drier, and/or experienced more summer-seasonal precipitation through time.

The distribution of lithofacies and paleosols in the Camp Rice and Palomas Formations were controlled primarily by basin tectonics (Mack and Seager, 1990; Mack and James, 1993). In half grabens, as a result of asymmetrical subsidence, the belt of axial-fluvial lithofacies is narrow (<5 km) and positioned within a kilometer or less of the footwall block. Fluvial sediment in half grabens contains few overbank deposits and paleosols are relatively uncommon and immature. In contrast, in full grabens, such as the HatchRincon and Corralitos basins, the axial-fluvial lithofacies occupies almost the entire width of the basin and is characterized by thick, laterally persistent floodplain deposits and relatively mature calcic paleosols.

Age of the Camp Rice and Palomas Formations

The age of the Camp Rice and Palomas Formations is bracketed between early to late Pliocene and middle Pleistocene by a combination of radiometric dates of interbedded volcanic and volcaniclastic rocks, tephrochronology, magnetostratigraphy, and vertebrate paleontology. There is a variety of data to indicate that the age of the lower part of the Palomas and Camp Rice Formations is late Pliocene (3.4-1.6 Ma). Basalt lava flows dated by the K-Ar method at 3.1 and 2.9 Ma are interbedded within the Palomas Formation (Bachman and Mehnert, 1978; Seager et al., 1984), and both formations contain a medial to late Blancan vertebrate fauna (3.7-1.8 Ma) (Tedford, 1981; Lucas and Oakes, 1986; Vanderhill, 1986). In addition, five stratigraphic sections of the Camp Rice Formation between Las Cruces and Hatch display high-resolution reversal magnetostratigraphy that correlates to the Gauss Chron (3.4-2.48 Ma) (Mack et al., 1993). There also is evidence to suggest that the lowest part of the Palomas Formation may be early Pliocene (5.3-3.4 Ma) in age. Repenning and May (1986) collected an early Blancan fauna from an interval of the Palomas Formation that has normal polarity. They correlated the normal-polarity interval with the Nunivak subchron (4.05-4.20 Ma) of the Gilbert Chron. Furthermore, magnetostratigraphic data collected from two stratigraphic sections north of Garfield also suggest the presence of Gilbert-age strata in the lowermost Palomas Formation (G. Mack, M. Leeder, and S. Salyards, unpublished data). The oldest of three normal-polarity intervals in one of the Garfield sections may correlate with the Sidufjal subchron (4.47-4.32 Ma). None of the magnetostratigraphic sections of the Camp Rice Formation, however, appear to cross the Gauss-Gilbert boundary, and, therefore, are younger than 3.4 Ma (Mack et al., 1993).

An early Pleistocene age for the bulk of the upper part of the Camp Rice and Palomas Formations (fluvial facies) is also well documented. An early Irvingtonian (1.4-1.0 Ma) vertebrate fauna has been collected from the upper Camp Rice Formation in the Mesilla basin (Hawley et al., 1969; Tedford, 1981; Vanderhill, 1986), and the upper parts of the Palomas and Camp Rice Formations display primarily reversed polarity corresponding to the Matuyama Chron (2.48-0.78 Ma) (Vanderhill, 1986; Mack et al., 1993). Fluvial-channel lithofacies of the Camp Rice Formation also contain at least four and perhaps five previously unrecognized pumice-clast conglomerates presumably derived from the Jemez Volcanic Field of northern New Mexico. Single-crystal sanidine 40Ar /^{39}Ar radiometric dates of the upper four pumice-clast conglomerates reveal ages of 1.8, 1.6, 1.4, and 1.3 Ma (G. Mack and W. McIntosh, unpublished data).

The age of the top of the fluvial facies of the Camp Rice and Palomas Formations is constrained by tephrochronology and reversal magnetostratigraphy and appears to be close to the Matuyama-Brunhes boundary, which was defined by Mankinen and Dalrymple (1979) at 0.73 Ma and recently redefined by Baksi et al. (1992) at 0.783 Ma. The Matuyama-Brunhes boundary is not crossed in three stratigraphic sections of the Palomas Formation and three sections of the Camp Rice Formation and in five of the aforementioned sections the Jaramillo subchron is present, bracketing the age of the top of the formations to between 0.9 and 0.78 Ma (Vanderhill, 1986; Mack et al., 1993); however two magnetostratigraphic sections of the Camp Rice Formation display a few meters of normal polarity just below the constructional top, which may correspond to the Brunhes chron (Vanderhill, 1986; Mack et al., 1993). Three fallout ash beds also provide constraints on the age of the top of the Camp Rice Formation. At Grama, north of the town of Rincon, the Bishop ash (0.74 Ma; Izett and Naeser, 1976; Izett et al., 1988) is present within fluvial sediment that is inset against the Camp Rice Formation (Seager and Hawley, 1973; Kortemeier, 1982; Mack et al., 1993). Similarly, the Lava Creek B ash (0.62 Ma; Izett and Wilcox, 1982) is inset beneath the top of the Camp Rice Formation at Ash Mesa in Selden Canyon (Reynolds and Larsen, 1972; Seager et al., 1975; Mack et al.,1993). These data indicate that incision by the Rio Grande and its tributaries, and concomitant cessation of Camp Rice deposition, began prior to 0.74 Ma; however, the Bishop ash is also present within the uppermost part of the Camp Rice Formation near Anthony Gap (Kelley and Matheny, 1983). This apparent discrepancy, along with the possible local existence of Brunhes-age sediment in the Camp Rice Formation, suggests that basin entrenchment was not a geologically instantaneous event. Entrenchment may have commenced in some basins or parts of basins while deposition continued for a short time elsewhere.

In summary, the Camp Rice and Palomas Formations range primarily from late Pliocene to middle Pleistocene in age, although the lowest part of the Palomas Formation may be early Pliocene. Deposition of the bulk of the fluvial facies of the formations ended close to the Matuyama-Brunhes boundary, about 0.78 Ma ago.

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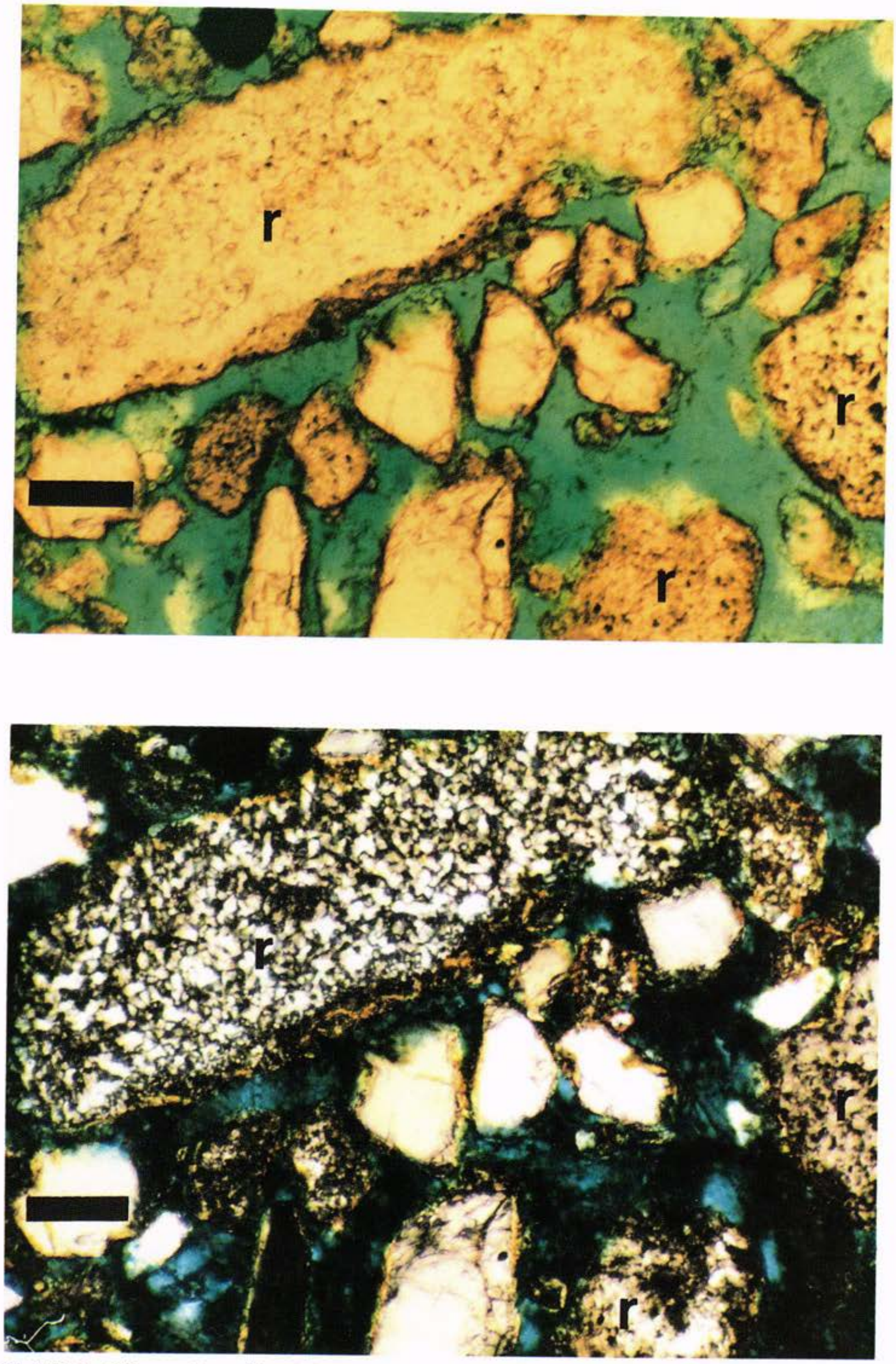


PLATE 1—Thin section of the Bt horizon of the Typic Haplocambid, Tugas, at study area 3a. Grains are dominantly quartz and rhyolite (r). Some of the grains appear to be "floating" (not in contact with another grain). Thin argillans are common on grains. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 µm.

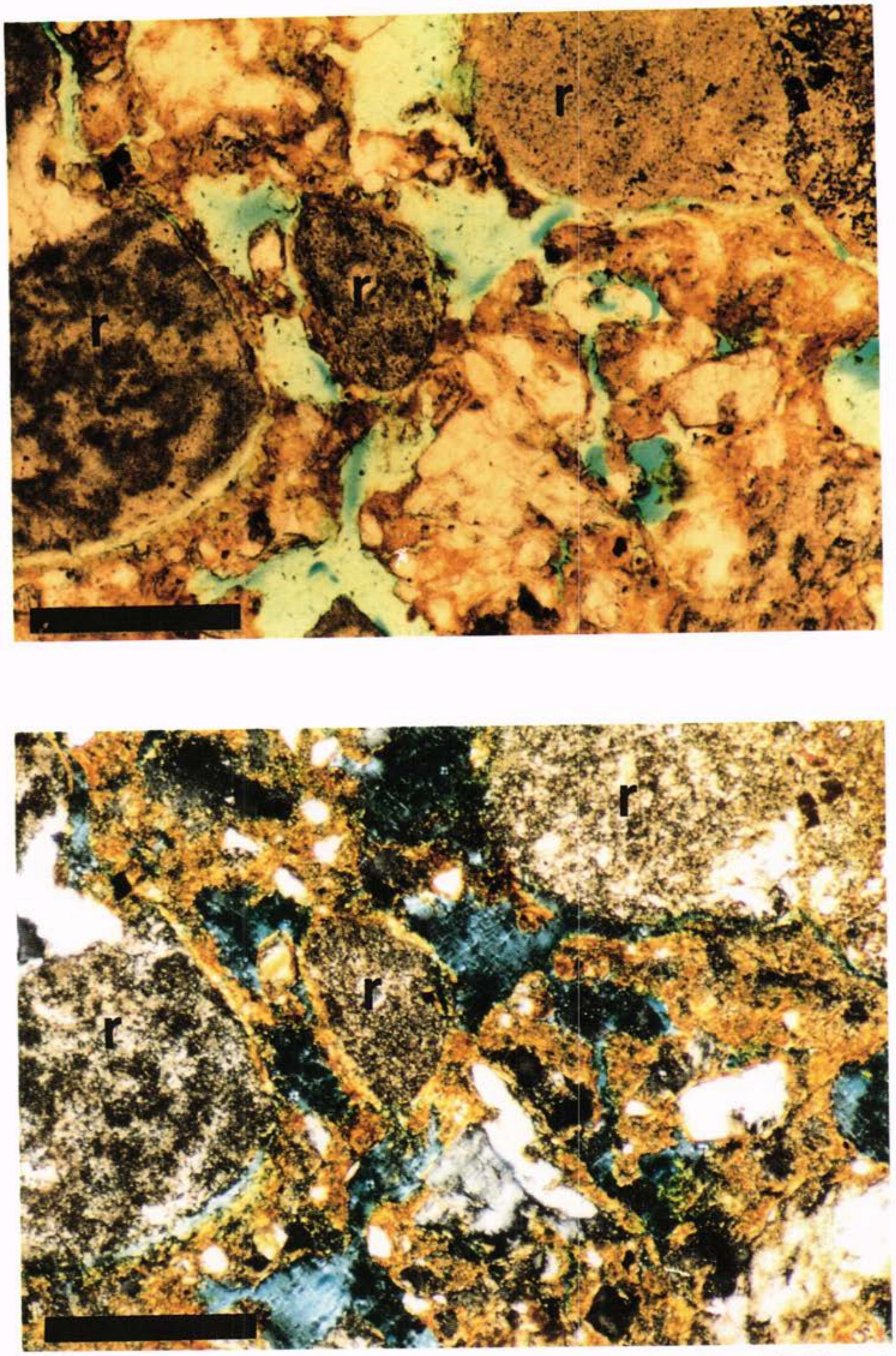
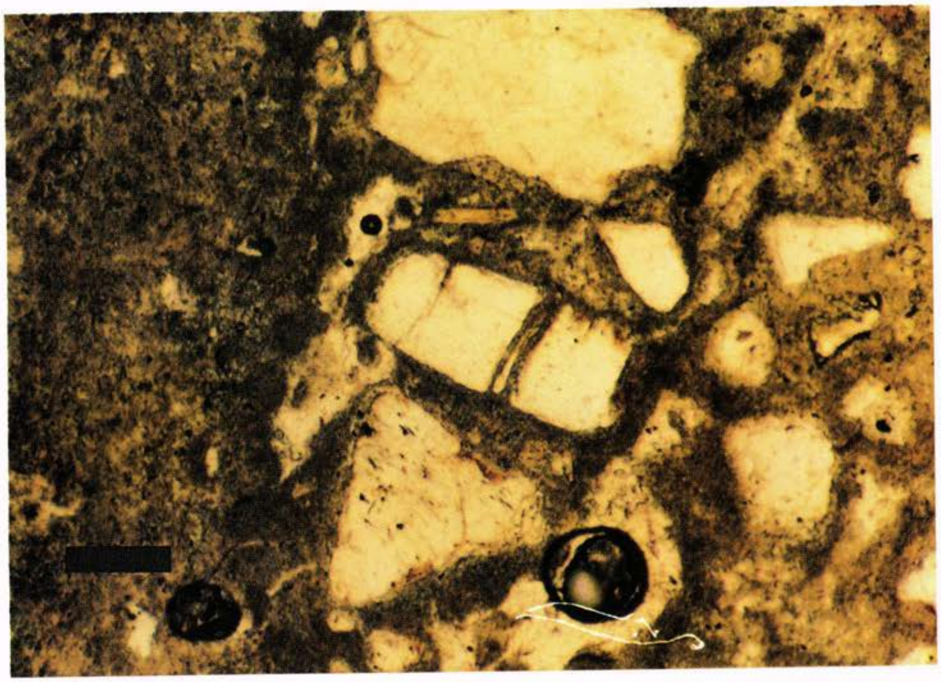


PLATE 2—Thin section of the Bt horizon of the Argic Petrocalcid, Hachita, just north of the west end of trench at study areas 4a and 4b. Grains are dominantly rhyolite (r) with lesser amounts of quartz and feldspar. A clay-rich matrix occurs between the grains, which have prominent argillans. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 0.5 mm.



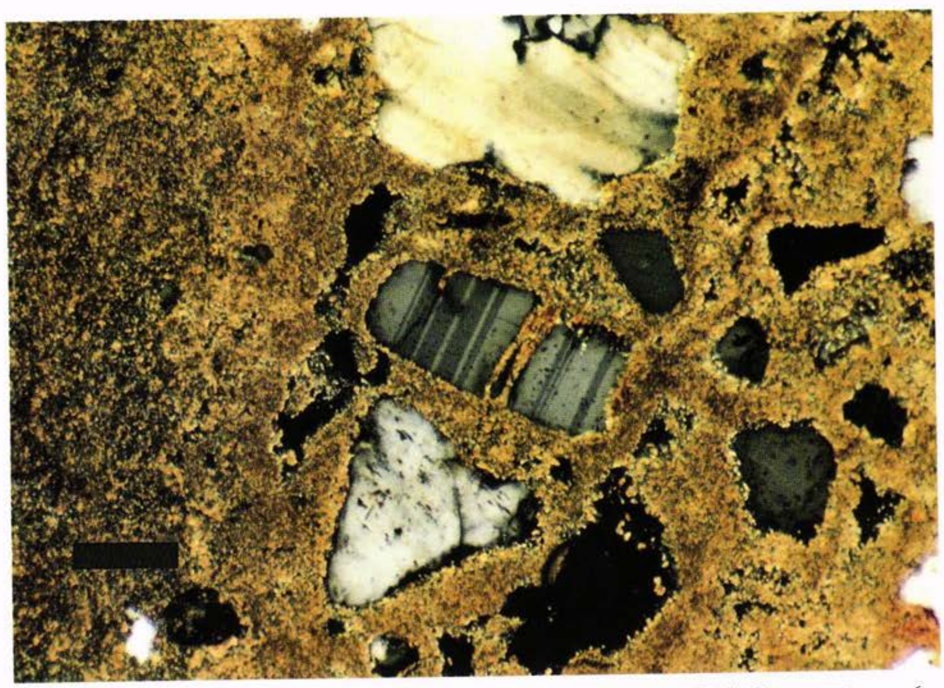
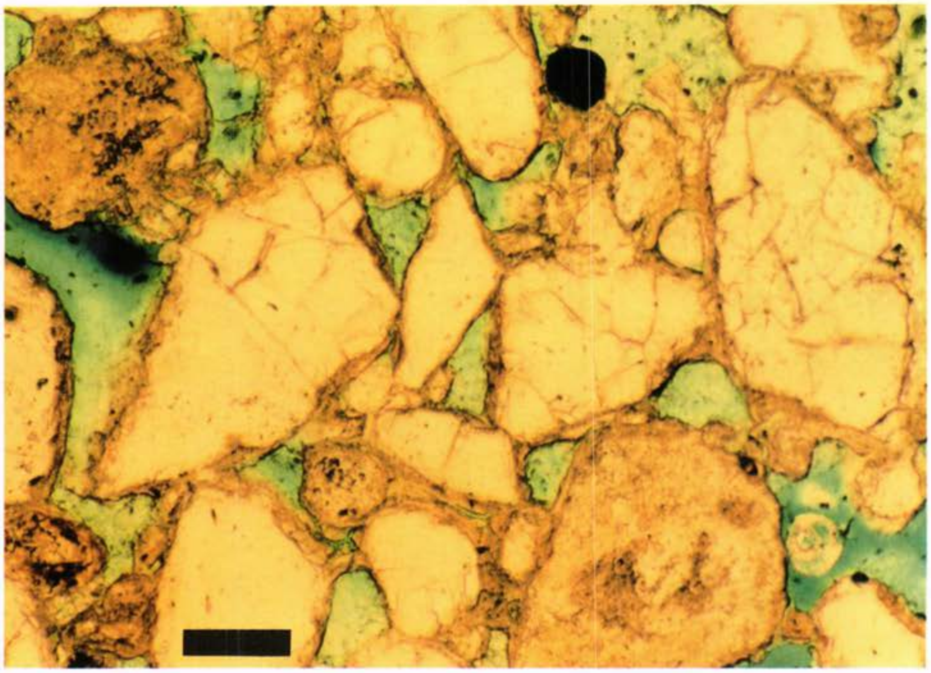


PLATE 3—Thin section of the K21m horizon of the Argic Petrocalcid, Cruces, at area 6a. Grains are dominantly feldspar, with some quartz. The matrix material is micrite. The plagioclase in the center has been partly dissolved and replaced by micrite. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 µm.



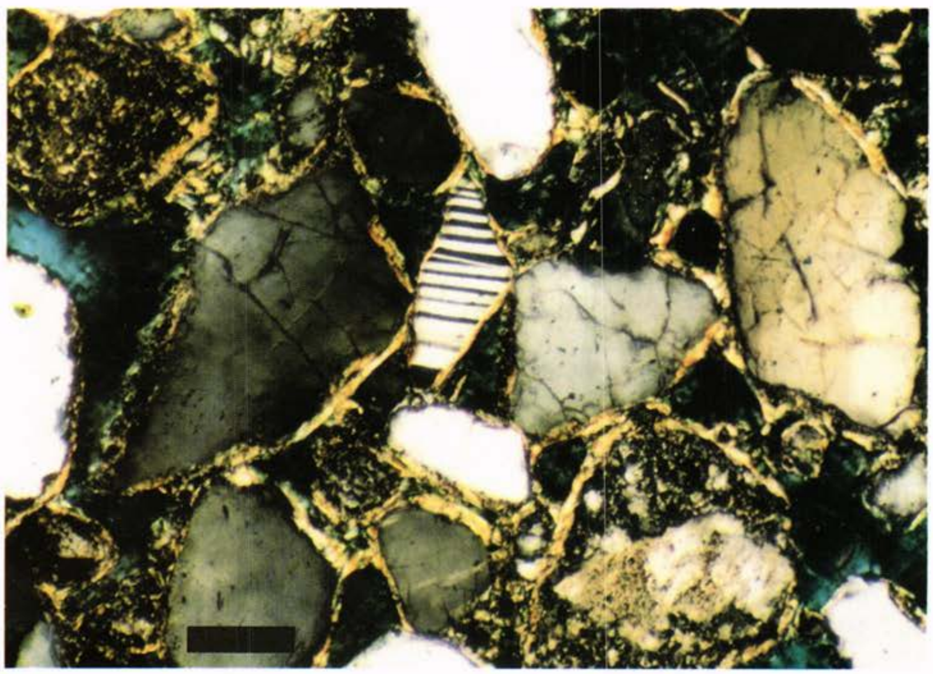
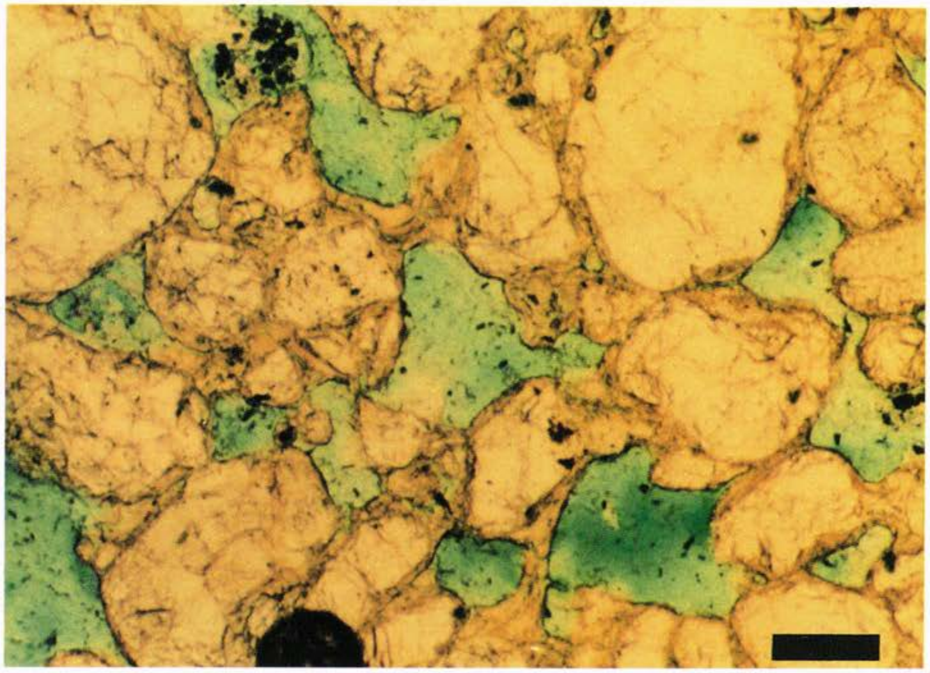


PLATE 4—Thin section of the Btk horizon of the Typic Calciargid, Berino, in the pipe at study area 6b. This horizon is at a depth of nearly 3m and represents the very thick Bt horizon in the pipe. Grain argillans are prominent and are the thickest grain argillans found to date in the Bt horizons of the Desert Project Area. Grains are commonly in contact with several adjacent grains, contrasting with the "floating grains" of some of the other Bt horizons (e.g., the Bt horizon of the Haplocambid at area 3a). Grains are dominantly quartz, with some feldspar and volcanic lithics. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 μm.



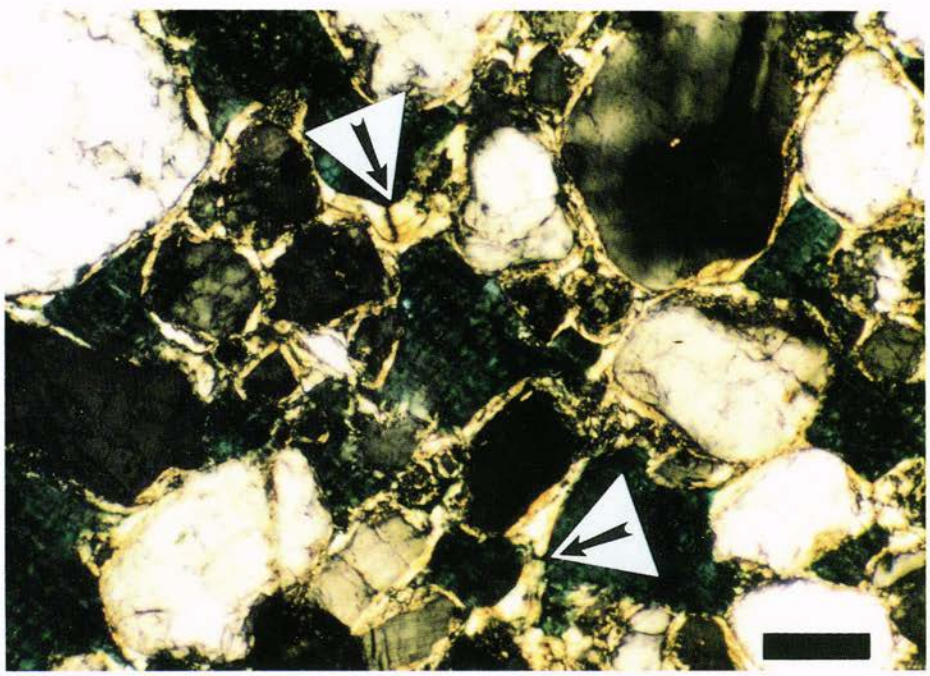
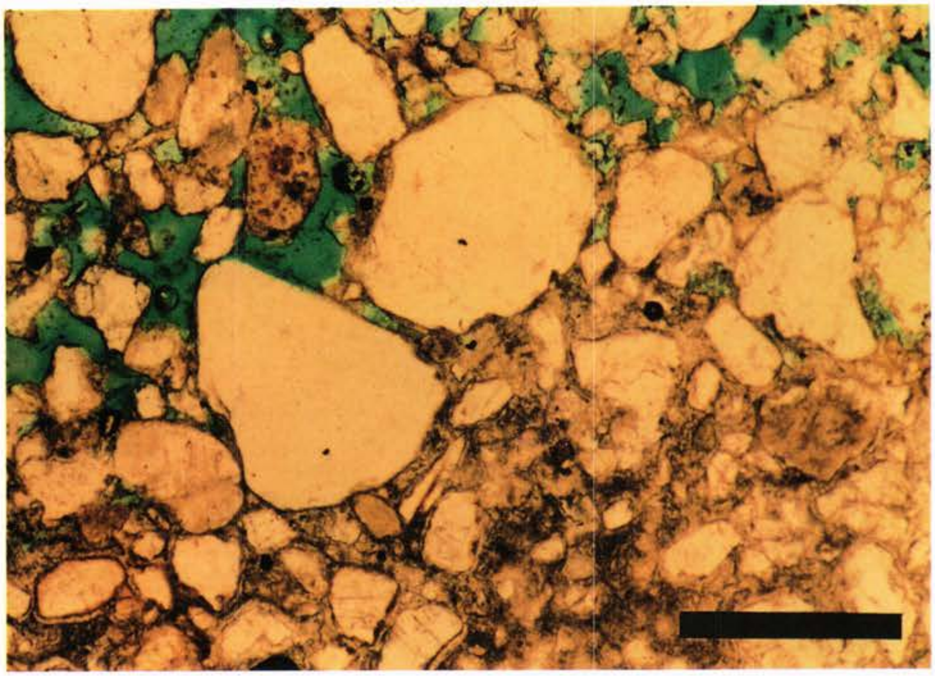


PLATE 5—Thin section of the Btk horizon of the Typic Calciargid, Berino, in the pipe at study area 6b. Grains are dominantly quartz, with some feldspar. Argillans are prominent; arrows locate laminated clay bridges. Upper, plane-polarized light; lower, crossed polarizers. Bar scale=100 µm.



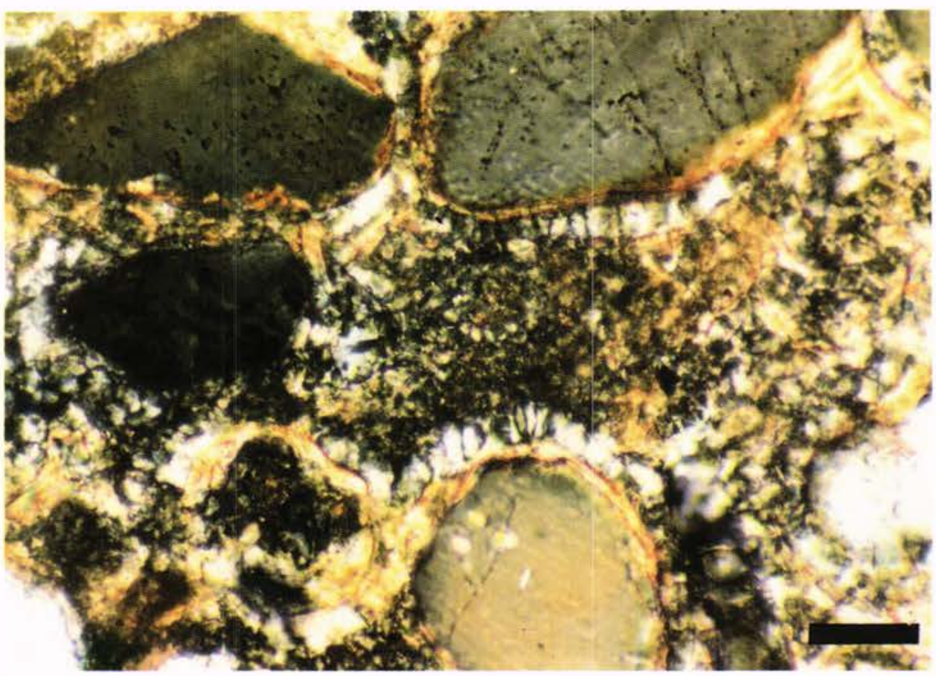


PLATE 6—Upper: thin section of the Btk horizon of the Typic Calciargid, Berino, in the pipe at study area 6b, showing the margin of a silica nodule. The dominant fabric of the Btk horizon, at upper left, has grain argillans and voids between them. Voids in the nodule below have been filled with silica cement. Grains are dominantly quartz, with some feldspar. Plane-polarized light. Bar scale = 0.5 mm. Lower: a closer view of the silica nodule shown above. Silica crystals on the grains are perpendicular to them, representing silica formation in place. The silica is outside the grain argillan, indicating that the argillan formed before the silica accumulated. Grains are mostly quartz. Lower, crossed polarizers. Bar scale = 50 μm.

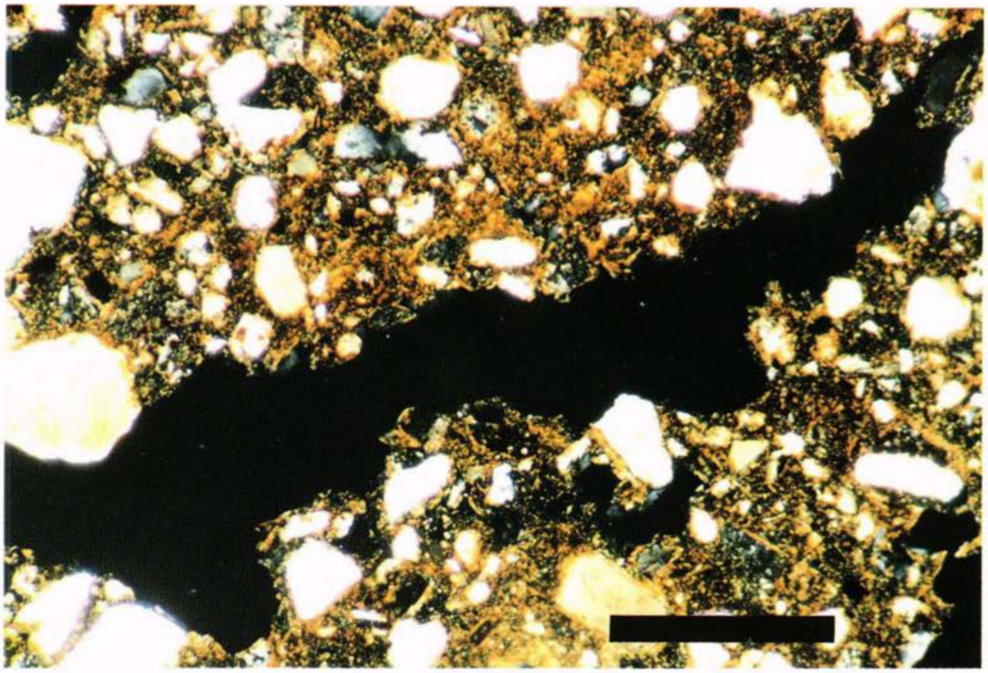


PLATE 7—Thin section showing prism faces in the Bt horizon of the Typic Calciargid, Berino, at study area 8. Argillans are common on sand grains, which are dominantly quartz, but do not occur on prism faces. Crossed polarizers. Bar scale = 0.5 mm.

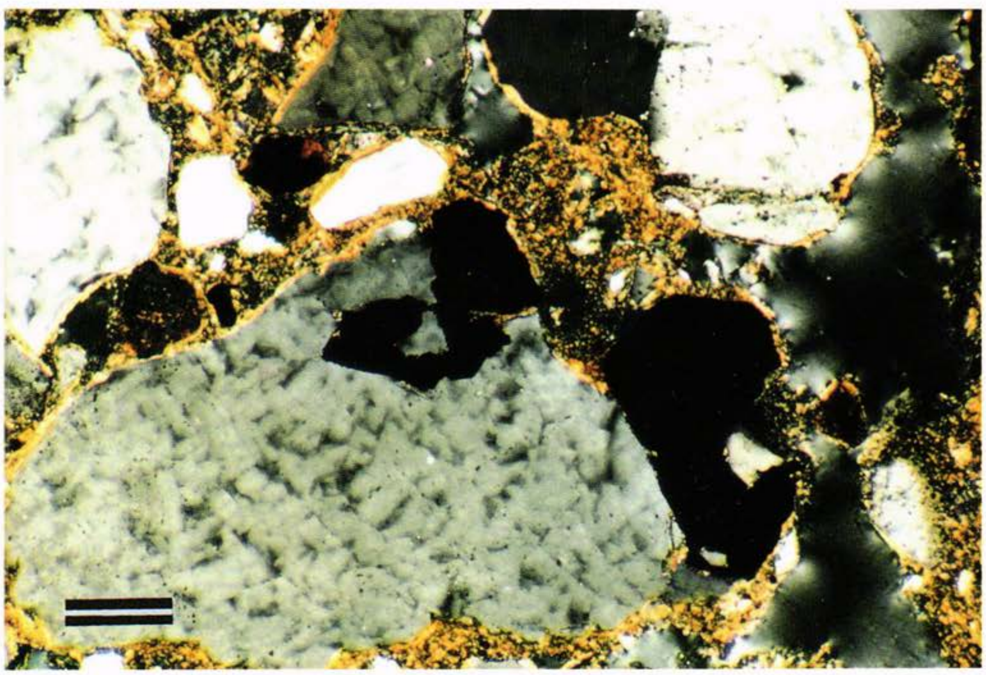


PLATE 12—Thin section of the Bt horizon of the Typic Calciargid, Yucca, at study area 10b (sample taken from a pit nearby the description site, in the same soil). Opaque grains are magnetite grains. Magnetite also occurs in the center and lower right. Argillans are prominent on sand grains and are thicker than those of the Haplocambid at area 10a (Plate 10). Crossed polarizers. Bar scale = 100 μm.

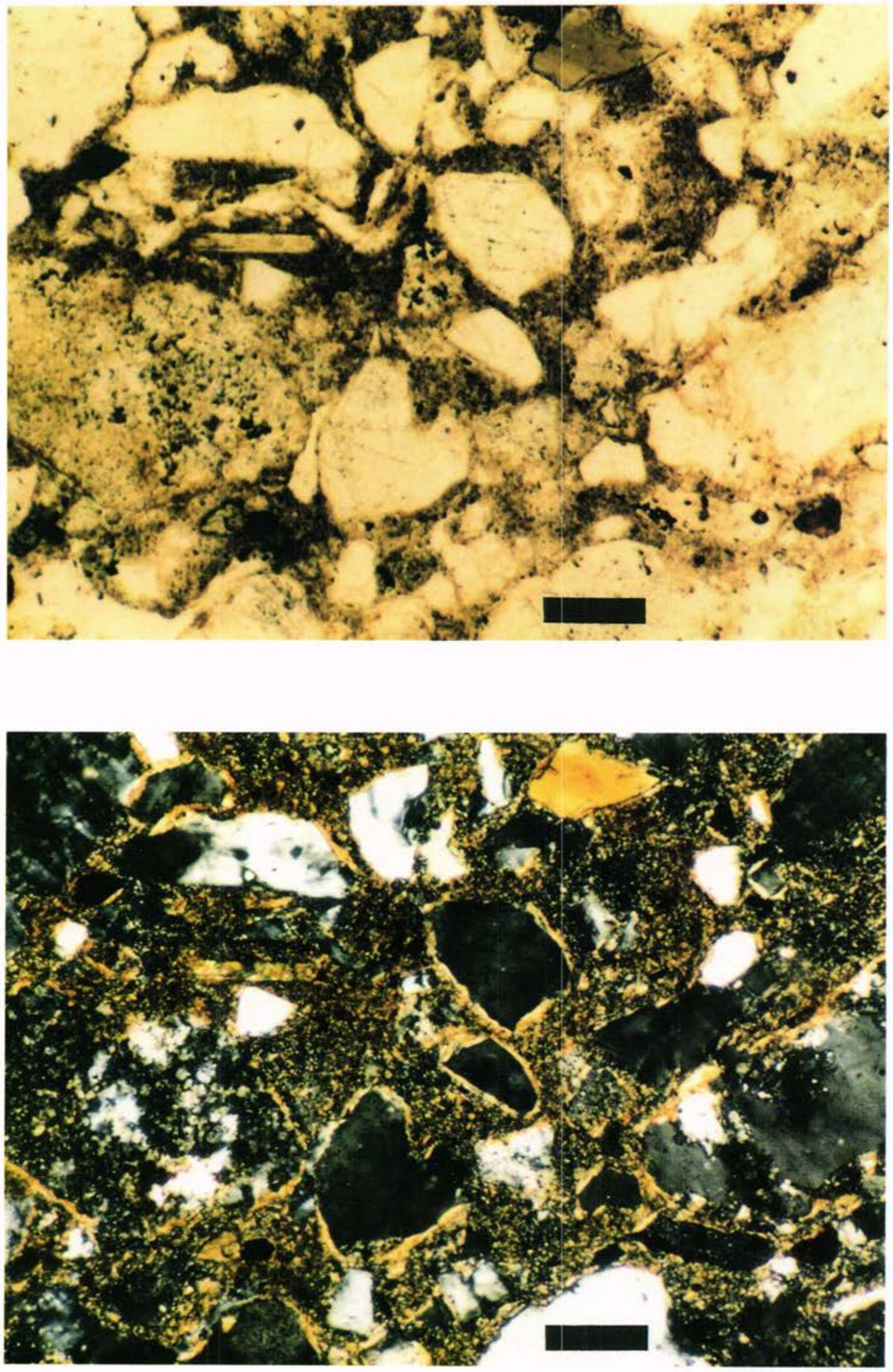
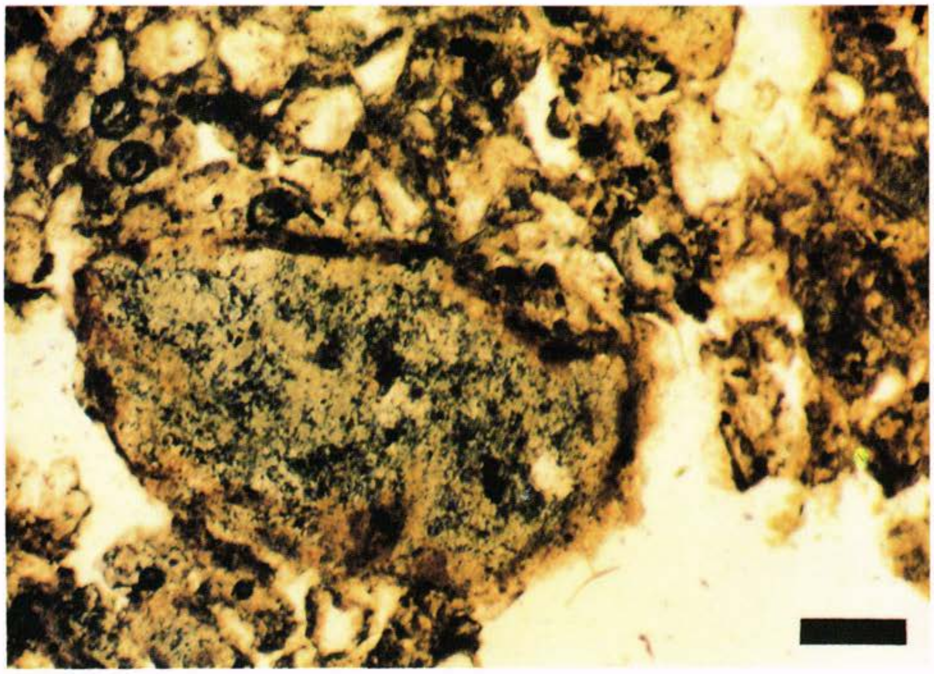


PLATE 8—Thin section of the Bt horizon of the Typic Haplargid, Bucklebar, at study area 9c. Grain argillans are common. Grains are dominantly quartz, with some feldspar, rhyolite, and biotite. Upper, plane-polarized light; lower, crossed polarizers. Bar scale=100 µm.



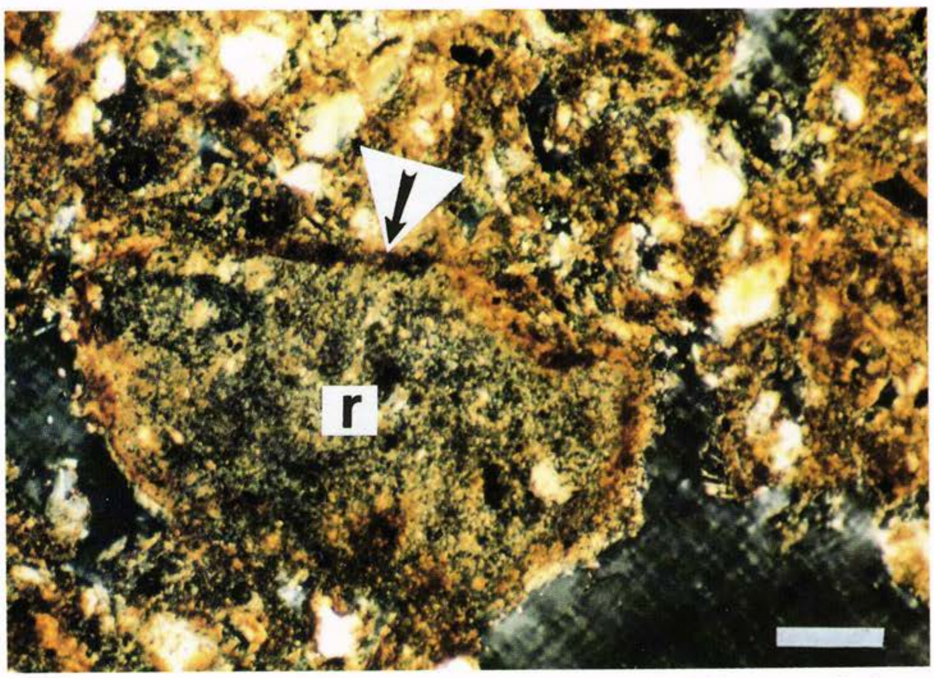
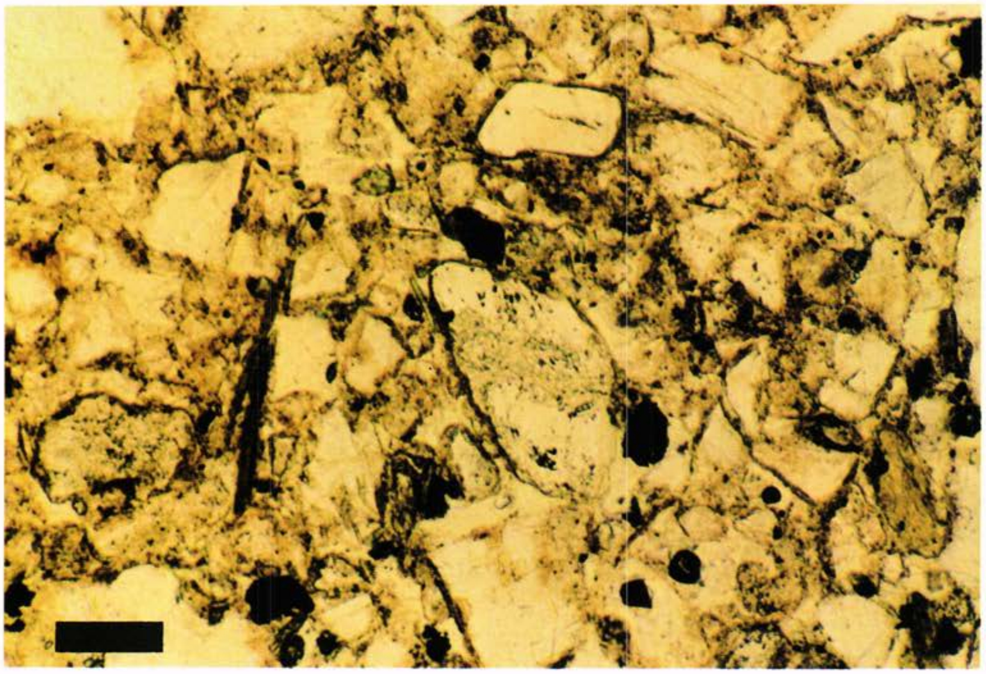


PLATE 9—Thin section of the Btk horizon of the Typic Haplargid, Bucklebar, at area 9c. Arrow locates obliterated argillan on a rhyolite grain (r). Although a reddish coating is still evident on the grain, enough carbonate has accumulated in the coating to obliterate the orientation. Other grains are quartz and feldspars. Argillans are still preserved in parts of the Btk horizon. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 µm.



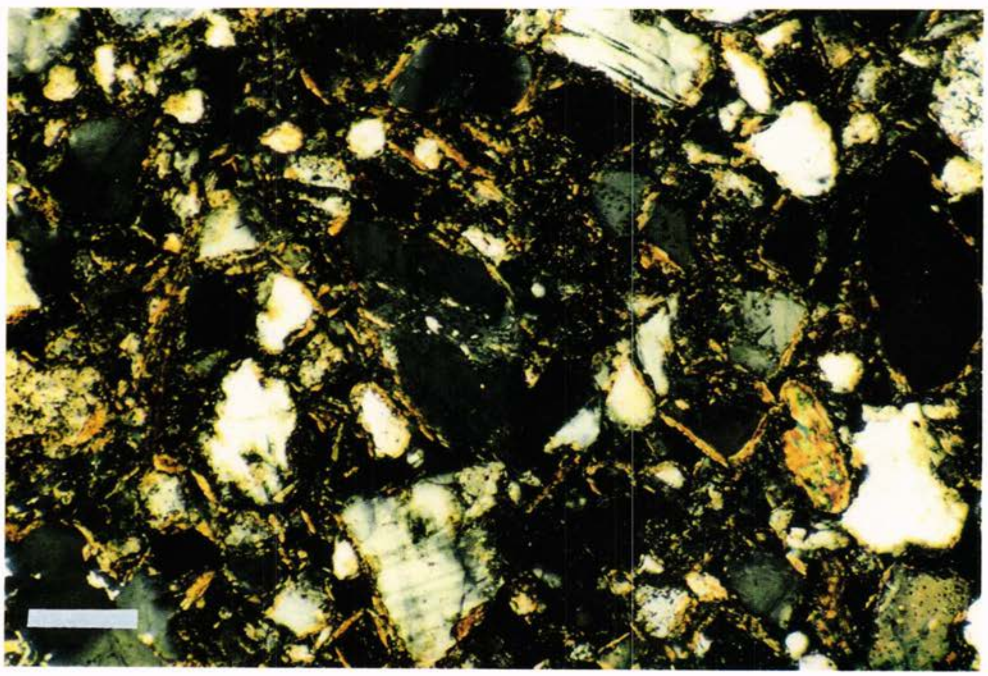
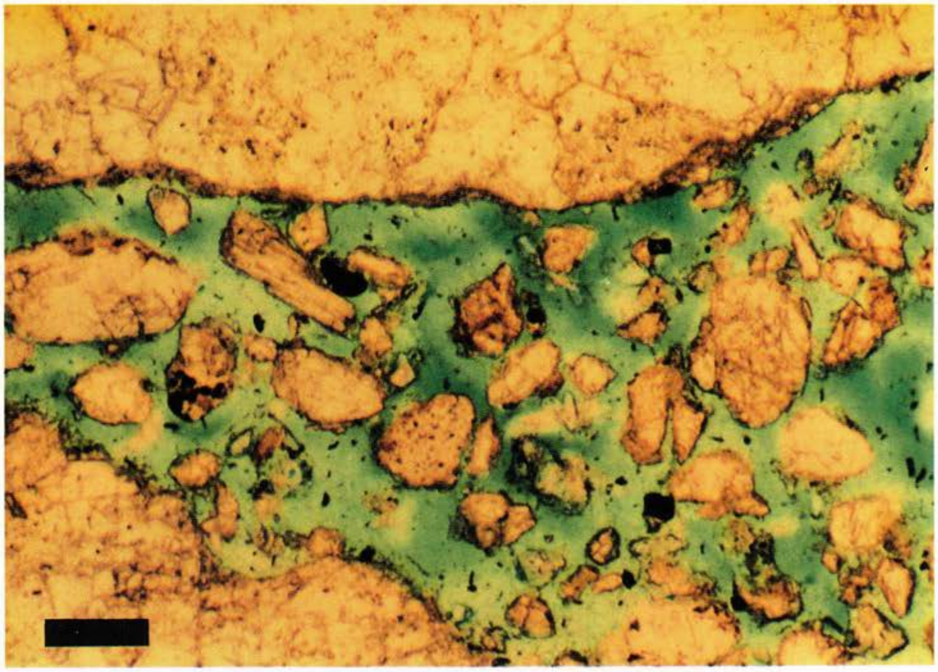


PLATE 10—Thin section of the Bt horizon of the Typic Haplocambid, Pajarito, at study area 10a. Feldspar grains are dominant with some quartz, magnetite and biotite. Argillans are common on sand grains. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 100 μm.



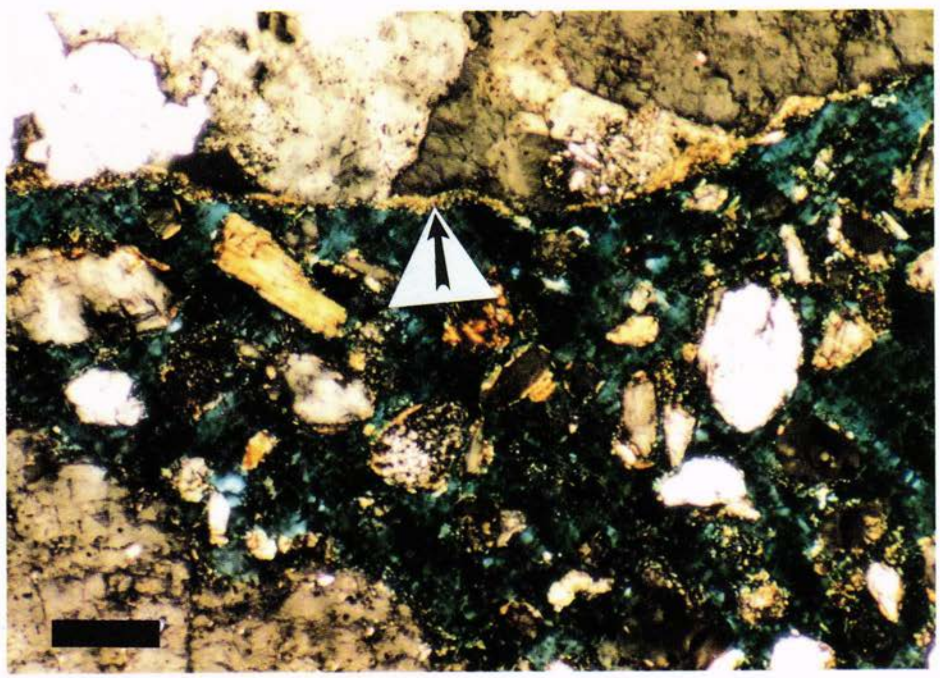
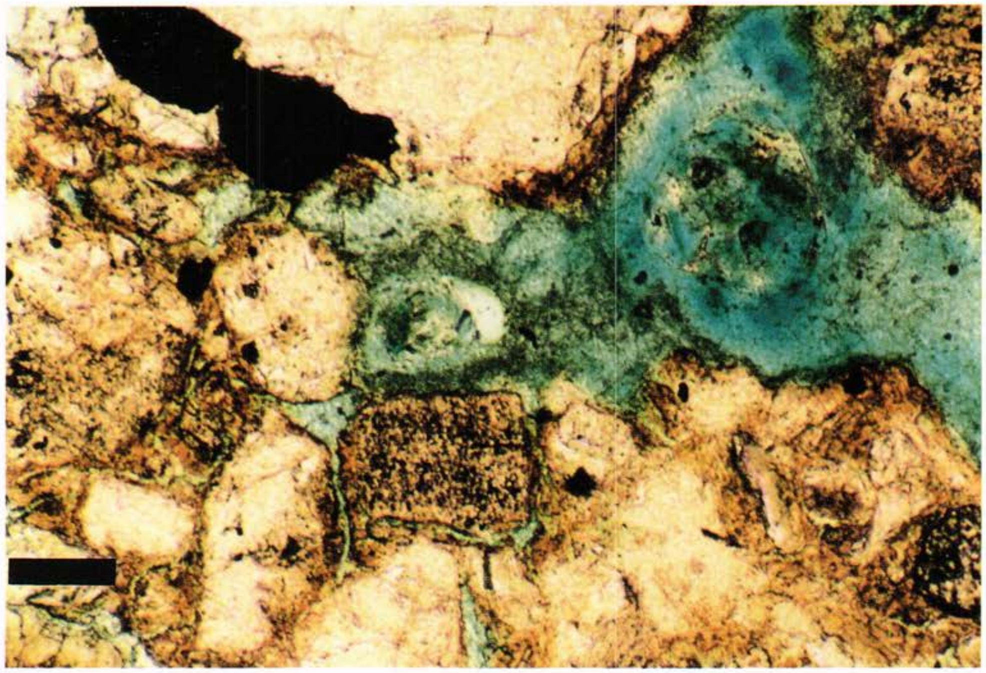


PLATE 11—Thin section of the Ck horizon of the Typic Haplocambid, Pajarito, at study area 10a. Thin stage I carbonate coatings (grain calcitans) occur on many grains; arrow locates a thin calcitan on the large grain at top. Monzonite is dominant, with some feldspar, quartz, and a minor amount of biotite. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 μm.



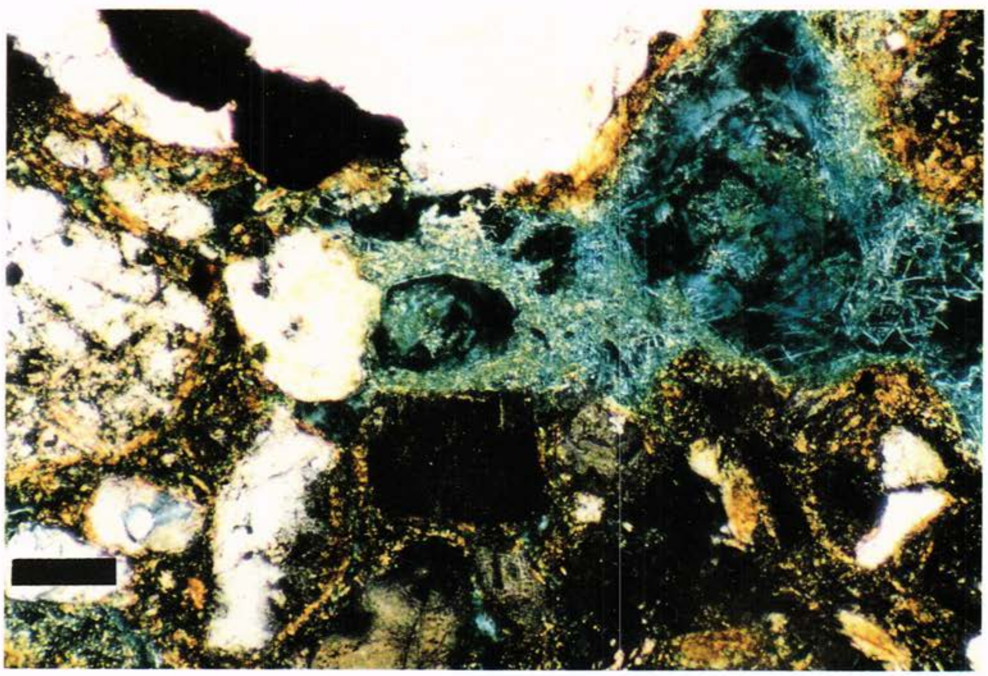
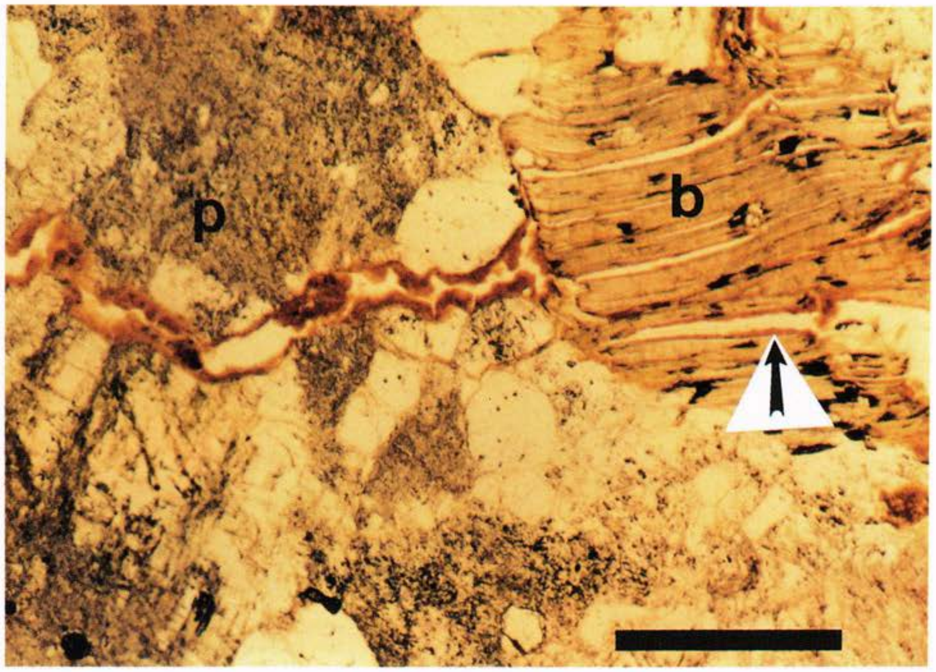


PLATE 13—Thin section of the Btk3 horizon of the Typic Calciargid, Yucca, at study area 10b. Argillans occur on some sand grains, but in the center, parts of grain argillans have been obliterated by carbonate. Note acicular carbonate (calcified fungal filaments) at lower right. Sand grains are dominantly feldspars. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 100 µm.



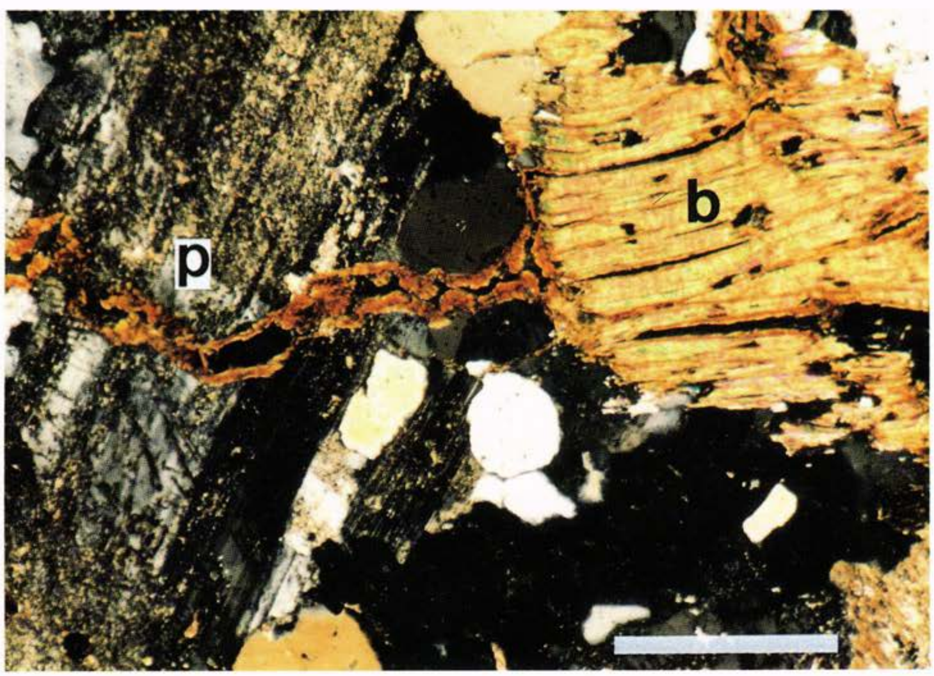


PLATE 14—Thin section of the Rt horizon of Jornada pediment near study area 11a. Plagioclase (p) is at left; exfoliating biotite (b) is at right. Arrow locates clay formation along cleavage plane in biotite; clay caused by illuviation is shown along a fracture in the plagioclase at left. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 0.5 mm.

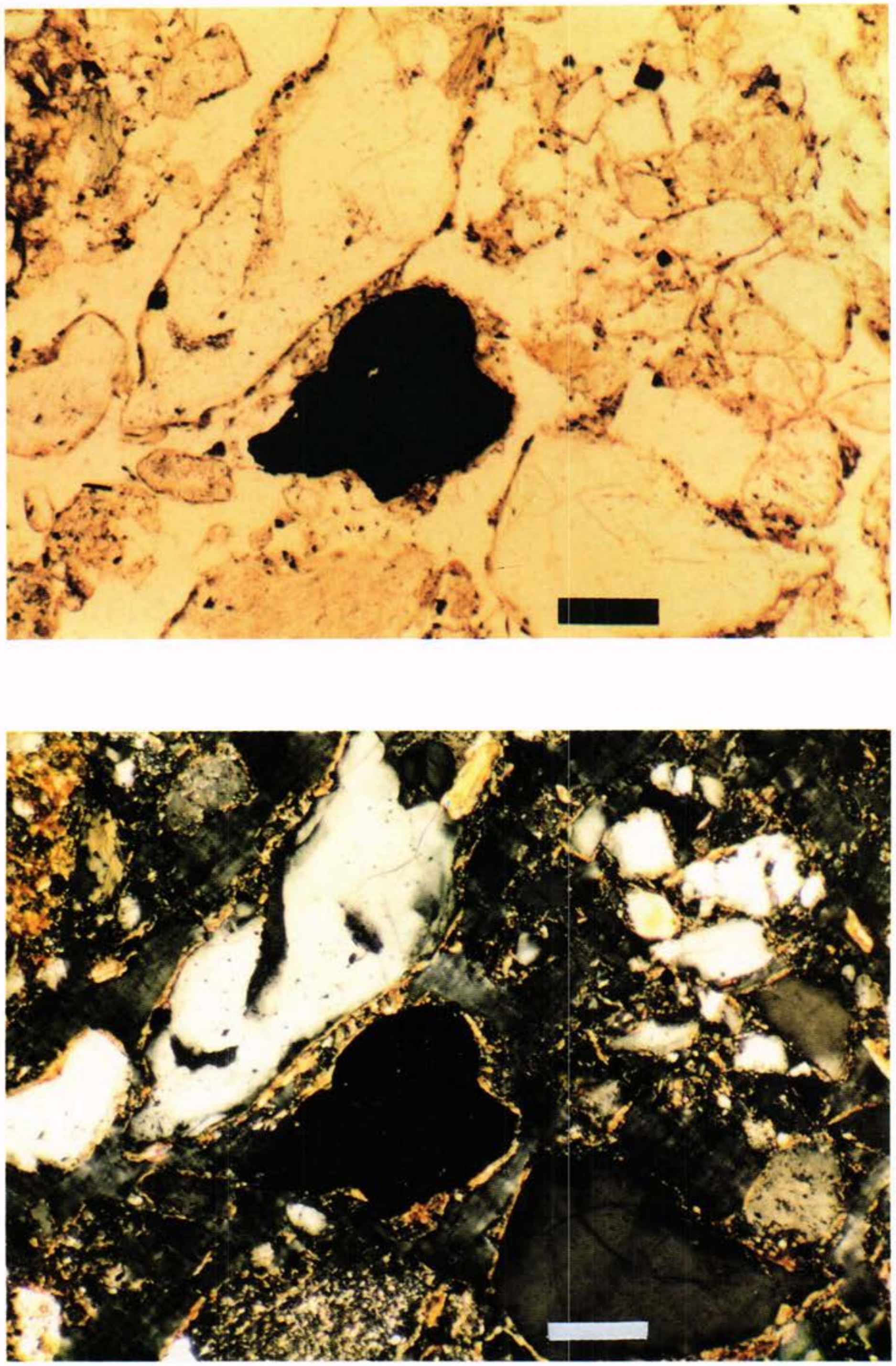
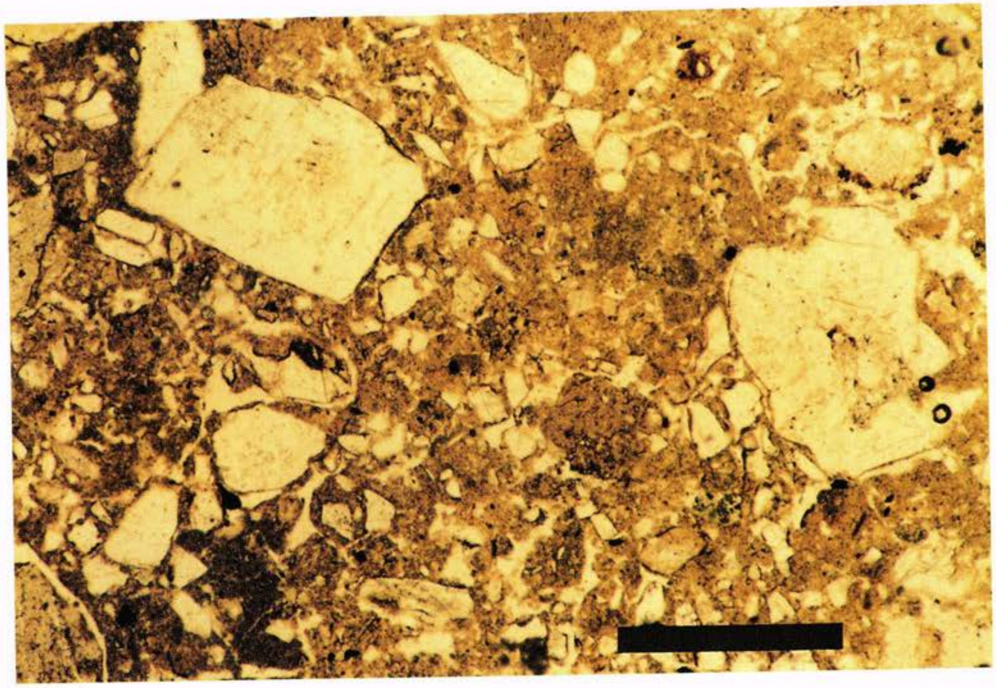


PLATE 15—Thin section of the Bt1 horizon of the Ustic Haplargid, Summerford, at study area 11c. Thin grain argillans are common. Grains are primarily feldspar and quartz, with some rhyolite (lower center) and magnetite (center). Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 µm.



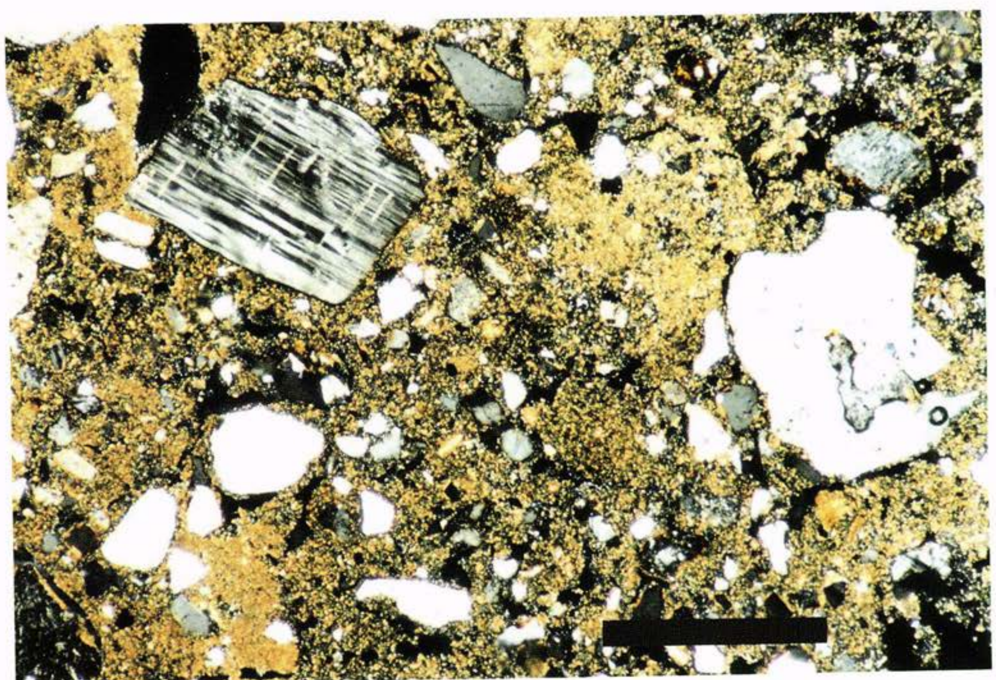


PLATE 16—Thin section of Bk3 horizon of the Ustic Haplocalcid, Reagan, at study area 16b. Clay increases markedly from A to B (table 71, Guidebook) but no argillans are present because carbonate in the parent materials prevents them from forming. Light-colored zones of K-fabric occur at lower left and at upper right center. Sands are dominantly quartz and feldspars. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 0.5 mm

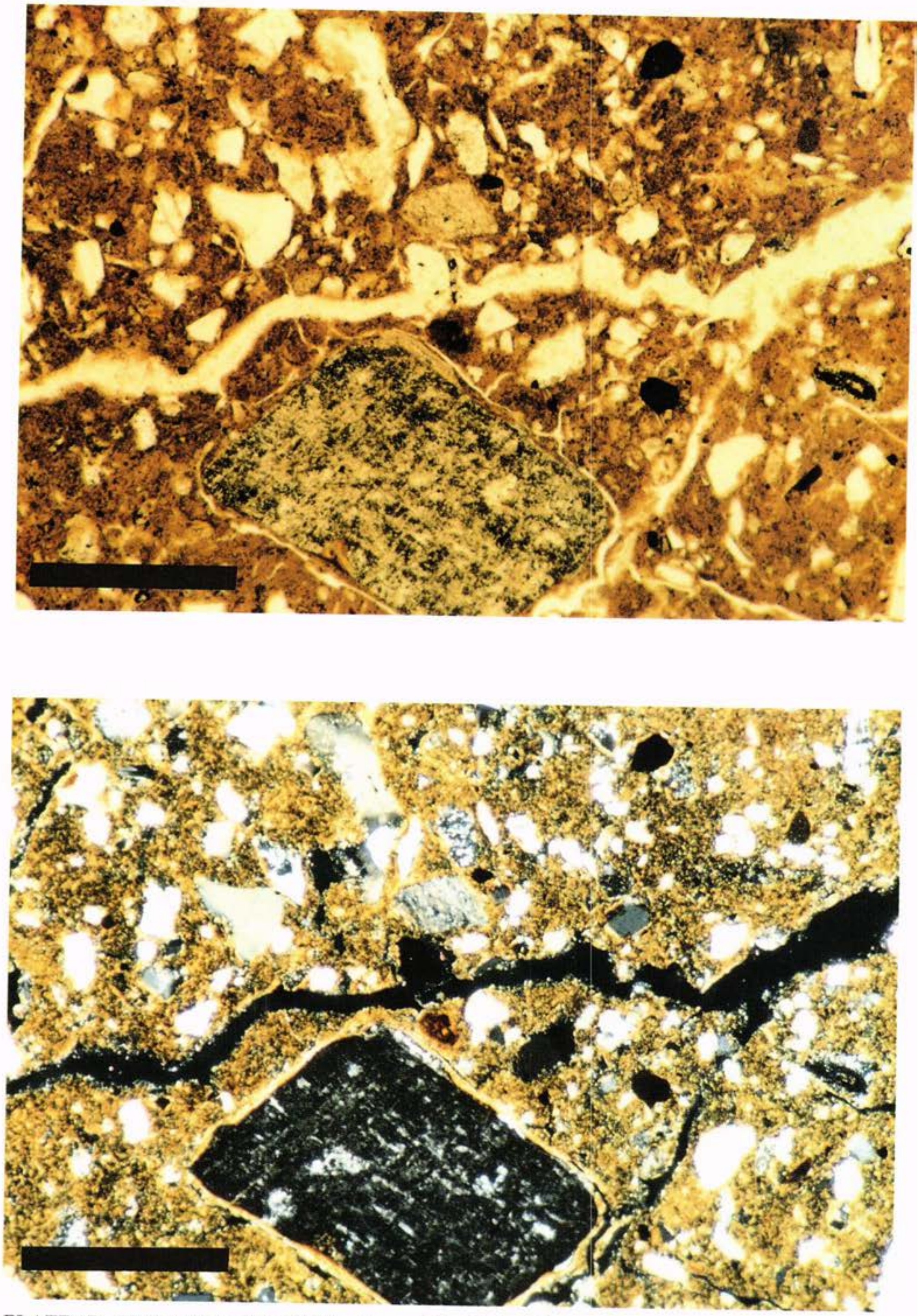


PLATE 17—Thin section of the Bt3 horizon of the Ustic Calciargid, Stellar, at study area 17. Ped faces lack argillans, but they are common on sand grains, which are dominantly quartz and feldspar with minor amounts of rhyolite. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 0.5 mm.

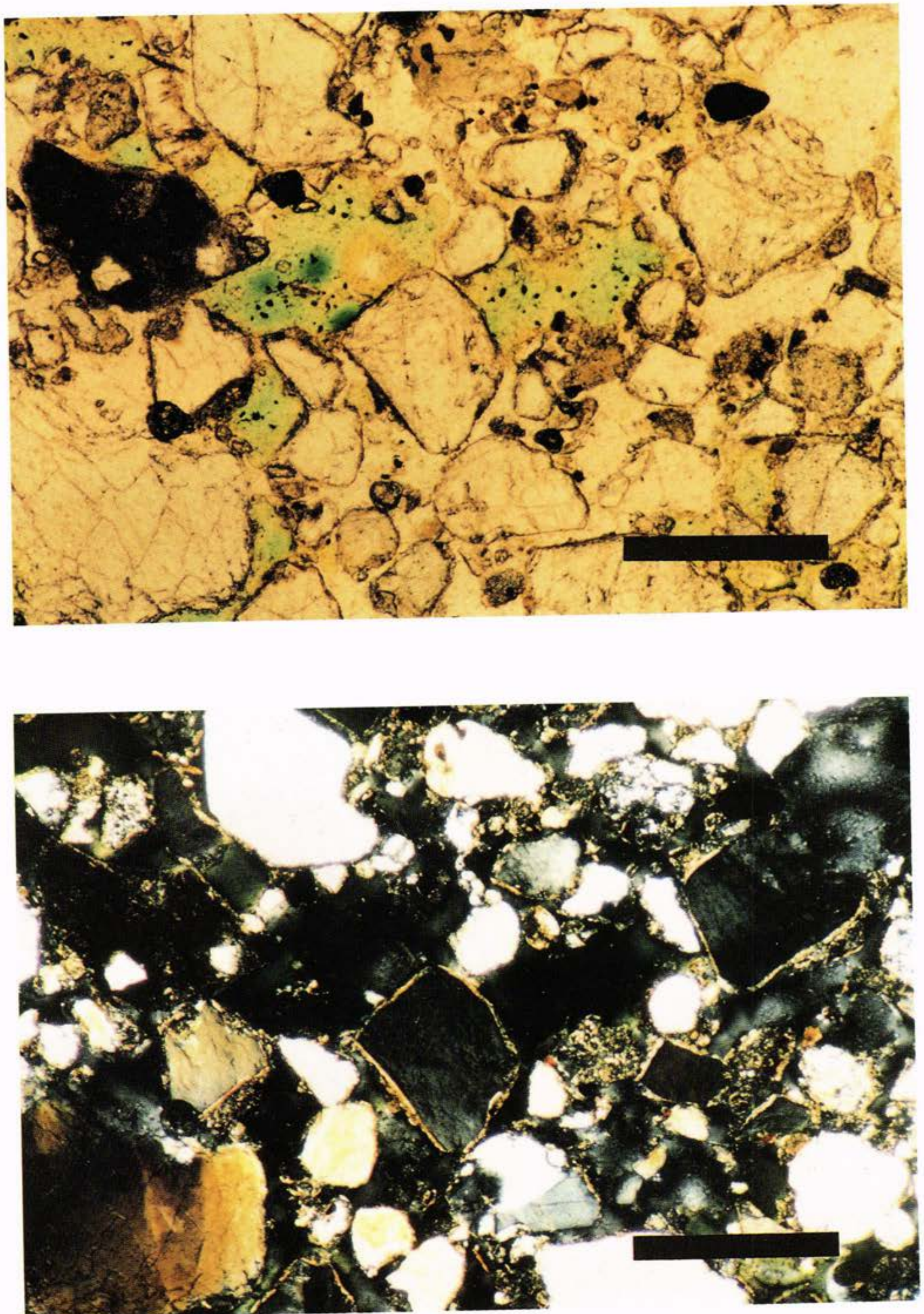


PLATE 18—Thin section of the B horizon of the Typic Torripsamment, University, at study area 19. Quartz grains are dominant with lesser amounts of feldspar, rhyolite, and magnetite. Thin argillans occur on many sand grains. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 0.5 mm.

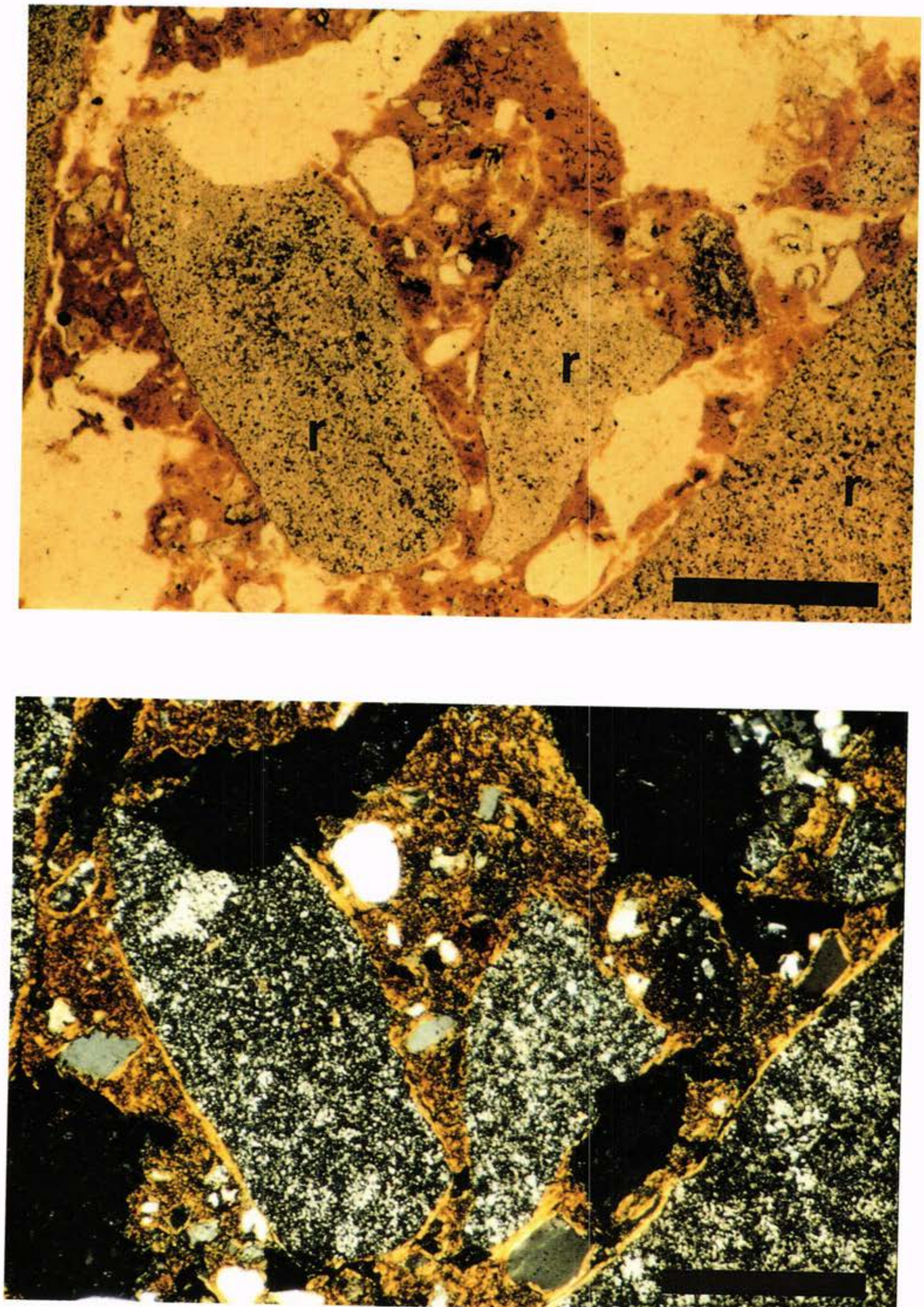


PLATE 19—Thin section of Bt2 horizon of the Typic Calciargid, Pinaleno, at study area 20. Clay-rich matrix surrounds rhyolite grains (r). Smaller grains are mostly feldspars, with some quartz. Prominent argillans occur on sand grains and pebbles. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 0.5 mm.

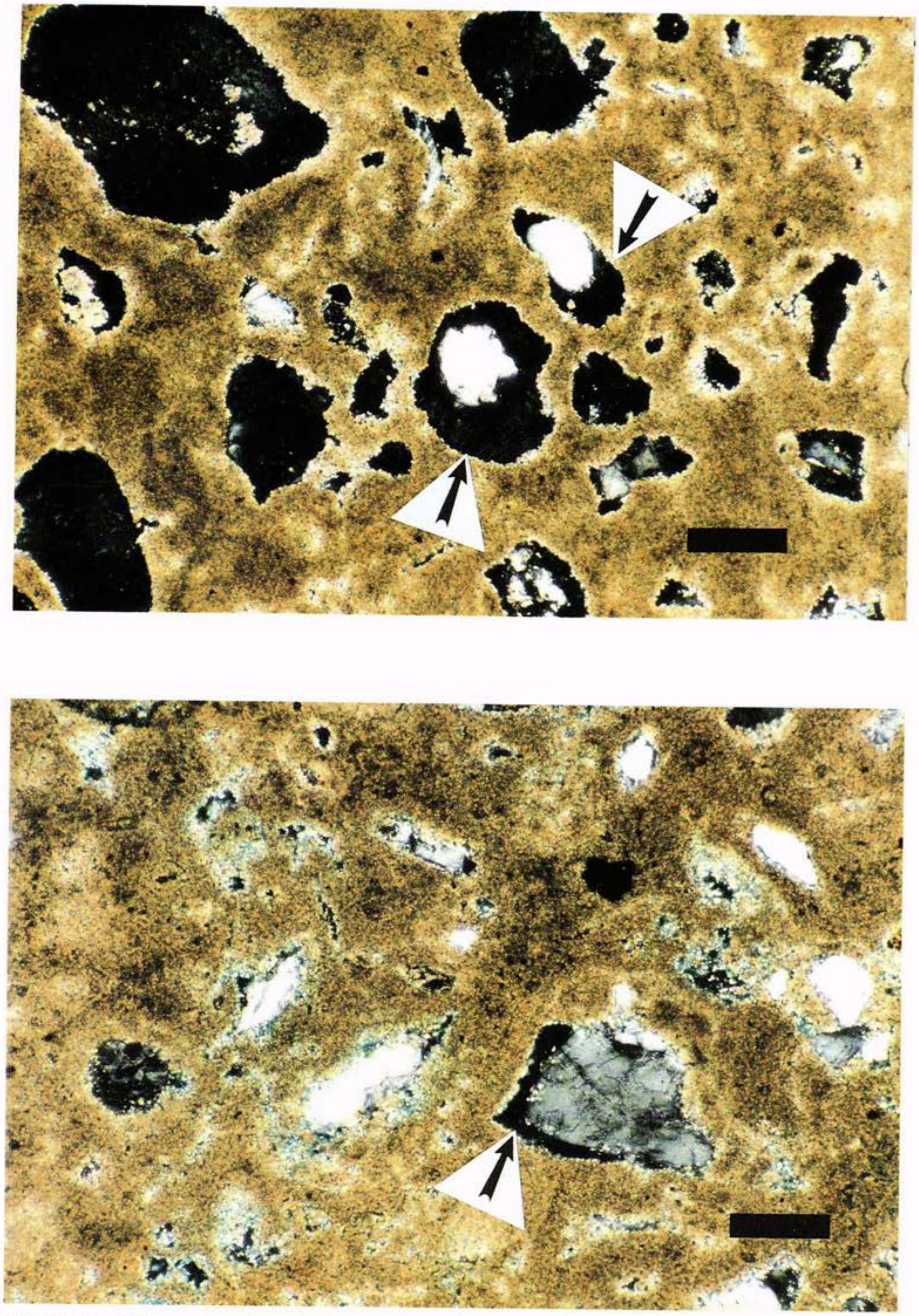
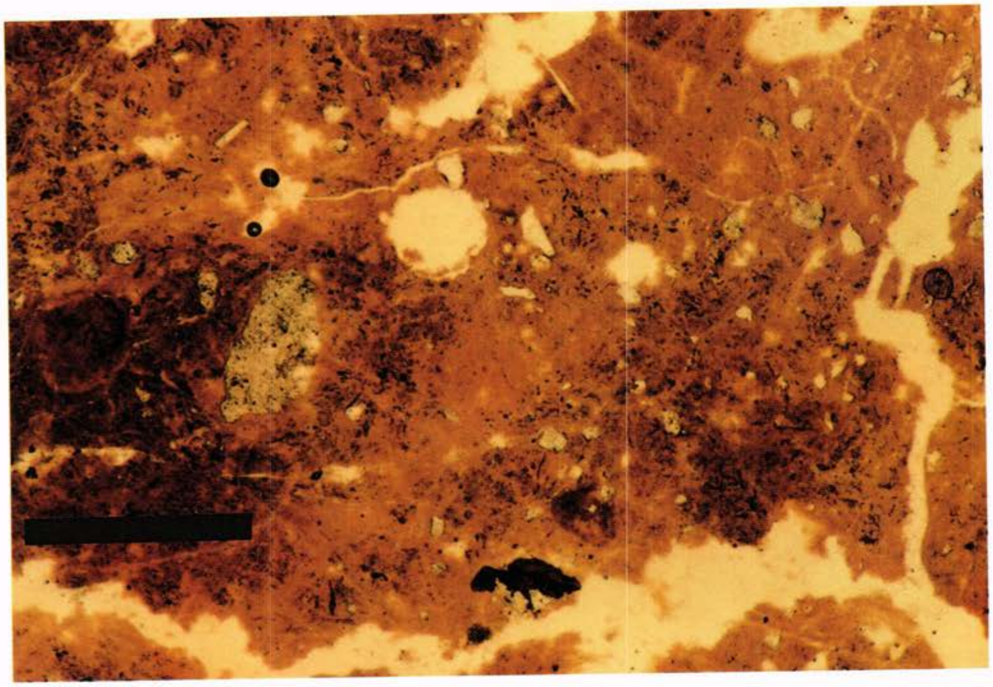


PLATE 20—Thin section of the K2 horizon of the Typic Haplocalcid at area 24a. Dissolution voids (arrows) surround many grains. Some grains have been completely or almost completely dissolved. The matrix material is micrite. Plane-polarized light. Bar scales = 100 μm.



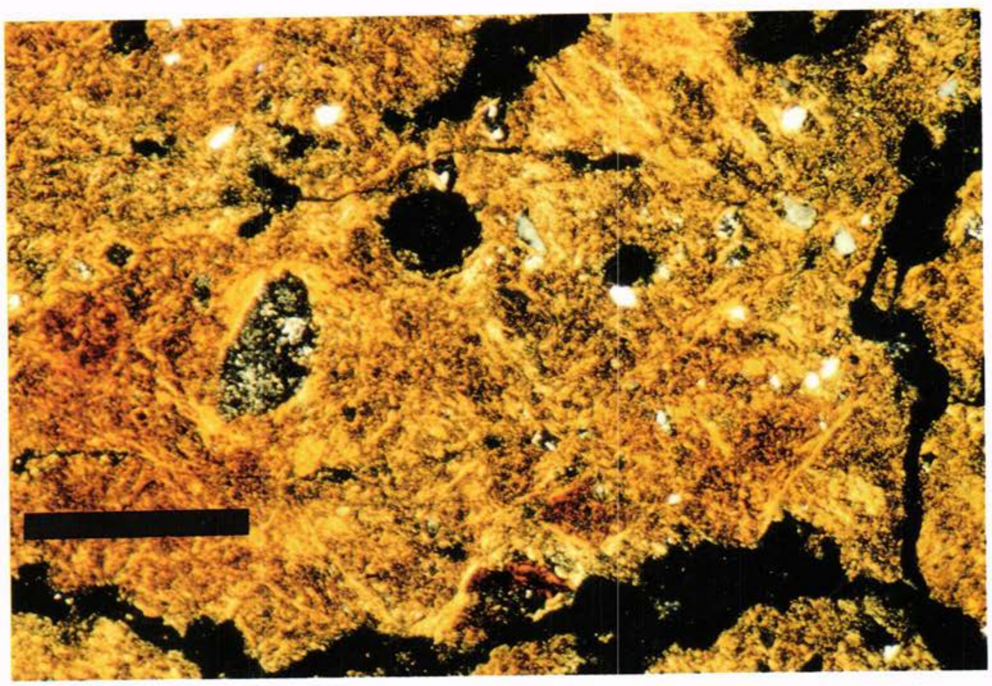


PLATE 21—Thin section of the Bty horizon of the Argic Ustic Petrocalcid, Hayner, at study area 25. The horizon contains abundant clay (74% on a <2 mm basis). The matrix is clayey, with some rhyolite and quartz. Ped faces lack argillans, but oriented striae within peds suggest former argillans now within peds. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 0.5 mm.

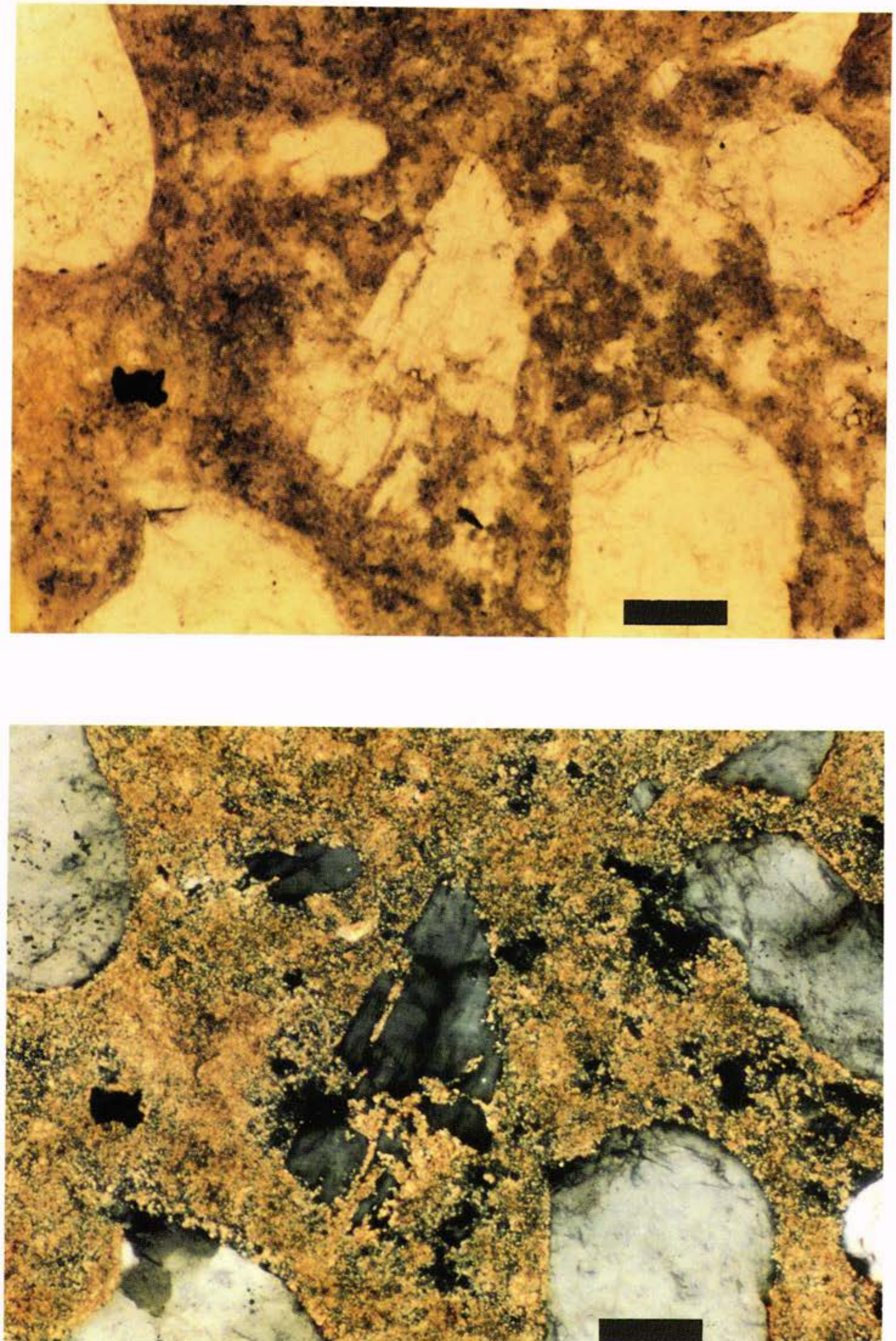


PLATE 22—Thin section of the plugged part of the K21m horizon of the Typic Petroargid, Rotura, at study area 26. The primary grain in the center has been partly dissolved and replaced with calcite. Grains are dominantly quartz, and are separated by the micrite matrix. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 10 µm.

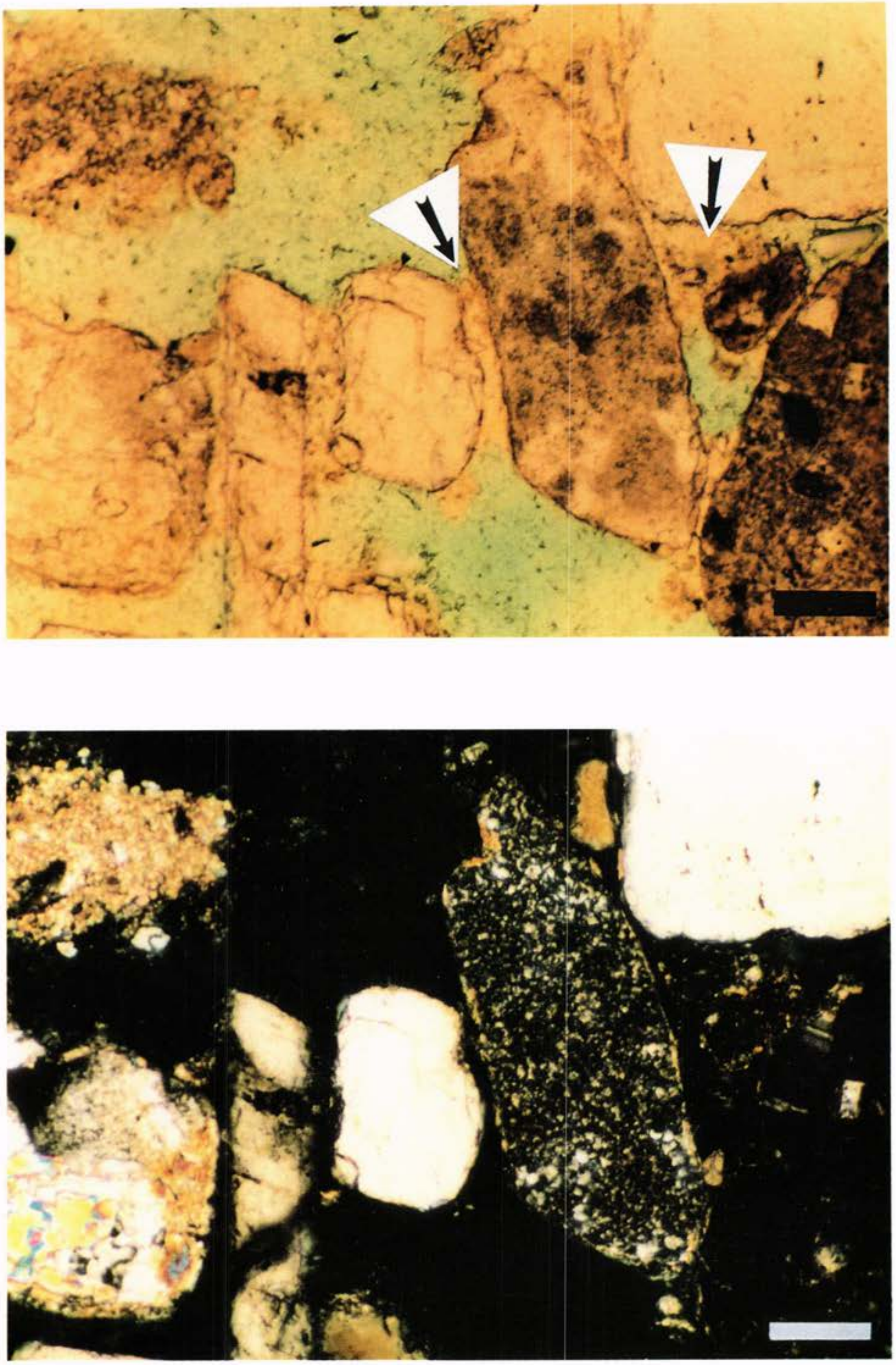
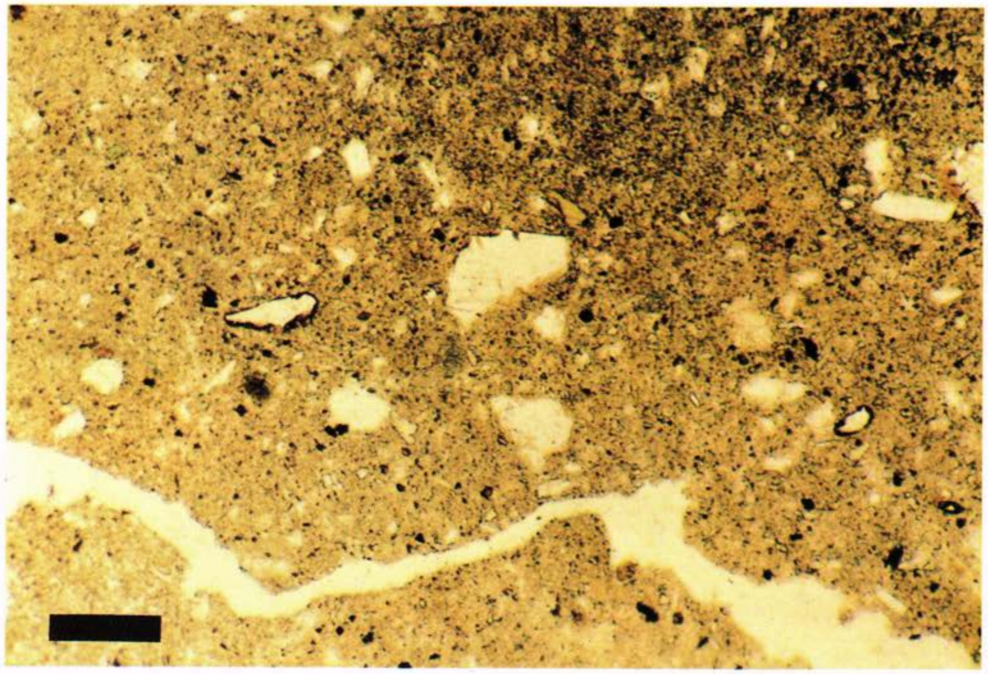


PLATE 23—Thin section of the C1 horizon of the Typic Petroargid, Rotura, at study area 26. Arrows locate opal miniscus bridges between grains, which are mostly quartz and rhyolite. Upper, plane-polarized light; lower, crossed polarizers. Bar scale = 100 µm.



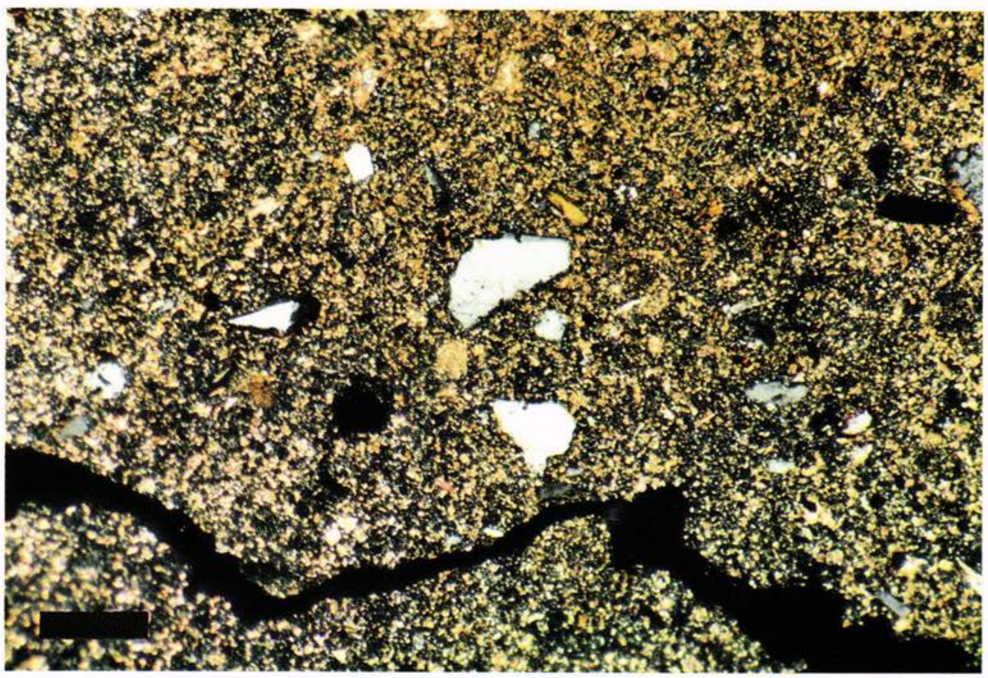
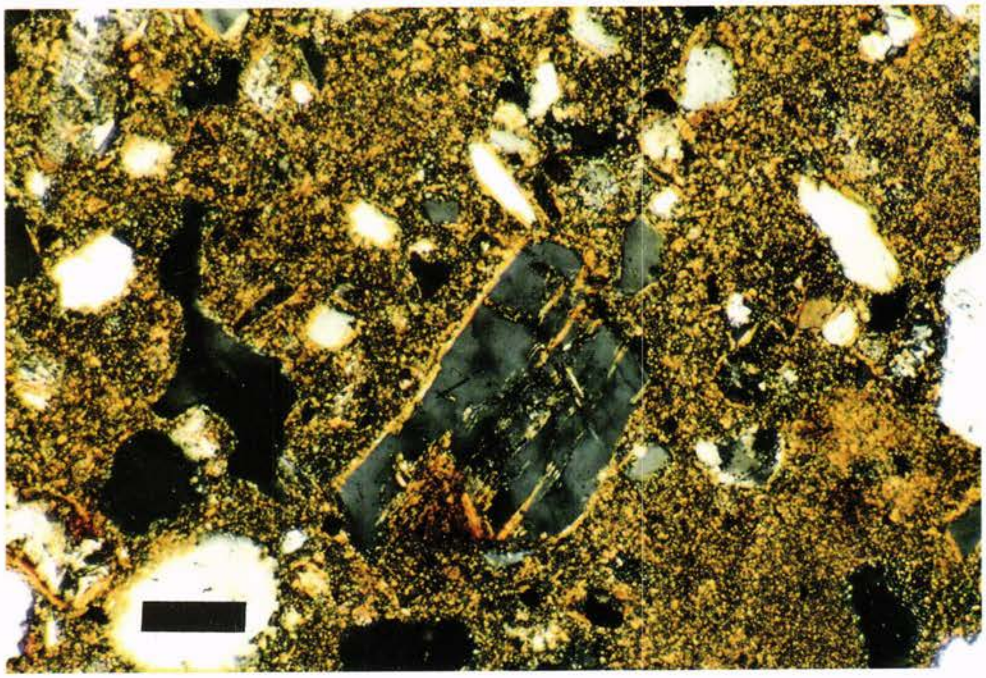


PLATE 24—Thin section of the Bk horizon of the Ustic Haplocalcid, Reagan, at study area 27. Although clay increases from A to B, argillans are not present because there is enough carbonate in the parent materials to prevent their formation. The sands are mostly very fine and are dominantly quartz. Upper, plane-polarized light; lower, crossed polarizers. Bar scales = 100 µm.



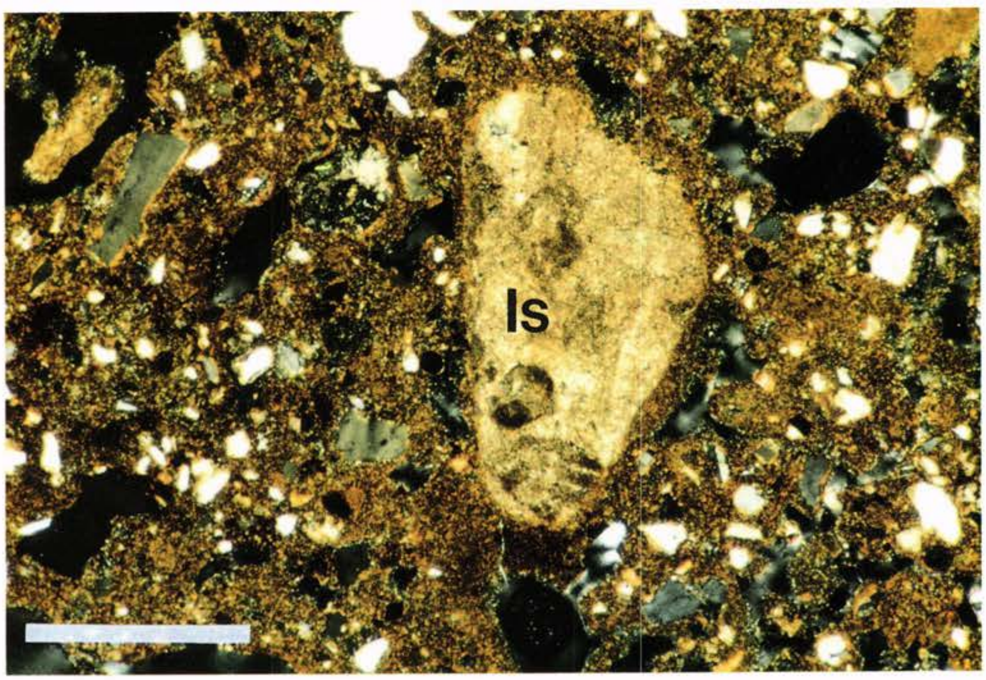


PLATE 25—Upper: Thin section of the Bt horizon of a buried argillic horizon beneath the Ustic Haplocalcid, Reagan, at study area 27. Feldspars and quartz are dominant. Distinct argillans occur on some grains but in others, argillans have been partly to wholly obliterated by carbonate. Clay along cleavage planes in the large feldspar grain in the center suggests the possibility of weathering, but the grain may have been deposited that way. Crossed polarizers. Bar scale = 100 µm. Lower: Another view of the same horizon shows influence of both primary and pedogenic carbonate on argillan development. No evidence of an argillan can be seen on the large limestone grain (1s) about in the center, and one may never have formed on this carbonate-rich material. Presence of primary carbonate shows that it is not necessary to leach out all of the limestone before argillans can form. Argillans are scarcer than in the view above, suggesting that large limestone grains may have a local depressing effect on the formation of argillans. Crossed polarizers. Bar scale = 0.5 mm.

Appendix-
pedon descriptions and
laboratory data

Appendix—pedon descriptions and laboratory data

Part 1: Berino 68-8

Soil Classification: Typic Calciargid, fine-loamy, mixed, thermic.
Series: Benno.
Pedon No.: S68NM-7-8.
Location: NE1/4 sec 23 T23S R1W, south bank of trench, Las Cruces Municipal Airport in pipe about 25 feet east of S61NM-7-7.
Geomorphic surface: La Mesa (upper).
Land Form: Relict basin floor, nearly level.
Elevation: 4,400 feet.
Parent Materials: Upper Camp Rice, basin-floor sediments consisting primarily of noncalcareous sand, with a few pebbles of mixed origin.
Vegetation: Snakeweed, *Yucca elate,* mesquite, fluffgrass.
Collected by: Horizons from 0-157 cm sampled by L. H. Gile, R. B. Grossman, and J. W. Hawley, December 13,1968; horizons from 120-292 cm sampled by L. H. Gile, May 20, 1987. Because of erosion along the trench and its later filling and subsequent reexcavation, there is overlap between the upper and lower sets of horizons.
Described by: Horizons from 0-157 cm described by L. H. Gile and R. B. Grossman; horizons from 120-292 cm described by L. H. Gile.

<u>Soil Surface</u> Covered by spoil pile.

<u>A 68L1400 0 to 5 cm</u> Reddish-brown (5YR 4.5/4 dry) and dark reddish-brown (5YR 3/4 moist) fine sandy loam; weak medium platy; slightly hard; no roots; noncalcareous; abrupt smooth boundary. (Not sampled because the horizon is overlain and disturbed by spoil pile. Sampled offset.)

<u>BAt 68L1401 5 to 30 cm</u> Yellowish-red (5YR, 4.5/6 dry) and dark reddish-brown (5YR 3.5/4 moist) fine sandy loam; weak very coarse prismatic, massive internally; hard; few roots; few insect burrows; noncalcareous; clear wavy boundary.

<u>Btkl 68L1402 30 to 48 cm</u> Yellowish-red (5YR 5.5/6 dry, 4/6 moist) and red (3YR 4.5/5 dry, 3/5 moist) sandy clay loam; weak very coarse prismatic breaking to weak coarse subangular blocky; hard; few roots; common fine carbonate filaments; effervesces strongly, clear wavy boundary.

<u>Btk2 68L1403 48 to 79 cm</u> Red (3 YR 4.5/5 dry, 3/5 moist) reddish-brown (5YR 5.5/4 dry, 4/4 moist) sandy clay loam; weak coarse prismatic breaking to moderate medium subangular blocky; hard; 10-20 percent 1/4 to 1/2 inch nonindurated carbonate nodules (segmented cylindroids); effervesces strongly; gradual wavy boundary.

<u>Btk3 68L1404 79 to 114 cm</u> Yellowish-red (5YR 5.5/6 dry, 4/6 moist) heavy fine sandy loam; weak coarse and medium subangular blocky; hard; about 20 percent red (3YR 4.5/5 dry, 3/5 moist) blebs; about 5 to 10 percent carbonate nodules and vertical veins that occur as prism coatings; some parts effervesce weakly; some strongly calcareous and a few parts noncalcareous; abrupt smooth boundary.

<u>K&B 63L1405114 to 157 an</u> About 70 percent of material with K-fabric, pink (7.5YR 8/4 dry) or light brown (7.5YR 6/4 moist) heavy sandy loam, and 30 percent of material with Bt-like fabric, reddish-brown (5YR 5.5/5 dry, 4/4 moist) sandy loam, occurring in nodular and cylindroidal form, with abrupt boundaries to adjacent K-fabric; generally breaks out as massive; hard; no roots; some of material with reddish-brown Bt fabric is noncalcareous; some parts effervesce weakly and the remainder effervesces strongly; clear wavy boundary.

<u>1987 sampling</u>

<u>K&B 88P4844S 120 to 138 cm</u> About 75 percent K-fabric colored pink (7.5YR 8/3 dry) or light brown (7.5 YR 6.5/3 moist); the remainder is light reddish brown (5YR 6/3 dry) or reddish brown (5YR 4.5/4 moist); sandy loam; weak and medium and fine subangular blocky; hard and very hard; no roots; sand grains in reddish-brown material coated with silicate clay; most of horizon effervesces strongly, the Bt material effervesces weakly or is noncalcareous; abrupt smooth boundary.

<u>K2 88P4845S 138 to 171 cm</u> Dominantly white (10YR 9/1 dry) or very pale brown (10YR 7.5/3 moist) with lesser amount of pinkish-white (7.5YR 8.5/2 dry) or pink (7.5YR 7/3 moist) cemented K-fabric that is easily removed by hammer; medium and coarse subangular blocky; extremely hard; no roots; this horizon disappears 30 cm to the east, at the boundary between the K2 and the pipe, and grades to a continuously indurated K2m just west of the sampled pedon; effervesces violently; clear wavy boundary.

<u>K3 88P4846S 171 to 195 cm</u> Dominantly white (10YR 9/2 dry), or light gray (10YR 7.5/2 moist) cemented K-fabric, that breaks out as medium and coarse subangular blocky, and is extremely hard; lesser amounts of pinkish gray (7.5YR 7/2 dry) or brown (7.5YR 5.5/3 dry) sandy loam that is massive and soft; no roots; effervesces violently; abrupt wavy boundary.

<u>Btkl' 88P4847S 195 to 208 cm</u> Light reddish-brown (5YR 6/4 dry) or reddish brown (5YR 4.5/4 moist) loamy sand; moderate fine and medium prismatic parting to weak medium subangular blocky; very and extremely hard; no roots; sand grains in reddish brown material coated with clay; prisms thinly coated with carbonate, colored pinkish white (7.5YR 9/2 dry), that descends along cracks between prisms, and that in many places is continuous with prism coatings that descend through the Btk subhorizons below; prism interiors noncalcareous; clear wavy boundary.

<u>Btk2' 88PR4848S 208 to 237 cm</u> Light reddish-brown (5YR 6/3 dry) or reddish-brown (5YR 4.5/4 moist) sand; moderate fine and medium prismatic; most prisms massive internally, others part to weak medium subangular blocky; generally very and extremely hard except for a discontinuous, irregular zone about 40 cm long and ranging from 5 to 15 **cm** in diameter, horizontal in part and making a right angle to

vertical, of soft to hard, calcareous material (not included in sample) that may represent an ancient krotovina; no roots; sand grains in reddish brown material coated with clay; prisms thinly coated with carbonate; prism interiors noncalcareous; dear wavy boundary.

Btk3' 88P48495 237 to 260 cm Light reddish-brown (5YR 6/3.5 dry) or reddish-brown (5YR 4.5/3.5 moist) sand; moderate fine and medium prismatic; most prisms massive, others part to weak medium subangular blocky; extremely hard; no roots; sand grains in reddish brown material coated with clay; prisms thinly coated with carbonate; prism interiors noncalcareous; clear wavy boundary.

Btk 88P48505 260 to 284 cm Light reddish-brown (5YR 6/4 dry) or reddish-brown (5YR 4.5/5 moist) sand; moderate fine and medium prismatic, parting to weak medium subangular blocky; extremely hard; no roots, sand grains in reddish brown material coated with clay; prisms thinly coated with carbonate; prism interiors noncalcareous; abrupt smooth boundary.

K2m 88P48515 284 to 292 cm Pinkish-white (7.5YR 9/2 dry) or pink (7.5YR 7/3 moist) cemented K-fabric; breaks with hammer into medium and coarse subangular blocky; extremely hard, no roots; effervesces strongly.

S68NM–013–008

PRIMARY CHARACTERIZATION DATA
(DOÑA ANA COUNTY, NEW MEXICO)
BERINO, FINE-LOAMY, MIXED, THERMIC TYPIC CALCIARGID

PRINT DATE 09/25/92
9/25/92

SSL – PROJECT 40A 1, SSIR SAMPLES
– PEDON 40A 807, SAMPLES 40 A 6103–6109
– GENERAL METHODS 1B1A, 2A1, 2B
SSL – PROJECT 88P 159, (RP88NM237) DESERT PROJECT
– PEDON 88P 898, SAMPLES 88P 4844– 4851
– 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	———	WT	———		WT
SAMPLE	DEPTH	HORIZON	LT	.002	.05	LT	LT	.002	.02	.05	.10	.25	.5	1	2	5	20	.1	PCT OF
NO.	(CM)		.002	–.05	–2	.0002	.002	–0.02	–.05	–.10	–.25	–.50	–1	–2	–5	–20	–75	–75	WHOLE
			<———				PCT OF < 2 MM (3A1) *a*						———	>	<PCT OF < 75 MM (3B1)>				SOIL
40A6103S	0–5	A	18.1	5.7	76.2			2.1	3.6	10.1	38.1	15.6	9.3	3.2	–	–	–	66	–
40A6104S	5–30	BAt	20.4	6.8	72.8			2.6	4.2	11.3	36.5	13.2	8.8	2.9	–	–	–	61	–
40A6105S	30–48	Btk1	18.3	3.8	77.9			1.2	2.6	9.6	39.2	15.5	9.8	3.8	–	–	–	68	–
40A6106S	48–79	Btk2	14.3	4.1	81.6			1.6	2.5	10.5	44.1	15.1	8.8	3.1	–	–	–	71	–
40A6107S	79–114	Btk3	13.9	8.2	77.9			2.6	5.6	11.2	40.4	13.3	9.3	3.7	–	–	–	67	–
40A6108S	114–157	K&B	10.4	8.4	81.2			3.1	5.3	11.4	42.9	14.0	9.7	3.3	–	–	–	70	–
40A6109S	157–188														–	–	–		–
88P4844S	120–138	K&B	11.6	14.1	74.3	5.7	3.4	7.4	6.7	10.9	38.2	16.1	6.4	2.7	3	1	1	65	5
88P4845S	138–171	K2	8.5	15.5	76.0	3.4	5.6	8.7	6.8	9.6	22.3	13.8	14.3	16.0	–	–	–	66	–
88P4846S	171–195	K3	8.5	14.5	77.0	3.6	3.4	8.2	6.3	10.7	28.8	15.0	11.6	10.9	2	1	–	67	3
88P4847S	195–208	Btk1'	5.0	12.9	82.1	2.4	0.8	8.1	4.8	14.5	43.6	15.7	6.4	1.9	1	–	–	68	1
88P4848S	208–237	Btk2'	2.5	9.1	88.4	1.6	0.8	4.6	4.5	14.6	43.5	21.8	6.8	1.7	TR	–	–	74	TR
88P4849S	237–260	Btk3'	1.2	5.9	92.9	0.9	0.3	1.8	4.1	9.4	41.9	26.4	11.4	3.8	1	–	–	84	1
88P4850S	260–284	Btk	0.6	7.6	91.8	0.6	0.6	2.9	4.7	9.7	42.7	27.9	9.7	1.8	TR	–	–	84	TR
88P4851S	284–292	K2m	3.8	13.5	82.7	1.1	2.0	4.1	9.4	11.5	21.1	19.7	17.5	12.9	–	–	–	71	–

a Horizons above 157 cm on carbonate-free basis, remainder on carbonate-containing basis.

DEPTH	ORGN	TOTAL	EXTR	TOTAL	(—DITH-CIT—		)	(RATIO/CLAY)		(ATTERBERG)		(—BULK DENSITY–)			COLE	(——WATER CONTENT—			)	WRD
	C	N	P	S	EXTRACTABLE				15	–LIMITS–		FIELD	1/3	OVEN	WHOLE	FIELD	1/10	1/3	15	WHOLE
DEPTH					FE	AL	MN	CEC	BAR	LL	PI	MOIST	BAR	DRY	SOIL	MOIST	BAR	BAR	BAR	SOIL
(CM)	6A1c	6B3a	6S3	6R3a	6C2b	6G7a	6D2a	8D1	8D1	4F1	4F	4A3a	4A1d	4A1h	4D1	4B4	4B1c	4B1c	4B2a	4C1
	PCT	<2MM	PPM	<—PERCENT OF <2mm —>						PCT	<0.4mm	<———	G/C	———>	CM/CM	<—PCT OF <2MM —>				CM/CM
0–5	0.23							0.67	0.36										6.6	
5–30	0.19							0.65	0.38										7.7	
30–48	0.11							0.66	0.40										7.4	
48–79	0.04							0.68	0.41										5.9	
79–114	0.04							0.55	0.47										6.6	
114–157	0.02							0.61	0.48										5.0	
157–188																				
120–138	0.08								0.51										5.9	
138–171	0.17								1.11										9.4	

	-1-	-9-	-19-
171–195	0.12	0.93	7.9
195–208	0.06	1.28	6.4
208–237	0.06	2.32	5.8
237–260	0.06	5.00	6.0
260–284	0.05		6.2
284–292	0.11	1.97	7.5

	-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	ITY	AL	SUM	NH4-	BASES	SAT	SUM	NH4	CACO3	OHMS		MMHOS		CACL2	H2O
DEPTH	5B5a	5B5a	5B5a	5B5a	BASES			CATS	OAC	+ AL			OAC	<2MM	/CM		/CM		.01M	
(CM)	6N2e	602d	6P2b	6Q2b		6H5a	6G9b	5A3a	5A8b	5A3b	5G1	5C3	5C1	6E1g	8E1		8I		8C1f	8C1f
	<——MEQ / 100 G——>									<——PCT——>									1:2	1:1
0–5									12.1					TR						
5–30									13.3					2						
30–48									12.1					6						
48–79									9.7					3						
79–114									7.6					10						
114–157									6.3					10						
157–188																				
120–138														14					7.8	8.2
138–171														55					7.9	8.4
171–195														40					7.9	8.4
195–208														6					7.8	8.3
208–237														6					7.8	8.2
237–260														6					7.7	8.2
260–284														4					7.7	8.1
284–292														63					8.1	8.5

ANALYSES: S=ALL ON SIEVED <2mm BASIS

CLAY MINERALOGY < .002 MM)

SAMPLE NUMBER	FRACTION	X-RAY 7A2i (peak size)	THERMAL DTA 7A6 (Percent)	THERMAL TGA 7A4b (Percent)	SiO2	Al_2O3	Fe2O3	MgO	CaO	K2O	Na2O	<>	EGME RETN 7D2 <mg/g>	INTERPRETATION < >
					ELEMENTAL 7C3 Percent									
88P4844	TCLY	MT 3 MC 2 CA 2 MI 2 KK 1				7.8	4.3			1.4				
88P4845	TCLY	CA 3 MT 1 MI 1 MC 1				2.8	1.3			0.4				
88P4846	TCLY	CA 3 MT 2 MC 2 MI 1 KK 1				3.0	2.6			0.8				
88P4847	TCLY	CA 3 MT 2 MC 2 MI 2 KK 1				5.7	4.4			1.5				
88P4848	TCLY	MT 3 MI 2 CA 2 KK 1				2.6	4.7			1.6				
88P4849	TCLY	MT 2 MI 2 MC 1 CA 1 KK 1				2.8	3.3			1.0				
88P4850	TCLY	MT 2 CA 2 MI 1				0.2	3.1			0.9				
88P4851	TCLY	CA 3 MC 2 MI 1				0.8	1.1			0.3				

FRACTION INTERPRETATION: TCLY Total clay, <0.002mm
MINERAL INTERPRETATION: MT montmorill MC mont-chlor CA calcite MI mica KK kaolinite
RELATIVE PEAK SIZE: 5 very large 4 large 3 medium 2 small 1 very small 6 no peaks

Part 2: Bucklebar 88-1

Soil classification: Typic Haplargid, fine-loamy, mixed, thermic.
Series: Bucklebar.
Pedon No. 588NM-013-001.
Location: SE1/4 NW¼ sec 18 T22S R3E, north bank of "Highway 70 gully", about 400 feet south of Highway 70.
Geomorphic surface: Isaacks' Ranch.
Land form: Broad drainageway in the coalescent fan piedmont, sloping 1 percent to the west-northwest.
Elevation: 4500 feet.
Parent materials: Broad drainageway sediments overlying a thick gully fill, both of Isaacks' Ranch age.
Vegetation: Barren.
Collected by: L. H. Gile, Aug. 6, 1988.
Described by: L. H. Gile.

Soil surface A barren area that has been eroded because it is between the deep gully along which the south-facing exposure is situated, and a roadside ditch only 4.5 m north. The soil surface is about 50 percent covered with the coarser sand grains and pebbles, up to 3 cm diameter, derived mostly from monzonite and rhyolite; there are a few limestone pebbles. A smooth crust of fine earth occurs between these fragments.

Bt 88P4852S 0 to 3 cm Brown (7.5YR 5/3 dry) or dark brown (7.5YR 3.5/4 moist) sandy clay loam; moderate very fine and fine granular, soft and loose; no roots; effervesces strongly; abrupt smooth boundary.

Btkl 88P48553S 3 to 8 cm Brown (7.5YR 5/3 dry) or dark brown (7.5YR 3.5/4 moist) sandy clay loam; weak medium and coarse subangulai blocky; slightly hard and hard; few roots; few carbonate filaments; effervesces strongly; clear wavy boundary.

Btk2 88P48545 8 to 14 cm Brown (7.5YR 5/3 dry) or dark brown (7.5YR 3.5/4 moist) sandy clay loam; weak medium prismatic, parting to weak medium and coarse subangular blocky; hard; few roots; a few carbonate filaments, and a few carbonate nodules in lower part, effervesces strongly; clear wavy boundary.

Btk3 88P48555 14 to 25 cm About 50 percent brown (7.5YR 5.5/3 dry) or dark brown (7.5YR 3.5/4 moist): 40 percent K-fabric colored pink (7.5YR 7/4 dry) or brown (7.5YR 5.5/4 moist), and 10 percent carbonate nodules colored white (7.5YR 9/2 dry) or pink (7.5YR 8/3 moist), ranging from about $^{1}/2$ to $1^{1}/2$ an diameter; sandy clay loam; weak medium prismatic, parting to weak fine and medium subangular blocky, hard and very hard; effervesces strongly; few roots; clear wavy boundary.

Btk4 88P4856S 25 to 42 cm Brown (7.5YR 5.5/3 dry) or dark brown (7.5YR 4/4 moist) sandy clay loam; weak medium prismatic, parting to weak medium and coarse subangular blocky; hard and very hard; very few roots; about 5 percent carbonate nodules, ranging from about 1/2 to $1^{1}/2$ cm diameter; effervesces strongly; dear wavy boundary.

Btk5 88P48575 42 to 56 cm Brown (7.5YR 5.5/3 dry) or dark brown (7.5YR 4/4 moist) sandy loam; weak coarse subangular blocky; hard and very hard; very few roots; about 1 percent carbonate nodules, ranging from $^{1}/2$ to 11/2 an in diameter; effervesces strongly; clear wavy boundary.

BCtkl 88P4858S 56 to 69 cm Light brown (7.5YR 6/3 dry) or dark brown (7.5YR 4/4 moist) sandy loam; weak coarse subangular blocky, hard; very few roots; a thin (1-3 cm), discontinuous zone of slightly redder, finer and harder material occurs at the base of the horizon and is less than 1 m wide along the exposure; this zone has about 10 to 20 percent carbonate nodules, commonly 1-2 cm diameter and some with a tendency to platiness; effervesces strongly; abrupt smooth boundary.

BCtk2 88P4859S 69 to 85 cm Brown (7.5YR 5.5/3 dry) or dark brown (7.5YR 4/4 moist) sandy loam; weak coarse subangular blocky and massive; slightly hard; few roots; very few carbonate nodules, about 1 cm diameter; effervesces strongly; abrupt and clear wavy boundary.

Ck 88P4860S 85 to 101 cm Light brown (7.5YR 6.5YR dry) or brown (7.5YR 5/4 moist) gravelly sandy loam; massive; slightly hard; very few roots; very few carbonate nodules, about 1 cm diameter; stratified; effervesces strongly; abrupt wavy boundary.

Cl 88P48615101 to 118 cm Light brown (7.5YR 6.5/4 dry) or brown (7.5YR 4.5/4 moist) sandy loam; massive; slightly hard; very few roots, stratified; effervesces strongly; abrupt wavy boundary.

C2 88P4862S 118 to 136 cm Light brown (7.5YR 6.5/4 dry) or brown (7.5YR 4.5/4 moist) gravelly sand; massive; soft; no roots; effervesces strongly; clear wavy boundary.

C3 88P48635136 to 148 cm Light brown (7.5YR 6/4 dry) or brown (7.5YR 4.5/4 moist) gravelly sand; massive; soft and slightly hard; nc roots; effervesces strongly; abrupt smooth boundary.

Ck' 88P4864S 148 to 152 cm Light reddish-brown (6YR 6/4 dry) or reddish-brown (6YR 4.5/4 moist) sandy loam; massive; hard and very hard; very few fine roots; few carbonate filaments and nodules; effervesces strongly; abrupt smooth boundary.

C 88P4865S 152 to 164 cm Light reddish-brown (6YR 5.5/4 dry) or reddish-brown (6YR 4/4 moist) loamy sand; massive; soft; no roots effervesces strongly.

PRIMARY CHARACTERIZATION DATA
(DOÑA ANA COUNTY, NEW MEXICO)

BUCKLEBAR, FINE-LOAMY, MIXED THERMIC TYPIC HAPLARGID

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

SSL - PROJECT 88P 159, (RP88NM237) DESERT PROJECT
- PEDON 88P 899, SAMPLES 88P 4852-4865
- 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-
			(——TOTAL——		)	(–CLAY—	)	(——SILT——	)	(———	SAND			)	(COARSE FRACTIONS(MM))					(>2MM)
			CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC	———	WT	———			WT
SAMPLE	DEPTH	HORIZON	LT	.002	.05	LT	LT	.002	.02	.05	.10	.25	.5	1	2	5	20	.1		PCT OF
NO.	(CM)		.002	-.05	-2	.0002	.002	-0.02	-.05	-.10	-.25	-.50	-1	-2	-5	-20	-75	-75		WHOLE
			<——					PCT OF < 2 MM (3A1)						——>	<PCT OF <75 MM (3B1)>					SOIL
88P4852S	0-3	Bt	20.1	21.5	58.4		0.6	14.3	7.2	13.0	21.9	10.8	7.4	5.3	10	9	1	56		20
88P4853S	3-8	Btk1	26.8	24.4	48.8		2.6	14.8	9.6	11.1	13.8	7.5	7.7	8.7	9	2	-	45		11
88P4854S	8-14	Btk2	26.1	24.5	49.4		3.7	13.9	10.6	12.1	13.4	7.7	7.8	8.4	7	TR	-	42		7
88P4855S	14-25	Btk3	26.0	28.3	45.7		5.7	14.0	14.3	11.3	16.0	7.6	5.9	4.9	5	-	-	38		5
88P4856S	25-42	Btk4	21.9	25.0	53.1		4.0	12.2	12.8	13.0	14.9	8.4	8.8	8.0	9	2	1	47		12
88P4857S	42-56	Btk5	18.3	24.4	57.3		2.0	12.4	12.0	10.3	14.2	10.4	10.9	11.5	13	4	2	57		19
88P4858S	56-69	BCtk1	16.3	21.8	61.9		1.4	11.1	10.7	8.9	14.1	12.3	12.6	14.0	17	6	4	66		27
88P4859S	69-85	BCtk2	14.9	20.1	65.0		1.1	11.4	8.7	8.0	14.0	14.1	16.5	12.4	15	4	4	67		23
88P4860S	85-101	Ck	13.1	16.0	70.9		0.8	8.7	7.3	6.6	16.0	16.7	15.6	16.0	15	14	4	76		33
88P4861S	101-118	C1	6.2	8.2	85.6		0.8	5.2	3.0	3.2	8.6	16.3	29.0	28.5	14	6	-	86		20
88P4862S	118-136	C2	4.1	4.6	91.3		0.6	3.1	1.5	1.9	6.7	16.1	31.2	35.4	33	8	-	94		41
88P4863S	136-148	C3	5.3	4.2	90.5		0.8	3.3	0.9	1.5	9.8	24.8	28.1	26.3	25	18	2	94		45
88P4864S	148-152	Ck'	12.8	9.1	78.1		1.7	5.3	3.8	11.3	33.7	13.7	9.5	9.9	14	10	1	75		25
88P4865S	152-164	C	6.6	6.2	87.2		1.1	1.7	4.5	1.0	33.9	37.9	9.2	5.2	5	2	1	87		8

	ORGN	TOTAL	EXTR	TOTAL	(—DITH-CIT—		)	(RATIO/CLAY)		(ATTERBERG)		(—BULK DENSITY—)			COLE	(——WATER CONTENT——			)	WRD
	C	N	P	S	EXTRACTABLE				15	—LIMITS—		FIELD	1/3	OVEN	WHOLE	FIELD	1/10	1/3	15	WHOLE
DEPTH					FE	AL	MN	CEC	BAR	LL	PI	MOIST	BAR	DRY	SOIL	MOIST	BAR	BAR	BAR	SOIL
(CM)	6A1c	6B3a	6S3	6R3a	6C2b	6G7a	6D2a	8D1	8D1	4F1	4F	4A3a	4A1d	4A1h	4D1	4B4	4B1c	4B1c	4B2a	4C1
	PCT	<2MM	PPM	<—PERCENT OF <2mm —>						PCT	<0.4mm	<———	G/C	———>	CM/CM	<———	PCT OF <2MM		——>	CM/CM
0-3	0.55								0.41										8.2	
3-8	0.55								0.39										10.5	
8-14	0.54								0.39										10.3	
14-25	0.41								0.35										9.1	
25-42	0.29								0.38										8.3	
42-56	0.27								0.40										7.3	
56-69	0.17								0.44										7.1	
69-85	0.11								0.43										6.4	
85-101	0.07								0.44										5.8	
101-118	0.06								0.66										4.1	
118-136	0.05								0.76										3.1	
136-148	0.01								0.66										3.5	

148–152	0.16	0.45	5.7
152–164	0.07	0.53	3.5

	-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	ITY	AL	SUM	NH4-	BASES	SAT	SUM	NH4	CACO3	OHMS		MMHOS		CACL2	H2O
DEPTH	5B5a	5B5a	5B5a	5B5a	BASES			CATS	OAC	+ AL			OAC	<2MM	/CM		/CM		.01M	
(CM)	6N2e	602d	6P2b	6Q2b		6H5a	6G9b	5A3a	5A8b	5A3b	5G1	5C3	5C1	6E1g	8E1		81		8C1f	8C1f
	<———MEQ / 100 G———								>	<———PCT———				>					1:2	1:1
0–3														2					8.0	8.4
3–8														8					7.9	8.4
8–14														11					7.8	8.0
14–25														15					7.8	8.1
25–42														12					7.8	8.3
42–56														4					7.8	8.3
56–69														4					7.8	8.1
69–85														5					7.9	8.3
85–101														5					7.8	8.1
101–118														4					7.9	8.2
118–136														3					7.9	8.1
136–148														5					7.9	8.2
148–152														8					7.8	8.2
152–164														4					7.9	8.2

ANALYSES: S=ALL ON SIEVED <2MM BASIS

Part 3: Yucca 88-2

Soil classification: Typic Calciargid, coarse-loamy, mixed, thermic.
Series: Yucca.
Pedon No.: S88NM-013-002.
Location: NE1/4 SE¼ sec 32 T21S R3E, 300 feet west of Moongate Road.
Geomorphic surface: Late Jornada II.
Land Form: Slight ridge sloping 2 percent west.
Elevation: 4590 feet.
Parent materials: Late Jomada II ridge alluvium.
Vegetation: Black grams, snakeweed.
Collected by: L. H. Gile, July 25, 1988.
Described by: L. H. Gile.

Soil surface The surface between grass clumps is 30-40 percent covered by the coarser sand grains and by pebbles up to 1 cm diameter. A smooth crust of fine earth is between these fragments.

E 88P4866S 0 to 5 cm Reddish-brown (5YR 5/4 dry) or dark reddish-brown (5YR 3.5/4 moist) sandy loam; weak medium platy; soft and loose; no roots; noncalcareous; abrupt smooth boundary. (Sample offset 2.3 m to north because of trench disturbance.)

Bt 88P4867S 5 to 18 an Reddish-brown (5YR 5/4 dry) or dark reddish-brown (5YR, 3.5/4 moist) sandy loam; weak coarse subangular blocky; slightly hard; sand grains coated with silicate clay; few roots; noncalcareous; dear boundary.

Btkl 88P4868S 18 to 29 cm Reddish-brown (5YR 5/4 dry) or dark reddish-brown (5YR 3.5/4 moist) gravelly sandy loam; weak coarse subangular blocky; slightly hard and hard; few roots; some sand grains coated or partly coated with silicate clay, others with carbonate; effervesces strongly; clear wavy boundary.

Btk2 88P4869S 29 to 43 cm Light brown (7YR 6/4 dry) or dark brown (7YR 4/4 moist) gravelly sandy loam, with a few parts reddish-brown (5YR 5/4, dry); weak coarse subangular blocky; hard; few roots; some sand grains coated or partly coated with silicate clay, others with carbonate; effervesces strongly; abrupt wavy boundary.

Btk3 88P4870S 43 to 53 cm Dominantly light brown (7.5YR 6/4 dry) or dark brown (7.5YR 4/4 moist) with lesser amount reddish-brown (5YR 5/4 dry); very gravelly sandy loam; weak coarse subangular blocky; hard and very hard; few roots; sand grain and pebbles in reddish brown parts have coatings and bridges of silicate clay, in light brown parts have carbonate coatings; reddish brown parts noncalcareous or effervesce weakly, light brown parts effervesce strongly; abrupt wavy boundary.

K1 88P4871S 53 to 60 cm Dominantly pinkish-white (7.5YR 7.5/2 dry) or pinkish-gray (7.5YR 6/3 moist) gravelly sandy loam, dominantly K-fabric; weak medium and coarse subanuglar blocky; hard and very hard; few roots; effervesces violently; abrupt wavy boundary.

K21 88P4872S 60 to 74 cm Pinkish-white and pinkish-gray (7.5YR 8/2 and 7/3 dry) or pinkish-white and light brown (7.5YR 8/3, 7/3, and 6/4 moist) gravelly sandy loam with K-fabric; weak medium and coarse subangular blocky; very and extremely hard; few roots; effervesces violently; dear wavy boundary.

K22 88P4873S 74 to 88 cm Pinkish-white and pinkish-gray (7.5YR 9/2 and 7/3 dry) or pinkish-gray and light brown (7.5YR 8/3, 7/3, and 6/4 moist) gravelly sandy loam with K-fabric; weak medium and coarse subangular blocky; very and extremely hard; few roots; effervesces violently; abrupt smooth boundary.

Bk 88P4874S 88 to 99 cm Light brown (7.5YR 6/4 dry) or brown (7.5YR 4.5/4 moist) gravelly loamy sand; weak medium subangular blocky; generally massive and soft, with some parts single grain and loose; very few roots; thin, discontinuous carbonate coatings on sand grains and pebbles; effervesces strongly; abrupt smooth boundary.

K 88P4875S 99 to 110 cm Pinkish-white (7.5YR 8/2 dry) or pink (7.5YR 7/3 moist) gravelly loamy sand with K-fabric; weak medium subangular blocky; very hard; very few roots; this horizon contains by far the largest rock fragment in the pedon, a flattish monzonite cobble about 11 cm in diameter and 5 cm thick (not included in sample); laterally to the east this horizon grades out as gravel content decreases; effervesces violently; abrupt wavy boundary.

Cl 88P4876S 110 to 130 cm Pinkish-gray (7.5YR 6/3 dry) or brown (7.5YR 4.5/4 moist) sand; massive slightly hard; very few roots; mostly stratified; a few reddish krotovinas, not stratified, and not included in sample; effervesces weakly; dear wavy boundary.

C2 88P4877S 130 to 143 cm Light brown (7.5YR 6/4 dry) or dark brown (7.5YR 4/4 moist) loamy sand; massive; slightly hard; effervesces weakly; abrupt smooth boundary.

Ck 88P4878S 143 to 153 cm Pinkish-gray (7.5YR 7.5/2 dry, 6/3 moist) sandy loam; weak medium subangular blocky; very hard; carbonate nodules colored pinkish-white (7.5YR 8/3 dry) or pinkish-gray (7.5YR 7/3 moist) occur in a single zone, on both sides of which there is much less carbonate; nodules again become more numerous about 15-20 cm to the east and west of the sampled zone; effervesces violently.

S88NM–013–002

PRIMARY CHARACTERIZATION DATA
(DOÑA ANA COUNTY, NEW MEXICO)
YUCCA, COARSE-LOAMY, MIXED, THERMIC TYPIC CALCIARGID

PRINT DATE 9/25/92

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

SSL – PROJECT 88P 159, (RP88NM237) DESERT PROJECT
– PEDON 88P 900, SAMPLES 88P 4866–4878
– 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-
			(——TOTAL———		)	(–CLAY–)		(—SILT——	)	(————	——SAND——			———)	(COARSE FRACTIONS(MM))(>2MM)				
			CLAY	SILT	SAND	FINE	CO3	FINE	COARSE	VF	F	M	C	VC	———	—WT—	———		WT
SAMPLE	DEPTH	HORIZON	LT	.002	.05	LT	LT	.002	.02	.05	.10	.25	.5	1	2	5	20	.1	PCT OF
NO.	(CM)		.002	–.05	–2	.0002	.002	–0.02	–.05	–.10	–.25	–.50	–1	–2	–5	–20	–75	–75	WHOLE
			<———	———	———	———	——PCT OF	< 2 MM (3A1)	———	———	———	———	———	——>	<–PCT OF	< 75 MM	(3B1)–>		SOIL
88P4866S	0–5	E	7.1	16.5	76.4			4.6	11.9	27.5	24.7	12.5	7.7	4.0	15	5	2	60	22
88P4867S	5–18	Bt	7.7	15.0	77.3			4.2	10.8	22.9	22.1	12.8	10.3	9.2	8	3	–	59	11
88P4868S	18–29	Btk1	8.8	16.2	75.0		–	4.2	12.0	24.2	21.0	12.0	10.4	7.4	11	3	1	58	15
88P4869S	29–43	Btk2	11.2	15.7	73.1		1.4	4.6	11.1	13.6	13.6	10.6	13.4	21.9	19	12	2	73	33
88P4870S	43–53	Btk3	15.0	17.5	67.5		1.4	6.4	11.1	15.7	13.4	10.9	12.0	15.5	43	24	18	93	85
88P4871S	53–60	K1	18.8	21.6	59.6		8.8	10.4	11.2	11.7	11.5	10.1	11.5	14.8	18	9	10	67	37
88P4872S	60–74	K21	16.3	19.9	63.8		7.0	10.9	9.0	11.0	11.7	11.9	14.1	15.1	21	14	10	74	45
88P4873S	74–88	K22	10.5	16.3	73.2		2.8	6.4	9.9	5.6	10.8	13.5	18.4	24.9	25	10	4	80	39
88P4874S	88–99	Bk	5.7	9.2	85.1		–	3.8	5.4	8.1	15.1	18.8	21.7	21.4	24	11	–	85	35
88P4875S	99–110	K	5.6	12.9	81.5		0.6	5.0	7.9	8.4	12.6	16.8	18.7	25.0	22	15	8	85	45
88P4876S	110–130	C1	2.6	4.4	93.0		–	1.3	3.1	5.2	13.1	19.5	25.0	30.2	26	2	–	91	28
88P4877S	130–143	C2	5.7	12.2	82.1		0.6	3.0	9.2	8.9	14.9	18.5	19.9	19.9	20	6	1	80	27
88P48785	143–153	Ck	14.4	26.8	58.8		–	12.6	14.2	15.5	16.1	11.0	8.6	7.6	11	12	–	56	23

	ORGN	TOTAL	EXTR	TOTAL	(– DITH-CIT –)			(RATIO/CLAY)		(ATTERBERG)		(-BULK DENSITY-)			COLE	(-WATER CONTENT-)				WRD
	C	N	P	S	EXTRACTABLE				15	—LIMITS—		FIELD	1/3	OVEN	WHOLE	FIELD	1/10	1/3	15	WHOLE
DEPTH					FE	AL	MN	CEC	BAR	LL	PI	MOIST	BAR	DRY	SOIL	MOIST	BAR	BAR	BAR	SOIL
(CM)	6A1c	6B3a	6S3	6R3a	6C2b	6G7a	6D2a	8D1	8D1	4F1	4F	4A3a	4A1d	4A1h	4D1	4B4	4B1c	4B1c	4B2a	4C1
	PCT	<2MM	PPM	<–PERCENT OF	<2mm	——>				PCT	<0.4mm	<———	G/C	———>	CM/CM	<——PCT OF	<2MM	——>		CM/CM
0–5	0.24								0.52										3.7	
5–18	0.39								0.53										4.1	
18–29	0.31								0.50										4.4	
29–43	0.35								0.49										5.5	
43–53	0.35								0.43										6.5	
53–60	0.45								0.31										5.9	
60–74	0.22								0.31										5.1	
74–88	0.13								0.33										3.5	
88–99	0.09								0.54										3.1	
99–110	0.09								0.55										3.1	
110–130	0.01								0.85										2.2	
130–143	0.07								0.58										3.3	
143–153	0.08								0.42										6.1	

	-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	ITY	AL	SUM	NH4-	BASES	SAT	SUM	NH4	CACO3		OHMS		MMHOS		CACL2	H2O
DEPTH	5B5a	5B5a	5B5a	5B5a	BASES			CATS	OAC	+ AL			OAC	<2MM		/CM		/CM		.01M	
(CM)	6N2e	602d	6P2b	6Q2b		6H5a	6G9b	5A3a	5A8b	5A3b	5G1	5C3	5C1	6E1g		8E1		81		8C1f	8C1f
	<———MEQ/100 G———>										<———PCT———>									1:2	1:1
0–5														TR						7.2	7.8
5–18														TR						7.7	8.1
18–29														2						7.9	8.3
29–43														5						7.8	8.4
43–53														5						7.9	8.2
53–60														23						7.9	8.3
60–74														21						7.9	8.4
74–88														13						8.0	8.5
88–99														5						8.1	8.5
99–110														10						8.1	8.2
110–130														2						7.9	7.9
130–143														3						8.1	8.5
143–153														12						8.2	8.4

ANALYSES: S= ALL ON SIEVED <2mm BASIS

Part 4: Soledad 66-16

Classification: Typic Haplargid; loamy-skeletal, mixed, thermic.
Soil: Soledad.
Soil Nos.: S66NMex 7-16.
Location: NW¼ NE1/4 sec 30 T23S R3E, 100 feet north of arroyo channel, 400 feet west of pipeline, Dona Ana County, New Mexico.
Elevation: 4,350 feet.
Land Form: Low alluvial terrace sloping 2 percent to the west.
Geomorphic Surface: Fillmore.
Vegetation: Creosotebush and ratany.
Parent Material: Fillmore terrace alluvium derived from rhyolite.
Collected by: L. H. Gile, R. B. Grossman, J. W. Hawley, and W. C. Lynn, November 10, 1966.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface There is a concentration of cobbles and coarse pebbleson the surface—most about 3 to 4 inch diameter with a few ranging up to 6 inch diameter.

A2 66L790 0 to 5 cm Reddish-brown (6YR 5.5/4 dry, 6YR 4/4 moist) very gravelly light sandy loam; weak medium and thin platy; soft; no roots; noncalcareous; abrupt smooth boundary.

B21t 66L791 5 to 15 cm Reddish-brown (5YR, 4.5/4 dry, 5YR 3.5/4 moist) very gravelly sandy loam; weak very fine crumb; loose and soft; few roots; pebbles and sand grains weakly stained reddish-brown; noncalcareous; clear smooth boundary.

B22tca 66L792 15 to 25 cm Reddish-brown (5YR 4.5/4 dry, 5YR 3.5/4 moist) very gravelly sandy loam; interpebble material is weak very fine crumb; soft and loose; few roots; tops of many pebbles are noncalcareous and weakly stained reddish-brown; interpebble fine earth is noncalcareous or effervesces weakly; clear smooth boundary.

Clca 66L793 25 to 58 cm Brown (7.5YR 5.5/53 dry, 7.5/YR 4.5/3 moist) very gravelly sandy loam; single grain and weak fine crumb between pebbles; soft and loose; roots few to common; carbonate coatings mainly on pebble bottoms but with some discontinuous coatings and filaments on tops; effervesces strongly; clear wavy boundary.

C2ca 66L794 58 to 94 cm Light brown (7.5YR 6.5/4 dry) or brown (7.5YR 4.5/4 moist) very gravelly sandy loam; massive and single grain; soft and loose; few roots; thin, continuous and discontinuous coatings on pebbles and sand grains, with a tendency for carbonate to occur primarily on pebble bottoms; several low-gravel lenses, 1 to 2 inch diameter; laterally the very gravelly sediments grade into low-gravel sediments with only a few gravel lenses; effervesces strongly; clear wavy boundary.

C3ca 66L795 94 to 132 cm Reddish-brown (5YR 5/4 dry) or reddish-brown (5YR 4/4 moist) fine very gravelly sand; massive and single grain; soft and loose; no roots; thin, discontinuous carbonate coatings on pebbles; effervesces weakly.

B2 66L796 Description of offset sample from a 5- to 25-cm horizon, low in gravel Reddish-brown (5YR 5.5/4 dry, 5YR 4/4 moist) sandy loam; massive; slightly hard; few roots; some weak staining of sand grains and pebbles; noncalcareous.

Micromorphology, Method 4Elb The lower part of the B21 horizon was examined in thin section. The fabric consists largely of coarse fragments and larger sand-size grains. Fines form a loose network within the interstices. A continuous very thin coating of oriented clay on sand grains is very common. Many grains, in addition, have thicker, patchy coatings of clay-rich fabric. These latter coatings show moderate to weak internal orientation of the clay. They are often thicker in embayments. Some apparently are inherited from previous cycles of soil development. Fragments of rhyolite groundmass are the most common component. These fragments contain numerous small black opaque grains, and such grains are common also in the fines in the interstices. Discrete quartz and feldspar are next in abundance. Ferromagnesian minerals are scarce with biotite, epidote and hornblende in the order listed. The mica appears weakly altered for the most part. Peripheral alteration is rather strong for a minority of grains; this alteration may be inherited from earlier cycles of soil development. A few grains have patchy opaque coatings, and a larger number of grains have patchy reddish-brown coatings that absorb light very strongly and show only weak internal orientation of silicate clay. Overall, the impression of alteration from earlier cycles of soil development is strong

SOIL CLASSIFICATION: Typic Haplargid, loamy-skeletal, mixed, thermic
SOIL Soledad SOIL Nos. S66NMex-7-16 LOCATION Doña Ana County, New Mexico
SOIL SURVEY LABORATORY Lincoln, Nebraska LAB Nos. 66L790-66L799
GENERAL METHODS: 1A1, 1B1b, 2A1, 2B

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Depth (cm)	Horizon	Sand class and particle diameter (mm) 3A1: Total Sand (2–0.05)	Total Silt (0.05–−0.002)	Total Clay (<0.002)	Sand Very coarse (2–1)	Sand Coarse (1–0.5)	Sand Med. (0.5–0.25)	Sand Fine (0.25–0.1)	Sand Very fine (0.1–0.05)	Silt (0.05–0.02)	Silt Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	<0.074	*a* 3B2 Vol. 250–2 %<250	2A2 Coarse fragments 3B1 Wt. 76–19 % <76 mm	*b* 19–5	5–2
		← Pct. of < 2 mm →																
0–5	A2	73.2	18.2	8.6	3.0	4.3	5.4	29.2	31.3	13.0	5.2	64.8	41.9	44.4				
5–15	B21t	70.3	17.4	12.3	7.8	6.8	6.9	24.8	24.0	12.3	5.1	52.8	46.3	43.3	60	37	25	8
15–25	B22tca	68.7	19.3	12.0	5.6	7.3	7.6	24.6	23.6	14.1	5.2	53.2	45.1	45.5	60	37	25	8
25–58	Clca	73.2	17.8	9.0	13.7	11.2	7.5	21.2	19.6	12.2	5.6	44.8	53.6	38.0	60	17	36	17
58–94	C2ca	74.3	17.6	8.1	19.9	11.0	7.5	19.2	16.7	10.7	6.9	38.9	57.6	35.5	60	17	36	17
94–132	C3ca	83.8	9.3	6.9	31.7	19.6	9.5	15.3	7.7	4.7	4.6	20.3	76.1	20.3				
5–25	B2	72.3	17.8	9.9	5.4	6.5	5.8	26.9	27.7	12.8	5.0	58.8	44.6	42.3				

Depth (cm)	6A1a Organic Carbon *d* Pct.	N Pct.	C/N	Carbonate as $CaCO_3$ 6E1b, 6E2a >2 mm Pct.	Carbonate <2 mm Pct.	6C2b Ext. Iron as Fe Pct.	Bulk density *e* g/cm³	Bulk density g/cm³	Bulk density g/cm³	6S1a Phos. Total Pct.	Water Content Pct.	Water Content 4B2 15-Bar Pct.	Water Content Pct.	8D1 15-Bar to Clay Ratio	pH (1:1)
0–5	0.20				−(s)	0.9	1.4			0.021		4.0		0.47	
5–15	0.32				tr(s)	0.8	1.4			0.021		4.8		0.39	
15–25	0.46				1	0.7	1.4			0.025		4.6		0.38	
25–58	0.30				2	0.7	1.4			0.018		4.3		0.48	
58–94	0.22				3	0.7	1.4			0.029		5.1		0.63	
94–132	0.09				1	0.6	1.4			0.021		3.8		0.55	
5–25	0.16				tr(s)		1.5			0.021		4.0		0.40	
25–94				1 *b*											
25–94				tr(s) *c*											

a Large samples from 5 to 25 and 25 to 94 cm zones sieved and weighed in field.
b <19 mm.
c 76–19 mm.
d 2.2 kg/m^2 to 94 cm (Method 6A).
e Assumed bulk density of moist fine-earth fabric for calculations.

Part 4
Soledad
66–16

Part 5: Hachita 59-16

Soil Classification: Argic Petrocalcid, loamy-skeletal, mixed, thermic, shallow.
Soil: Hachita.
Soil Nos.: S59NMEX-7-16.
Location: SE1/4 SE1/4 sec 19 T23S R3E, north bank of arroyo, 1,500 feet east of pipeline, Dona Ana County, New Mexico.
Parent Material: Picacho terrace alluvium derived from rhyolite.
Geomorphic Surface: Picacho.
Land Form: Alluvial terrace sloping 2 percent to the west.
Elevation: 4,410 feet.
Vegetation: Creosotebush, whitethorn, and ratany.
Collected by: J. S. Allen, L. H. Gile, R. B. Grossman, and R. V. Ruhe, May 21, 1959.
Described by: L. H. Gile and R. B. Grossman.

Soil Surface Desert pavement of pitted and varnished fine rhyolite pebbles; discontinuous layer of loose reddish sand occurs between pebbles.

A21 11341 0 to 1 cm Brown (7.5YR 4.5/2 dry) or dark brown (7.5YR 3/2 moist) gravelly loam; moderate medium platy; soft; no roots; strongly vesicular; noncalcareous; abrupt wavy boundary.

A22 11342 1 to 5 cm Brown (7.5YR 5/4 dry) or dark brown (7.5YR 3.5/3 moist) gravelly fine sandy loam; weak fine and very fine platy; soft; few roots; noncalcareous; abrupt smooth boundary.

B21t 11343 5 to 15 cm Reddish-brown (5YR 5/4 dry, 4/4 moist) very gravelly heavy fine sandy loam; weak very fine crumb; slightly hard; roots common; thin, discontinuous coatings of silicate clay on pebbles and sand grains, and there are some day bridges; dominantly noncalcareous; abrupt to clear wavy boundary.

B22tca 11344 15 to 28 cm Reddish-brown (5YR 5/4 dry) or dark reddish-brown (5YR 3.5/4 moist) very gravelly sandy day loam; slightly hard; roots common; interstice filings are weak fine crumb and adhere weakly to pebble surfaces; powdery carbonate coatings intermingled with reddish-brown day coatings on pebbles; effervesces strongly; abrupt smooth boundary.

K21m (Clcam) 11345 28 to 30 cm The laminar subhorizon occurs in the upper 1/4 to 1/2 inch, uppermost laminae (Lab. No. 15029) are pink (7.5YR 7/4 dry) or light brown (7.5YR 6/4 moist), and score readily with a knife; remaining laminae (Lab. No. 15030) score difficulty with a knife and range from white (10YR 9/2 dry) or very pale brown (10YR 8/3 moist) to very pale brown (10YR 7/4 dry) or light yellowish-brown (9YR 6/4 moist); underlying the laminar subhorizon (Lab. No. 15031) is pink (7.5YR 7/4 dry) and light brown (7.5YR 6/4 moist) massively cemented material; very and extremely hard; powdery, white carbonate coatings on most pebbles with flaky, brittle, olive-colored coatings occurring on some pebbles; no roots; effervesces strongly; dear wavy boundary.

K22m (C2cam) 11346 30 to 64 cm Pink (5YR 8/3 dry 7/4 moist) and white (10YR 9/1 dry) or very pale brown (10YR 8/3 moist) massively cemented material; some interstice fillings are pinkish-gray (5YR 7/2 dry) and light brown (7.5YR 6/4 moist); dominantly very hard with some parts only weakly cemented; the upper 10 inches contain cracks filled with reddish-brown loam in which roots are concentrated; effervesces strongly; clear wavy boundary.

K3 (C3ca) 11347 64 to 127 cm Mostly lenses of loose fine gravel and weakly cemented fine gravel with pockets of light brown (7.5YR 6/4 dry) or dark brown (7.5YR 4/4 moist); massive; very hard but nonindurated loamy material; few roots; pebbles in loose gravel bands have hard, flaky carbonate coatings on undersides; many fine carbonate nodules in loamy material; effervesces strongly.

Radiocarbon Dates

Sample Description	Radiocarbon Age yrs. B.P.
B22tca	
Carbonate in whole material (LSL 15027; 1-374)	5,725 ± 200
Carbonate associated with >2mm *a* (LSL 15027; 1-1039)	10,226 ± 400
Carbonate in <2 mm (LSL 15027)	1,300 (computed *c*)
Organic carbon in < 2mm (LSL 11344; 1-2222)	565 ± 95
Organic carbon in water-dispersed <0.002 mm; see method 3Alc (LSL 11344; 1-2223)	910 ± 100
K2lm	
Carbonate in soft laminar part (LSL 15029; 1-375)	4,575 ± 170
Carbonate in hard laminar part (LSL 15030; 1-392)	13,850 ± 600 *d*
Organic carbon in hard laminar part (LSL 15030; 1-616)	9,550 ± 300
Carbonate in non-laminar part (LSL 15031; 1-391)	18,300 ± 600
K22m	
Carbonate in whole material (LSL 15032; 1-376)	15,300 ± 400
Carbonate associated with >19 mm *b* (LSL 20849; 1-2128)	27,900 + 1,100 - 1,000

a >2 mm washed, dried, and ground to form the sample.
b > 19 mm washed in water, dried, and loosely adhering carbonate remoed with an electric buffing wheel. Pebbles were then ground to form the sample.
c From dates on whole material and > 2 mm plus carbonate percentages.
d The ð (C^{13})% is + 2.0.

Mineralogy The 0.05 to 0.02 mm of the 1(21m (28-30 cm) was examined by Method 7B1 by the Beltville Laboratory. The light fraction contains 75 percent feldspar, the majority microcrystalline aggregates, 15 percent quartz, and 10 percent mica, mostly altered. The heavy fraction consists mostly of ore minerals with 10 percent each hornblende and epidote, 5 percent zircon and 2 percent tourmaline.
The B22tca horizon (15-28 cm, 11344) contains small amounts of montmorillonite, mica and kaolinite (Method 7A2). The montmorillonite is very poorly ordered. Removal of the carbonate with pH 5 NaOAc buffer from the sample of the B22tca did not lead to a change in the X-ray traces of the clay minerals. Only a trace of calcite is present in the untreated sample. The K3 horizon (64-127 cm, 11347) contains moderate to abundant montmorillonite with small amounts of mica and kaolinite. The montmorillonite is fairly well ordered.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION: Argic Petrocalcid, loamy-skeletal, mixed, thermic, shallow
SOIL Hachita SOIL Nos. S59(61)NMex-7-16 LOCATION Doña Ana County, New Mexico
SOIL SUREY LABORATORY Lincoln, Nebraska LAB Nos. 11341-11347, 15029-15031
GENERAL METHODS: 1A1, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Sand class and particle diameter (mm) 3A1: Total Sand (2–0.05)	Total Silt (0.05–-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.05)	Sand Med. (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt 0.05-0.02	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	2A2 Coarse fragments g 3B1 Vol. 250-2 %<250	Wt. b 76-19 %<76	Wt. b 19-2 %<19
		<					Pct. of < 2 mm						>			
							Carbonate removed a									
0-1	A21	57.1	30.1	12.8	4.0	2.8	2.4	17.1	30.8	19.7	10.4	62.7	26.3	15	25	25
1-5	A22	60.0	26.7	13.3	5.9	3.6	2.6	18.4	29.5	16.1	10.6	58.4	30.5	25	39	26
5-15	B21t	63.8	19.6	16.6	12.2	4.2	3.0	18.6	25.8	12.7	6.9	51.3	38.1	40	53	39
15-28	B22tca	53.8	23.8	22.4	16.7	3.9	2.4	13.5	17.3	13.4	10.4	39.9	36.5	45	63	46
28-30	K21m	58.0	18.5	23.5	25.3	8.7	3.3	9.9	10.8	14.9	3.6	31.6	47.2	40	80	57
30-64	K22m	62.3	15.7	20.0	27.8	7.3	3.4	11.8	14.0	10.4	5.3	31.9	48.3	65	87	26
64-127	K3	73.8	12.9	13.3	27.2	9.5	4.6	17.1	15.4	9.3	3.6	35.5	58.4	55	71	30
j	K21m	20.1	26.6	53.3	9.2	2.7	0.8	1.2	6.2	13.1	13.5	19.6	13.9			
j	K21m	46.9	22.0	31.1	16.7	6.4	2.9	9.0	11.9	11.4	10.6	29.0	35.0		22	22
j	K21m	66.3	13.8	20.4	11.6	5.8	10.1	20.8	18.0	8.9	4.9	38.5	48.3		45	36

Depth (cm)	6A1a Organic Carbon b, h	6A1a Organic Carbon a	6B1a Nitrogen a	C/N	Carbonate as $CaCO_3$ d	5A1a CEC NH_4OAc a	6C1a Ext. Iron as Fe a	i			Water Content 4B2 15-Bar	Composition Whole Material c, g: Noncarbonate > 2mm	Sand	Silt	Clay	Carbonate as $CaCO_3$
	Pct.	Pct.	Pct.		Pct.		Pct.	g/cm³	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
0-1	0.44	0.44	0.053	8	-	13.0		1.4				25	42	22	10	-
1-5	0.29	0.29	0.034	8	-	12.6		1.4			6.6	39	34	18	9	-
5-15	0.37	0.37	0.047	8	tr	13.6	0.8	1.4			6.8	53	28	11	8	tr
15-28	0.74	0.82	0.086	10	10	17.1	0.8	1.4			10.7	60	19	9	8	4
28-30	0.15	0.73	0.075	10	80	16.3	0.9	2.0				45	6	2	3	44
30-64	0.14	0.34	0.040	8	58	16.4	0.8	1.8				74	7	2	2	15
64-127	0.11	0.14	0.019		23	10.1	0.9	1.7				65	20	3	4	8
28-30	0.49	1.89	0.425	14	74	35.9	1.4					-	5	7	13	74
28-30	0.15	0.91	0.089	10	83	21.8	0.9					4	7	4	5	80
28-30	0.25	0.46	0.054	8	46	16.8	0.7					10	38	8	12	32

TOTAL ANALYSIS *e*

LSL. No.	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	K_2O	MgO	Ign. Loss	Total
	<			% < 2 mm a				>	
11341									
11342									
11343	72.3	11.3	3.64	0.63	0.79	3.26	0.93	2.70	95.6
11344	70.1	11.4	3.38	0.55	0.77	3.38	0.84	3.02	93.4
11345	58.8	16.5	4.72	0.68	1.06	3.08	1.81	9.44	96.1
11346	66.3	12.9	3.36	0.54	0.89	3.72	1.92	6.04	95.7
15029	74.2	10.2	3.34	0.55	0.76	2.66	1.30	3.64	96.7
15030	69.5	11.9	3.15	0.50	0.59	3.86	0.93	3.00	93.4
15031	70.6	10.7	2.37	0.41	0.45	4.05	0.80	1.90	91.3
	<			% > 2 mm a				>	
15030	73.8	13.2	1.36	0.23	0.13	5.32	0.20	0.91	95.2
15031	73.9	12.2	1.50	0.27	0.09	5.34	0.16	0.77	94.2
	<			Whole Material a				>	
15029	58.8	16.5	4.72	0.68	1.06	3.08	1.81	9.44	96.1
15029 f	59.0	17.2	3.76	0.67	1.07	3.17	1.82	9.42	96.1
15030 f	66.4	14.8	2.13	0.35	0.71	4.76	1.52	4.89	95.5
15031 f	72.2	13.8	1.16	0.26	0.46	5.11	0.66	1.97	95.6

a Carbonate removed by Method 1B3 and the determination made on and reported for the sample so treated.
b Determination on sample treated by Method 1B3 to remove carbonate; values expressed on a carbonate-containing basis.
c Inclusive of coarse fragments, carbonate, gypsum; carbonate directly on whole material by Method 6E1a.
d Determination on whole material by Method 6E1a and calculated as a percentage of the < 2 mm
e Beltsville Soil Survey laboratory, Method 7C2. Borate glass disks used for all elements except magnesium, which was determined on a soil powder.
f Computed from total analyses on separate samples of the whole material before and after removal of the carbonate by Method 1B3. The computations for 15030, 15031 require summing the analyses on the > 2 mm and the < 2 mm after treatment by Method 1B3.
g Volume on carbonate-containing basis; weight on carbonate-free basis.
h 1.2 kg/m² to 28 cm (Method 6A).
i Assumed bulk densities of moist fine-earth fabric for calculations.
j Upper part, soft laminar zone; middle, the hard laminar zone: lower, the adhering non-laminar material.

Part 6: Delnorte 67-2

Soil Classification: Typic Petrocalcid, loamy-skeletal, mixed, thermic, shallow.
Series: Delnorte.
Pedon No.: S67NMex-7-2.
Location: In the NE1/4 SE1/4 sec 19 R3E T23S, Doña Ana County, New Mexico.
Geomorphic Surface: Jomada I.
Land Form: Summit of broad ridge remnant of coalescent alluvial-fan piedmont surface; sloping 2 percent to the southwest.
Elevation: 4,425 feet.
Parent Material: Upper Jomada I alluvium derived from rhyolite.
Vegetation: Creosotebush, ratany, a few pricklypear.
Collected by: L. H. Gile, June 19, 1967.
Described by: L. H. Gile.

Soil Surface 90 to 95 percent covered with a desert pavement or rhyolite pebbles, mainly <1 inch in diameter, but with a few up to 2 inches in diameter. Most of the pebbles are carbonate-free, with only a very few having thin, discontinuous carbonate coatings. Some of the pebbles are partially to completely coated with black desert varnish. A thin, discontinuous layer of reddish-brown sand, about 1 mm thick, occurs between and beneath the pebbles.

A2ca 0 to 5 cm Dominantly pinkish-gray (7.5YR 6/2 dry) or dark brown (7.5YR 4/2 moist) with some light brown (7.5YR 6/4 dry) or dark brown (7.5YR 4/3 moist); gravelly fine sandy loam; weak fine platy; soft; some thin (<1 mm) reddish-brown layers between plates in upper part; pebble tops are usually carbonate-free, and some are stained reddish-brown; pebble bottoms have thin, discontinuous carbonate coatings; very few roots; effervesces weakly; abrupt smooth boundary.

Bca 5 to 18 cm Brown (7.5YR 5/4 dry) or dark brown (7.5YR 4/4 moist) very gravelly light sandy clay loam; structure is pebble controlled, and is weak fine crumb and weak medium and fine subangular blocky; soft and slightly hard; few roots; they primarily continuous carbonate coatings on pebbles with coating thickest on undersides and generally becoming thicker in the lower part of the horizon; some pebble tops in the upper part of the horizon are carbonate-free and a few are stained reddish-brown; a few carbonate filaments occur in interpebble fine earth; effervesces strongly; clear smooth boundary.

K1 18 to 30 cm Dominantly white (10YR 9/2 to 9/3 dry) or very pale brown (10YR 8/3 moist), carbonate-cemented fragments; massive; hard; the horizon consists largely (80 to 90 percent) of fractured laminar and plugged horizons; fragments of a formerly continuous, uppermost laminar horizon occur from about 7 to 8 inches with another at from about 10 to 11 inches; although the lowest one is more continuous, it is broken enough so it can usually be removed with the fingers; the plugged horizon has scattered pinkish parts, suggesting a former Bt horizon; fine earth between the fragments is brown (7.5YR 5.5/4 dry, 7.5YR 4.5/4 moist) and is a very gravelly light sandy day loam; soft mass of weak fine crumbs; fine roots are common in the fine earth; effervesces strongly; abrupt smooth boundary.

K21m 30 to 36 cm The continuous laminar horizon and adherent plugged horizon, dominantly white (10YR 9/2 dry or 10YR 8/2 moist) with some colors slightly darker, and some pinkish parts, suggesting a former Bt horizon; massive; extremely hard; no roots; pebbles in plugged horizon are widely separated by carbonate; laminar horizon ranges from 1/8 to 1/2 inch in thickness; effervesces strongly; clear smooth boundary.

K22m 67L192 36 to 56 cm Pink (7.5YR 8/4 dry) or light brown (7.5YR 6/4 moist) carbonate-cemented material; very and extremely hard; massive; no roots; many pebbles separated from each other by carbonate; effervesces strongly; dear wavy boundary.

IIK31 56 to 89 cm Dominantly very pale brown (10 YR 9/3 dry, 10YR 8/3 moist) with some pink (7.5YR 7/4 dry) or light brown (7.5YR 6/4 moist) day loam; weak medium subangular blocky; hard and very hard; no roots; a few pebbles, carbonate-coated; virtually all of the horizon is K-fabric with sand grains separated by carbonate; effervesces strongly; dear smooth boundary.

IIIK32 89 to 132 cm Pink (8YR 8/4 dry) or light brown (8YR 6/4 moist) very gravelly sandy day loam; massive and weak fine and very fine crumb; soft and loose; no roots; pebbles largely discrete but a few are weakly cemented together; thin, continuous carbonate coatings or pebbles and sand grains; effervesces strongly.

Radiocarbon Dates

A date of 19,700 years B.P. (I-3009, LSL 67192) was obtained for the carbonate removed from the >20 mm pebbles from the K22m horizon (36-56 cm). The pebbles were allowed to stand in water two days. They were then sieved, dried, and the surface abraided by hand with a steel brush. Massive but non-laminar carbonate that still adhered was removed by scraping with a knife. A Vibratool was used to remove the largely laminar coatings. These coatings were ground to form the sample, which contained 70 percent carbonate.

Part 7: Hachita 70-8

Soil Classification: Argic Petrocalcid, loamy-skeletal, mixed, thermic, shallow.
Series: Hachita.
Pedon Nos.: S70NMex-7-8.
Location: The SE1/4 SW1/4 sec 17 R23S R3E, 600 feet east of road, Doña Ana County, New Mexico.
Geomorphic Surface: Jornada I.
Land Form: Broad crest of ridge on alluvial-fan piedmont sloping 3 percent to the west.
Elevation: 4,500 feet.
Parent Materials: Jornada I alluvium derived from rhyolite.
Vegetation: Creosotebush, ratany, fluffgrass, zinnia, Mormon tea, few dumps three-awn, and snakeweed.
Collected by: L. H. Gile, R. B. Grossman, and J. W. Hawley, April 16, 1970.
Described by: L. H. Gile and R. B. Grossman.

<u>Soil Surface</u> About 90-95 percent covered with desert pavement of rhyolite pebbles, mainly from 1/2 to 3 cm diameter, a few up to 10 cm diameter.

<u>A2 70L229 0 to 5 cm</u> Light brown (7.5YR 6/3 dry) or dark brown (7.5YR 4/3 moist) very gravelly fine sandy loam; weak medium and thin platy; soft; few roots; few parts slightly redder than above; noncalcareous; abrupt smooth boundary.

<u>B21t 70L230 5 to 18 cm</u> Yellowish-red (4YR 4.5/5 dry; 4YR 3.5/5 moist) very gravelly sandy day loam; weak fine and very fine crumb; soft; roots common; reddish-brown and red day coatings on pebbles and sand grains; noncalcareous; dear wavy boundary.

<u>B22t 70L231 18 to 28 cm</u> Red (2.5YR 4/6 dry) or dark red (2.5YR 3.5/6 moist) very gravelly heavy sandy day loam; breaks out as medium subangular blocky parts with induded pebbles; fine earth breaks to weak fine and very fine crumb; slightly hard; roots common; coatings of red day on pebbles; a few pebbles in lower part have thin, discontinuous carbonate coatings; noncalcareous, except for lower part, which effervesces weakly and strongly; dear wavy boundary.

<u>B23tca 70L232 28 to 46 cm</u> Dominantly reddish-brown (5YR 5/4 dry; 5YR 4/4 moist) very gravelly heavy sandy day loam; a few parts red (2.5YR 4/6 moist); breaks out as weak medium subangular blocky, with induded pebbles, and as weak fine crumb; soft; fine roots common; some pebbles and sand grains partially coated with reddish-brown day, mainly on pebble tops; pebbles thinly carbonate-coated, with most carbonate on bottoms of pebbles; effervesces strongly; abrupt wavy boundary.

<u>K2m 70L233 36 to 46 cm (offset sample)</u> The upper part, which ranges from about 1 to 10 an in thickness is dominantly light brown (7.5YR 6/4 dry) or brown (7.5YR 5/4 moist) with some parts redder; carbonate-cemented material; in places there is a laminar horizon up to 1/2 cm thick; massive; extremely hard; few roots; tends to be continuously indurated; pebbles widely separated by carbonate; the lower part has dominant color of reddish-yellow (5YR 7/6 dry; 5YR 5.5/6 moist) with parts less yellow than this; massive; slightly to extremely hard; a few roots; effervesces strongly; abrupt smooth boundary to underlying K2m which is the top of the Km between the indurated zones, and is the K22m where this horizon is above it. This horizon is present over much of the north face of the pit but is usually absent on the south side.

<u>K2m 70L234 46 to 64 cm</u> Dominantly very pale brown (10YR 8/3 dry; 10YR 7/3 moist) carbonate-cemented material, with thin (1-5 mm) laminar horizon in upper part; massive; extremely hard; very few roots; pebbles widely separated by carbonate; some pebbles have coatings of white (10YR 9/2 dry; 10YR 8/2 moist) other coatings are light yellowish-brown (2.5Y 6/4 dry) or light olive-brown (2.5Y 5/4 moist); effervesces strongly; clear wavy boundary.

<u>K31 70L235 64 to 82 cm</u> Dominantly pink (7.5YR 8/4-7/4 dry) or light brown (7.5YR 6/4 moist) and brown (7.5YR 5/4 moist) discontinuously carbonate-cemented material; massive; very hard to soft; few roots; a few parts are not cemented at all and have they partial coatings of reddish-brown fine earth; pebbles thinly coated with carbonate and there are scattered carbonate-cemented dusters; 2.5Y coatings also occur on pebbles in this horizon; effervesces strongly; dear wavy boundary.

<u>K32 70L236 82 to 121 cm</u> Dominantly very pale brown (10YR 8/3 dry; 10YR 7/3 moist) weakly carbonate-cemented material; massive; hard; no roots; smaller parts light brown (7.5YR 6/4 dry) or brown (7.5YR 5/4 moist) very gravelly sandy loam; soft; loose; the two types of morphology occur in nearly horizontal lenses ranging from about 5 to 15 cm thick; a few pebbles are carbonate-free; effervesces strongly; dear wavy boundary. (Note: this sample offset about 6 feet to the west to get a more typical K horizon; the K31 and K2m sampled in place.)

<u>K33 70L237 121 to 159 cm</u> Dominantly pink (7.5YR 7/4 dry) or brown (7.5YR 5.5/4 moist) weakly carbonate-cemented material occurring as lenses 5-10 cm thick; some of the coatings are 2.5Y 6/4 dry; a few coatings of 7.5YR 6/4 dry; pebbles separated by carbonate; the above alternates with lesser amounts of lenses of light brown (7.5YR 6/4 dry) or brown (7.5YR 4.5/4 moist) very gravelly loamy sand; massive; soft; no roots; pebbles have thin discontinuous carbonate coatings; effervesces strongly; dear and abrupt wavy boundary.

<u>C 70L238 159 to 179 cm</u> Pale brown (10YR 6.5/3 dry) or dark brown (10YR 4/3 moist) very gravelly sand; massive; soft; no roots; some pebbles in a lens 3-4 cm thick have thin, partial carbonate coatings and some have a very few gypsum crystals on bottoms of pebbles; generally noncalcareous or effervesces weakly.

<u>Remarks:</u> A composite sample was taken from 0-15 and from 15-38 cm for organic carbon and coarse fragments. The samples are 70L238 and 70L239, respectively. In places the upper part of the K2m appears to be intermediate between a K2 horizon and a B2 horizon. A sample of this material was taken for analysis under 70L240. Carbonate coatings of 2.5Y hue are analyzed under 70L087. These samples were obtained by abraiding the coated surface with a rotating electric drill.

SOIL CLASSIFICATION: Argic Petrocalcid, loamy-skeletal, mixed, thermic, shallow
SOIL Hachita SOIL Nos. S70NMex-7-8 LOCATION Doña Ana County, New Mexico
SOIL SURVEY LABORATORY Lincoln, Nebraska LAB Nos. 70L229-70L240, 70L087 May 1971
GENERAL METHODS: 1A1, 1B1b, 2A1, 2B

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Size class and particle diameter (mm) 3A1 *a*

Depth	Horizon	Total Sand	Total Silt	Total Clay	Sand Very Coarse	Sand Coarse	Sand Medium	Sand Fine	Sand Very Fine	Silt	Silt Int. III	Int. II			Coarse fragments 3A1a	Coarse fragments 3B1, 2A2 20–2
		(2–0.05)	(0.05–0.002)	(<0.002)	(2–1)	(1–0.5)	(0.5–0.25)	(0.25–0.1)	(0.1–0.05)	(0.05–0.02)	(0.02–0.002)	(0.2–0.02)	(2–0.1)	<0.074	<0.0002	<20mm
(cm)		<						Pct. of < 2 mm							>	Pct.
						Carbonate removed from < 2mm and > 2mm										
0–5	A2	60.1	25.7	14.2	4.6	4.9	3.9	24.4	22.3	16.6	9.1	56.1	37.8	51.1	5.0	39
5–18	B21t	50.9	19.5	29.6	6.9	5.0	3.1	18.3	17.6	14.1	5.4	44.3	33.3	58.0	12.1	76
18–28	B22t	45.8	22.1	32.1	9.2	4.3	2.3	14.4	15.6	14.6	7.5	40.3	30.2	62.2	20.2	80
28–46	B23tca	42.3	23.4	34.3	9.9	3.6	2.0	12.2	14.6	15.0	8.4	38.4	27.7	65.5	24.2	82
46–64	K2m	57.3	17.5	25.2	22.4	8.4	4.2	12.8	9.5	10.9	6.6	28.7	47.8	47.3	14.2	71
64–82	K31	72.1	14.3	13.6	24.3	13.3	6.6	16.8	11.1	9.2	5.1	30.9	61.0	33.3	8.9	68
82–121	K32	66.3	17.6	16.1	20.6	12.2	5.9	15.0	12.6	11.1	6.5	33.0	53.7	40.1	8.8	82
121–159	K33	74.0	14.5	11.5	22.4	17.6	8.1	16.2	9.7	9.1	5.4	28.4	64.3	30.4	6.2	74
159–179	C	80.6	10.4	9.0	21.3	30.0	12.1	12.3	4.9	5.7	4.7	16.6	75.7	21.6	4.3	75
46–64	K2m *b*	56.1	18.3	25.6	19.6	10.5	4.5	12.3	9.2	10.6	7.7	27.5	46.9	48.5	14.8	81

Depth	Horizon	Sand	Silt	Clay	Very Coarse	Coarse	Medium	Fine	Very Fine	Silt	Int. III	Int. II	(2–0.1)	<0.074	3B2 Vol. 250–2 % <250	2A2 Coarse fragments Wt. *c* 75–20 % < 75	2A2 Coarse fragments Wt. 20–5 % < 75	3B1 5–2 % < 75
0–15	*d*	60.2	24.9	14.9	6.8	5.5	4.2	23.6	20.1	17.0	7.9	53.6	40.1	49.2	40	19	30	10
15–38	*d*	54.2	22.4	23.4	6.6	6.2	3.7	20.4	17.3	15.1	7.3	46.4	36.9	54.2	75	51	26	8
46–64	*d*														50	24	46	8
64–82	*d*														55	20	39	15
82–159	*d*														75	29	40	12
159–179	*d*														65	10	46	22

Depth (cm)	6A1a Organic Carbon *h* Pct.	Nitrogen Pct.	C/N	6E1b, 6E2a Carbonate as $CaCO_3$ Pct.	Bulk Density g/cm^3	Bulk Density *k* g/cm^3	Bulk Density g/cm^3	4B2 15-bar Pct.
0–5	0.27			tr(s)		1.3		5.7
5–18	0.53			tr(s)		1.4		8.7
18–28	0.76			tr		1.5		11.2
28–46	0.81			6		1.4		13.2
46–64	0.16			63		1.8		
64–82	0.09			41		1.6		
82–121	0.10			29		1.5		
121–159	0.08			25		1.5		
159–179				4		1.4		4.7
46–64*b*	0.09			78				
46–64*f*	0.53			86				
0–15	0.40*i*			tr				
15–30	0.77*i*			4				

Composition Whole Material *g*

Depth *e* (cm)	>2mm Pct.	Noncarbonate Sand Pct.	Noncarbonate Silt Pct.	Noncarbonate Clay Pct.	Carbonate as $CaCO_3$ Pct.
0–15	59	25	10	6	tr
15–28	85	8	3	3	1
46–64	56	9	3	4	28
64–82	63	16	3	3	15
85–159	83	9	2	1	5
159–179	77	18	2	2	1

Depth (cm)	Ca	Extractable bases 5B4a 6O4c Mg	6P2a Na	6Q2a K	5A6a CEC NH_4OAc	8C1a pH (1:1)	Base saturation Pct.	Pct.
0–5		2.0	tr	1.1	12.4	7.8		
5–18		2.5	0.1	1.4	18.3	7.8		
18–28		3.3	0.1	1.1	23.1	8.0		
28–46		3.7	0.2	0.9	21.4	7.9		
46–64		1.1*j*	0.2*j*	0.3*j*	3.9*j*			
64–82		1.5*j*	0.2*j*	0.4*j*	5.1*j*			
82–121		1.7*j*	0.3*j*	0.4*j*	5.1*j*			
121–159		2.4*j*	0.5*j*	0.3	3.1*j*			
159–179		4.0	1.7	0.3	7.1	8.2		
46–64*b*		1.9*j*	0.1*j*	0.4*j*	5.8*j*			

a Pretreatment of < 2 mm with 0.1 N NaOH; Method 1B4, 70L233-237, 70L240.
b See remarks in pedon description.
c 5 percent >75 mm in 1(33; none in other horizons; no > 250 mm.
d Large samples obtained for > 20 mm; uppermost two from across 6 m of pit face; samples 70L238, 70L239.
e Sampling depths from which large samples for > 20 mm obtained.
f Carbonate coatings. See remarks in pedon description. The calculated organic carbon for the carbonate-free material is 4 percent.
g Inclusive of > 2 mm, carbonate and gypsum. Weighted average separate percentages calculated from horizon data where needed.
h 1.5 kg/m^2 to 46 cm (Method 6A).
i 1.1 kg/m^2 to 38 cm (Method 6A)
j The determinations were made on the whole sample, inclusive of coarse fragments, which was ground to pass 2 mm. The values may be put on a carbonate-containing < 2 mm basis by first adjusting the 20-2 mm as a percent of the < 20 mm to a carbonate-containing basis and then dividing by the proportion of material exclusive of the > 2 mm, expressed on a part per part basis. For example, the extractable magnesium for sample 70L234, expressed on a carbonate-containing < 2 mm basis, would be 3.4 meq. The CEC as calculated the same way would be 11.6 meq. Such calculations are subject to some error since the > 2 mm percentage is not the same for the subsample treated to remove the carbonate and the one prepared for chemical characterization.
k Assumed values for moist fine-earth fabric for calculations.

Mineralogy (Method 7B). Counts of 300 grains were made on the 0.1–0.05 mm (very fine sand, vfs) and on the 0.25–0.1 mm (fine sand, fs). The microcrystalline aggregates are mostly frgaments of groundmass of rhyolite; orthoclase is the dominant feldspar with albite and microcline present. Minerals of the epidote group are the dominant component of the ferromagnesian minerals.

	Quartz %	Feldspar IR <1,550 %	IR >1,550 %	Microcrystalline Aggregates %	Feromagnesian Minerals %	Opaques %
70L029, vfs	42	20	6	27	3	2
70L030, vfs	41	29	3	21	3	3
70L030, fs	47	23	2	28	tr	tr
70L032, vfs	39	34	3	22	1	1
70L035, vfs	38	28	3	29	1	1
70L037, vfs	39	23	2	33	2	1
70L037, fs	39	24	2	34	tr	1

Part 8: Hayner 60-5

Soil Classification: Argic Ustic Petrocalcid, clayey-skeletal, mixed, thermic.
Soil: Hayner.
Soil Nos.: S60(61)NMex-7-5.
Location: Center sec 12 T23S R3E, in Ice Canyon, Doña Ana County, New Mexico.
Elevation: 5,880 feet.
Geomorphic Surface: Doña Ana.
Parent Material: Upper Camp Rice fan alluvium derived from rhyolite.
Land Form: Remnant of an alluvial fan with about 9 percent slope to west; at sampling site, 1 to 3 percent convex transverse slope and weakly convex longitudinal slope.
Vegetation: Snakeweed spaced 1 to 3 feet apart, scattered mesquite and cholla cactus; bunches of sideoats and black grama about a foot apart; few juniper on sideslopes; few squawbush; scattered pricklypear.
Collected by: L. H. Gile, R. B. Grossman, J. L. Millet, and F. F. Peterson, April 13, 1960, and F. F. Peterson, 1961.
Described by L. H. Gile and F. F. Peterson, 1960, and F. F. Peterson, 1961.

Soil Surface Desert pavement covers about 80 to 90 percent of the soil surface and consists of angular rhyolite gravel, 1 to 3 inches in diameter, and some larger (3 to 7 inches) angular rhyolite cobbles; most of these surface fragments are stained reddish-brown; thin layer of loose reddish sand occurs between pebbles and is lighter colored than the underlying A.

Al 13142 0 to 8 cm Reddish-brown (5YR 4/4 dry) or dark reddish-brown (5YR 3/3 moist) very gravelly loam; weak very fine granular; soft in place; slightly sticky; many roots; noncalcareous; abrupt smooth boundary. Desert pavement included in the sample.

Blt 13143 8 to 20 cm Reddish-brown (5YR 4/4 dry) or dark reddish-brown (5YR 3/4 moist) very gravelly heavy loam; very weak fine subangular blocky breaking easily to weak very fine granular; slightly hard; many roots; pebbles with reddish-brown (5YR 4/4 dry) loam coatings; majority of sand grains have a dull coating and a few appear dean; noncalcareous; abrupt wavy boundary.

A2 13144 20 to 23 cm Reddish-brown (5YR 5/3 dry) or dark reddish-brown (5YR 3.5/4 moist) very gravelly sandy loam; moderate medium to fine subangular blocky; friable; slightly hard; roots common; vesicular; many dean (7.5YR to 10YR 6/2 to 7/2 dry) fine sand grains, especially on exteriors of peds, give grayish cast to the soil; some parts similar to superjacent horizons; peds have rough-textured surface; bottoms of pebbles coated with reddish-brown loamy material; tops of pebbles at bottom of horizon are coated with grayish material; horizon is discontinuous; noncalcareous; abrupt smooth boundary.

B21t 13145 23 to 38 cm Ped surfaces dark reddish-brown (2.5YR 3/4 moist) with larger peds having somewhat darker surfaces; gravelly day; firm; sticky; few roots; moderate to strong, medium and fine subangular blocky; larger peds separate into fine and very fine subangular blocky peds; ped interiors dark red (2.5YR 3/6 moist); ped surfaces very smooth and reflective; pebbles and cobbles have apparent day coatings; noncalcareous; dear wavy boundary.

B22tcs 15741 38 to 58 cm Dark red (2.5YR to 10R 3/6 moist) gravelly day; moderate medium to fine subangular blocky peds that do not break down to as small or as strong peds as in B21t horizon; firm; hard; sticky; very few roots; pebbles and cobbles coated with day; ped surfaces smooth and reflective; scattered lenses of sand-sized gypsum crystals, 1/8 to 1/4 inch wide, 1 to 4 inches long, and 2 to 3 mm thick; lenses commonly in a weakly effervescent clayey matrix; gypsum grains have reflective faces, crush easily, are yellow to reddish-yellow and not visibly stained with clay; mainly noncalcareous, some parts effervesce weakly; abrupt smooth boundary.

K1 (Clca) 15742 58 to 64 cm Mainly white (7.5YR 9/0 dry) or pinkish-white (7.5YR 8/2 moist) platy, very hard, carbonate-cemented fragments with prominent coatings of reddish-yellow (5YR 7/6 dry, or 5YR 6/6 moist); reddish colors occur throughout some fragments and in parts of others; plates are weakly laminated in some parts, are discontinuous and dig out rather readily; few roots; loamy material occurs between some plates; effervesces strongly; abrupt smooth boundary. Plates analyzed under LSL 15743.

K21m (C2cam) 15744, 15745 64 to 71 cm Laminar horizon and upper plugged horizon reported and analyzed under LSL 15744 and 15745, respectively. Upper 1/2 to 1 inch consists of extremely hard laminae ranging mainly from white (10YR 9/1 dry, or 8/1 moist) to white (10YR 8/2 dry) or very pale brown (10YR 7/3 moist), with few thin laminae slightly darker; overlies 2 to 3 inches of white (10YR 9/2 dry) or very pale brown (10YR 8/3 moist) very hard, massively cemented material; no roots; few included pinkish lenses; effervesces strongly; dear smooth boundary.

K22m (C3cam) 15746 71 to 86 cm Variegated white (10YR 9/1 dry) **or** very pale brown (10YR 8/3 moist) and pink (7.5YR 8/4 dry) or light brown (7.5YR 6/4 moist) gravelly material indistinctly banded with white (10YR 9/1 dry); hard to extremely hard; very few roots; most pebbles have 0.5 to 2 mm thick coatings of laminar carbonate; light brown bands with about 50 percent gravel, white bands with 15 to 25 percent gravel where bands relatively thick; effervesces strongly; clear smooth boundary.

K31 (C4ca) 15745 86 to 114 cm Pink (7.5YR 7/4 dry) or light brown (7.5YR 6/4 moist) finely variegated with reddish-brown (5YR 5/4 dry, 3.5/4 moist) and white (7.5YR 9/1 dry) or pinkish-white (7.5YR 8/2 moist) gravelly sandy loam; massive; slightly hard and hard; very few roots; indistinct banding 1 to 2 inches thick of reddish-brown, low-carbonate material with light gray carbonate-rich material; scattered blebs, small pockets and lenses of reddish-brown (2.5YR 4/4 dry) apparent day-coated sand and pebbles; pebbles commonly have thin, discontinuous, flaky carbonate coatings, mainly on pebble bottoms; effervesces strongly; dear to gradual wavy boundary.

K32 (C5ca) 15748 114 to 142 cm About 70 percent white and pink lenses, which are white and pink (7.5YR 8/1 dry, 8/3 moist; and 5YR 7/3 dry, 5.5/4 moist) very gravelly sandy loam; massive; slightly hard to very hard (where carbonate cemented); pebbles separated by carbonate; reddish-brown blebs in carbonate cement; lenses 1/2 to 2 inches thick, 12 to 30 inches long. About 30 percent reddish-brown lenses which are reddish-brown (5YR 5/4 dry, 4/4 moist) very gravelly sandy loam; massive; compact but looser than lighter colored lenses; common discontinuous clay coatings and bridging on and between pebbles; few discontinuous thin carbonate coatings on pebbles; very few roots; few black (MnO_2?) blebs; lenses 1/2 to 1 inch thick, 12 to 24 inches long; effervesces weakly and strongly; dear to gradual wavy boundary.

K&Cca (C6ca) 15749 142 to 168 cm Reddish-brown (5YR 5/4 dry, 3.5/4 moist) very gravelly loamy sand; massive and loose; discontinuous (and in pockets, continuous) clay films and bridges (some 2.5YR 4/6 dry) on sand grains and pebbles; scattered black (MnO_2?) blebs; pebbles commonly with loamy sand adhering to tops, thin, discontinuous carbonate coatings to bottoms; about 20 to 40 percent of horizon of 1/2 to 2 inches thick, 6 to 18 inches long, light brown (7.5YR 7/2 to 6/4 dry, 6/4 to 5/4 moist) carbonate-cemented lenses which are massive, slightly hard to hard, and have sand grains separated by carbonate; some parts noncalcareous, most parts effervesce weakly or strongly.

Remarks: The A2 horizon has the grayness and bleached appearance of an eluvial horizon. The boundary between the A2 and B2 is exceedingly sharp, and there is no evidence of extension of the A2 down around B2 peds.

Micromorphology, Method 4E1b Thin sections of the B21t and B22tcs show no oriented day on ped faces; all of the day in ped interiors is strongly oriented, both as grain coatings and linear bodies.

SOIL CLASSIFICATION: Argic Ustic Petrocalcid, clayey-skeletal, mixed, thermic
SOIL Hayner SOIL Nos. S60(61) NMex-7-5 LOCATION Doña Ana County, New Mexico U.S. DEPARTMENT OF AGRICULTURE
SOIL SURVEY LABORATORY Lincoln, Nebraska LAB Nos. 13142-13145; 15741-15749 SOIL CONSERVATION SERVICE
GENERAL METHODS: 1A, 1B1a, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very Coarse (2-1)	Sand Coarse (1-0.5)	Sand Meduim (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very Fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	1968 samples <0.002 *m*	3A1b <0.002 *m*	Coarse fragments 2A2 Vol. *o* 250-2 %<250	Wt. 76-2 %<76	3B1 19-2 %<19
		Pct. of < 2mm																
		Carbonate removed *a, b*																
0-8	A1	60.6	25.3	14.1	13.5	6.6	2.2	14.1	24.2	16.4	8.9	50.5	36.4	22.3	16	45	61	50
8-20	B1t	48.7	28.1	23.2	12.2	3.6	1.5	10.4	21.0	18.7	9.4	47.2	27.7	31.7	24	60	73	55
20-23	A2	51.4	33.9	14.7	14.2	4.8	1.6	9.0	21.8	22.8	11.1	51.0	29.6			50	68	62
23-38	B21t	20.5	16.4	63.1	3.9	2.0	0.8	4.2	9.6	10.8	6.2	22.9	10.9	69.9	61	25	40	32
38-58	B21tcs	18.2	7.6	74.2	7.5	2.9	1.0	2.8	4.0	3.9	3.7	9.7	14.2	71.7	61	35	49	24
58-64	K1*c*	28.3	11.8	59.9	9.9	5.8	2.1	4.2	6.3	5.7	6.1	14.5	22.0	58.8	52	20	54	49
58-64	K1*d*	33.5	9.2	57.3	10.5	9.0	3.3	5.1	5.6	2.5	6.7	10.9	27.9			5	42	42
64-71	K21m*e*	39.5	18.1	42.4	12.7	10.2	4.1	5.9	6.6	4.4	13.7	14.0	23.9	48.0	40	5	42	42
64-71	K21m*f*	52.3	11.0	36.7	18.6	15.3	5.7	7.1	5.6	3.2	7.8	12.3	46.7			5	54	54
71-86	K22m	61.0	12.2	26.8	24.6	17.3	5.4	8.2	5.5	2.7	9.5	12.4	55.5	28.5	19	45	76	64
86-114	K31	63.4	13.4	23.2	31.5	17.2	3.3	5.1	6.3	3.7	9.7	12.6	57.1			45	68	54
114-142	K32	45.4	31.4	23.2	17.8	8.6	3.5	7.3	8.2	6.7	24.7	19.2	37.2	24.2	8	55	75	66
142-168+	K&Cca	73.5	15.0	11.5	33.3	20.4	5.9	7.3	6.6	4.2	10.8	14.4	66.9	13.9	4	55	69	59

Depth (cm)	6A1a Organic Carbon *g* Pct.	6B1a Nitrogen Pct.	C/N *g*	6C2a Ext. Iron as Fe *a b* Pct.	Carbonate as $CaCO_3$ *h* *b* Pct.	5A1a CEC NH_4OAc *b* me/100g	Bulk density *n* g/cm3	Bulk density g/cm3	4B5 Air-Dry g/cm3	Water Content	Composition Whole Material *j* > 2mm Pct.	Noncarbonate Sand Pct.	Noncarbonate Silt Pct.	Noncarbonate Clay Pct.	Carbonate as $CaCO_3$ Pct.
0-8	0.88	0.092	10	0.8	-	10.2	1.4				61	24	10	5	-
8-20	1.16	0.116	10	1.2	-	13.3	1.4				73	13	8	6	-
20-23	0.70	0.070	10	1.1	-	6.9	1.4				68	16	11	5	-
23-38	0.87	0.087	10	1.7	-	30.9	1.4		1.43		40	12	10	38	-
38-58				2.1	1		1.5				49	9	4	38	tr
58-64	0.40	0.030	13		60	34.8	1.6				32	8	3	16	41
58-64	0.27	0.021	13		87	39.0	1.6				8	4	1	7	80
64-71	0.21				88	29.6	1.8				8	4	2	5	81
64-71	0.20				90	29.2	1.8				11	5	1	3	80
71-86	0.05				62	20.7	1.8				55	10	2	5	28
86-114					39	19.1	1.8				56	17	4	6	17
114-142					39	26.5	1.7				65	10	6	5	14
142-168+					17	16.4	1.6				65	21	4	46	

Depth (cm)	Extractable bases 5B1a 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	6H1a Ext Acidity	Cat. Exch. Cap. 5A1a NH_4OAC	Water extract from saturated paste 8A1 Ca	Mg	6P1a Na	6Q1a K	CO_3	6J1a HCO_3	6K1A Cl	6L1a SO_4	8A1a Electrical Conductivity mmho/cm
	meq/100g						meq/liter								
0-8	9.3	2.2	tr	1.1	2.2	11.7									
8-20	10.5	2.8	0.1	1.7	2.5	14.6									
20-23	4.5	1.9	1.2	0.2	1.5	7.8									
23-38	13.2	15.3	4.1	0.3	1.8	31.2			6.2	0.2		3.0	0.2	3.2	0.80
38-58		8.1	0.8	1.8		26.6			3.2						1.14
	See footnote *k* concerning data below.														
58-64		5.1	2.1	0.8		13			25	1.0					3.8
58-64		1.8	1.2	0.3		3.3			19	0.8					3.5
64-71		1.7	1.2	0.2		4.8						4.1	0.2	32	6.9
64-71		2.8	2.4	0.3		3.7			33	0.9		0.9	6.9	60	5.0
71-86		6.9	3.3	1.1		15			58	1.8		6.7	3.3	111	4.6
86-114		11	1.8	1.4		24			20	1.4					2.5
114-142		3.9	1.4	1.4		26			17	1.1					1.6
142-168+		10	1.1	1.1		26			23	0.9					1.6

Depth (cm)	8A Water at sat. Pct.	6F1a Gypsum Pct.
0–8		–
8–20		–
20–23		–
23–38	79	–
38–58		–
See footnote *k* concerning data below.		
58–64	56	
58–64	47	0.1
64–71		0.2
64–71	53	0.2
71–86	60	–
86–114	52	–
114–142	70	–
142–168	66	–

a Carbonate removed by Method 1B3 and the determination made on and reported for the sample so treated.
b In contact overnight with 0.1N NaOH in addition to regular treatment.
c Non-indurated part.
d Indurated plates.
e Laminar subhorizon.
f Upper part of carbonate-plugged horizon
g Determination on sample treated by Method 1B3 to remove carbonate; expressed on a carbonate-containing basis.
h Determination on whole soil and calculated as a percentage of the fine earth. Carbonate included with the fine earth. Explanation
i Inclusive of coarse fragments, carbonate and gypsum. Carbonate measured directly by Methods 6E1c and 6E1b.
k Determination on whole soil ground to pass 2 mm; calculated to a basis free of noncarbonate coarse fragments.
m The pedon was resampled in 1968. McKim determined the partide-size distribution and did mineralogical studies (McKim, H. L. 1%9). The mineralogical data are given below.
it Assumed bulk density of moist fine-earth fabric for calculations.
o Volume on a carbonate-containing basis; weight on a carbonate-free basis.

Mineralogy (Methods 7B1, 7A2). McKim, 1969, studied the mineralogy of pedon S60NMex-7-5. Point counts were made of composite thin sections (see Method 4E1c for preparation) of the >19 mm from the Blt, K22m, and Cca horizons. The rock fabric was divided into >0.05 mm grains and groundmass. The average values were 72 percent groundmass, 17 percent quartz, 7 percent feldspar, 2 percent biotite, and 2 percent opaque and isotropic minerals. It should be emphasized that resolvable grains smaller than 0.05 mm were included with the groundmass.

The table below lists the counts on several separates. Groundmass in this table is roughly equivalent to microcrystalline aggregate in other data for pedons of the study area. About 600 grains were counted.

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 a mica plus traces of interlayer montmorillonite, chlorite, and quartz. Clays in the Kl horizon and beneath contain a moderate amount of a 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 (<0.0002 mm), mica predominates above the K1 horizon and a mica-montmorillonite complex predominates below.

Mineralogy of the Noncarbonate 2–0.05 mm from Pedon S60NMex-7-5, resampled in 1968.

Depth (cm)	Horizon	Ground-mass %	Quartz and Feldspar n~1.550 %	Quartz %	Feldspar n<1.550 %	Feldspar n=1.550 (Oligoclase) %	Hornblende %	Epidote %	Biotite %	Opaques %	Isotropic *a* %
						2–0.5 mm. *b*					
0–8	A1	80	9		10		tr	tr	tr	tr	1
58–64	K1	75	14		10		tr	tr	tr	tr	1
						0.25–0.1mm					
0–8	A1	23	57		15		tr	–	–	4	1
23–38	B21t	24	60		14		tr	–	–	1	1
71–86	K22m	52	28		6		tr	–	–	3	11
142–168	K&Cca	51	27		5		tr	–	3	8	7
						0.1–0.05 mm					
0–8	A1	18		46	14	11	2	5	tr	1	2
8–20	B1t										
23–38	B21t	23		46	17	6	1	tr	tr	3	3
38–58	B22tcs										
58–64	K1	18		52	13	12	1	1	tr	2	tr
64–71	K21m	33		35	19	6	tr	tr	tr	2	4
71–86	K22m	29		35	13	5	tr	tr	tr	19	15
86–114	K31	34		32	17	9	tr	1	1	3	4
114–142	K32	36		27	15	9	1	tr	4	4	4
142–168	K&Cca	35		22	16	5	1	tr	14	3	4
						0.05–0.02 mm					
0–8	A1	17	51		17		2	2	tr	7	4
23–38	B21t	20	53		17		2	2	1	5	1
71–86	K22m	24	48		12		1	1	1	5	8
114–142	K32	25	23		20		1	1	21	5	4
142–168	K&Cca	19	15		14		1	2	44	2	3

a Index of refraction substantially below 1.550.
b Thin sections were prepared.

Sand Mineralogy, Method 7B1 The very fine and fine sand from the B22 horizon after carbonate removal by Method 1B3 was examined under the petrographic microscope. A count of 300 grains of very fine sand yielded 50 percent quartz, 35 percent feldspar, 10 percent microcrystalline aggregates, and 2 percent assorted ferromagnesian grains. The feldspar is mostly orthoclase with some microcline, albite, and roughly a fifth is plagioclase of intermediate calcium content. The microcrystalline aggregates are mostly altered small optical domains of feldspar, but some may be weathered chert. Some chert was included with the quartz. The discrete feldspar grains appear quite weathered. The biotite flakes mostly show dull yellowish interference color, consistent with appreciable alteration. Many grains have patchy coatings of reddish-brown clay. This day may have been cemented to the grains in the process of forming the sedimentary rock. The expression of these coatings may be somewhat weaker in the A (0-5 cm), but the difference is small.

Clay Mineralogy, Methods 7A2, 7A3. B21 horizon (Lincoln). Clay contains small amounts of vermiculite, mica, and kaolinite, plus additional component of interlayer mineral, involving vermiculite, mica, and chorite. Small to moderate amount of calcite is present.
B22 horizon (Beltsville). Carbonate removed by Method 3A3. A moderate amount of a poorly ordered montmorillonite-vermiculite mineral is present, plus small amount of vermiculite and kaolinite (10 percent kaolinite).
IIBb horizon (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.

Part 9: Reagan 60-14

Soil Classification: Ustic Haplocalcid, fine-silty, mixed, thermic.
Soil: Reagan.
Soil Nos.: S60NMex-7-14.
Location: SW1/4NW1/4 sec 19 T21S R3E, at a west-facing escarpment of about 4 feet cut into silty sediments, Doña Ana County, New Mexico.
Geomorphic Surface: Organ.
Elevation: 4,400 feet.
Land Form: Scarplet dissected coalescent fan piedmont sloping about 1 percent west.
Parent Material: Organ fan alluvium from limestone, calcareous sandstone and siltstone; calcareous dust.
Vegetation: On top of escarpment dominantly burro grass, with some tobosa, scattered tarbush, creosotebush, desert holly, and very few snakeweed.
Collected by: L. H. Gile, R. B. Grossman, J. L. Millet, and F. F. Peterson, April 19, 1960.
Described by: L. H. Gile and R. B. Grossman.

<u>Soil Surface</u> Cracked into polygonal plates up to 1/8-inch thick, several inches in diameter. A discontinuous layer of reddish sand is scattered over the surface and between the plates.

<u>A 13205 0 to 5 cm</u> Grayish-brown (10YR 5.5/2 dry) or dark grayish-brown (10YR 3.5/2 moist) silt loam; moderate medium platy breaking to fine platy; slightly hard; roots common under dumps of burrograss; layers of reddish very fine sand, less than 1 mm thick, between plates; effervesces strongly; dear smooth boundary.

<u>A 13206 5 to 28 cm</u> Light brownish-gray (10YR 6/2 dry) or brown (10YR 4/3 moist) somewhat heavy silt loam; weak medium subangular blocky; upper part very weak platy; hard; roots common; pores common and have smooth walls; effervesces strongly; dear wavy boundary.

<u>B21 13207 28 to 56 cm</u> Brown (10YR 5/2.5 dry, 4/3 moist) silty day loam; weak medium prismatic breaking to moderate medium subangular blocky; hard; few roots; many of pores and channels have carbonate linings; ped surfaces slightly lighter colored and smoother than fracture surfaces; very few carbonate filaments; effervesces strongly; dear wavy boundary.

<u>B2213208 56 to 76 cm</u> Light yellowish-brown (10YR 6/4 dry) or yellowish-brown (10YR 5/4 moist) silty day loam; weak medium prismatic, breaking to moderate fine subangular blocky; hard; few roots; few carbonate filaments on ped surfaces; effervesces strongly; dear wavy boundary.

<u>B23ca 13209 76 to 99 cm</u> Pale brown (10YR 6/3 dry) or yellowish-brown (10YR 4.5/4 moist) silty day loam; weak medium prismatic, breaking to moderate fine subangular blocky; hard; few roots; common carbonate filaments on ped surfaces and along channels and pores in ped interiors; effervesces strongly; dear wavy boundary.

<u>C 13210 99 to 122 cm</u> Light yellowish-brown (10YR 6/4 dry) or yellowish-brown (10YR 4.5/4 moist) silt loam; weak medium subangular blocky; slightly hard; few roots; very few carbonate filaments; few parts reddish brown (5YR 5/4 dry); effervesces strongly; dear wavy boundary.

<u>IIBb 13211 122 to 140 cm plus</u> Reddish-brown (5YR to 7.5YR 5/4 dry, 5YR 4/4 moist) fine sandy loam; massive; slightly hard to hard; few roots; few pores with smooth wall linings; few carbonate filaments; effervesces strongly.

Remarks: Structural expression is the basis for the recognition of the B horizon.

<u>Micromorphology, Method 4E1b</u> The A (5-28 cm), B21, B22, and IIBb horizons were examined in thin section. The upper four horizons contain abundant fine-grain carbonate. This carbonate has strong birefringence, which masks the interference color from the silicate day, except adjacent to sand grains. The fabric would be plasmic and asepic. Planar voids are common but there is also a dumpiness which is stronger nearer the surface. Quartz and feldspar predominate. Ferromagnesian minerals are scarce with biotite followed by pyroxene, the principal minerals. Mostly the sand grains are discrete minerals rather than being composites, although some feldspar grains do contain biotite and a yellowish-brown infilling is found, which in some instances is isotropic or nearly so. Occasional feldspar have patchy coatings of reddish-brown earthy material. Some feldspar grains appear rough and weathered along twining planes. Many sand grains have thin, nearly continuous day coatings. Most of the biotite has largely lost its second order interference color (as viewed on edge) and, although distinguishable from oriented day bodies, has altered towards day. The pyroxene grains are somewhat weathered, but alteration of the birefringence is only peripheral. A curious feature are bodies that may be glaebules of day, but which are largely isotropic and cannot be readily distinguished from altered plant remains. Occasional sand-size grains of carbonate showing optical continuity over much of the grain are present. These are interpreted to have a geological source and not pedogenic. They are rough and otherwise appear to have been etched. Dark bodies ranging downward in size from 100 microns, with most 5 microns or less, have an average repeat distance of perhaps 10 microns. These bodies are roughly equidimensional. Their occurrence shows no relationship to boundaries of pedological features.

The IIBb horizon has insufficient plasma to fill the spaces between sand grains. The plasma occurs as crudely oriented coatings on the sand grains. Fine grain carbonate partially fills the interstices. The mineralogy is similar to that of the sand in horizons above. The few grains of carbonate with sufficient optical continuity to suggest a geological origin are frayed and appear etched. Many of the sand grains have patchy, thick reddish-brown coatings of weakly oriented silicate day which fills cavities and extends inward along planes of weakness. These patchy coatings have the appearance of being allogenic. The fine grain carbonate on sand grains may obscure and possibly has disrupted authigenic day coatings.

SOIL CLASSIFICATION: Ustic Haplocalcid, fine-silty, mixed, thermic

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL Reagan SOIL Nos. S60-NMex-7-14 LOCATION Doña Ana County, New Mexico

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB Nos. 13205-13211

GENERAL METHODS: 1A1, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Med. (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	3A1b Fine Clay <0.0002	2A2 Coarse fragments Vol. -2 %<	Wt. 3B1 76-2 %<76	Wt. 3B1 19-2 %<19
		<—						Pct. of < 2 mm						—>			
								Carbonate Removed *a,b*									
0-5	A	28.3	45.1	26.6	0.2	0.5	0.8	6.6	20.2	18.2	26.9	43.3	8.1	3.6	-	-	
5-28	A	30.1	40.9	29.0	0.3	0.4	0.7	8.1	20.6	14.2	26.7	40.6	9.5	3.8	-	-	
28-56	B21	15.5	49.4	35.1	<0.1	<0.1	0.2	2.9	12.4	15.5	33.9	30.1	3.1	7.0	-	-	
56-76	B22	11.6	44.2	44.2	<0.1	0.1	0.3	2.6	8.6	11.4	32.8	21.9	3.0	8.9	-	-	
76-99	B23ca	12.2	44.8	43.0	<0.1	0.4	0.4	3.1	8.3	10.8	34.0	21.4	3.9	13.8	-	-	
99-122	C	24.2	44.2	31.6	<0.1	0.2	0.8	5.7	17.5	18.4	25.8	40.0	6.7	15.0	-	-	
122-140+	IIBb	63.7	20.1	16.2	1.0	3.5	3.8	25.4	30.0	10.0	10.1	57.5	33.7	8.6	-	-	
								Carbonate Not removed *b*									
0-5	A	24.5	53.5	22.0	0.5	0.6	0.7	5.4	17.3	42.0	11.5	63.3	7.2				
5-28	A	23.8	48.4	28.0	0.3	0.4	0.6	6.0	16.5	43.6	4.8	54.5	7.3				
28-56	B21	11.2	53.6	35.2	0.1	0.1	0.2	2.1	8.7	43.8	9.8	54.1	2.5				
56-76	B22	8.3	49.6	42.1	0.1	0.3	0.3	1.9	5.7	43.8	5.8	50.9	2.6				
76-99	B23ca	8.1	50.9	41.0	0.1	0.3	0.3	2.1	5.3	49.2	1.7	56.1	2.8				
99-122	C	20.3	47.3	32.4	0.2	0.4	0.7	5.0	14.0	32.5	14.8	49.9	6.3				
122-140+	IIBb	60.5	21.2	18.3	1.2	3.4	4.5	22.8	28.6	7.6	13.6	41.3	31.9				

Depth (cm)	6A1a Organic carbon *c,d*	6B1a N *c*	C/N	6C2a Ext. Iron *a* as Fe	Carbonate as $CaCO_3$ 6E1a <2mm	Carbonate as $CaCO_3$ 3A1a <0.002mm	Bulk density	Bulk density *e*	Bulk density 4A1b Air-dry	CEC 5A1a NH_4OAc *a*	CEC *f*	pH 1:1
	Pct.	Pct.		Pct.	Pct.	Pct.	g/cm³	g/cm³	g/cm³	meq/100g		
0-5	2.00	0.178	11		16	4		1.3		24.6	17.7	
5-28	1.13	0.111	10		15	7		1.4	1.47	25.2	18.8	
28-56	0.73	0.071	10		22	10		1.4	1.50	27.2	17.1	
56-76	0.70			1.3	23	12		1.4	1.48	29.2	18.0	
76-99	0.51				26	13		1.4	1.47	26.9	16.0	
99-122	0.36				21	9		1.3	1.37	21.6	14.1	
122-140+	0.19			0.8	8	3		1.6		11.8	9.9	

a Carbonate removed by Method 1B3 and the determination made on and reported for the sample so treated.
b In contact overnight with 0.1N NaOH in addition to regular treatments to aid disaggregation.
c Determination on sample treated by Method 1B3 to remove carbonate; values expressed on a carbonate-containing basis.
d 11 kg/m² to 99 cm (Method 6A).
e Assumed bulk densities of moist fine-earth fabric for calculations.
f Regular analysis. Carbonate-containing.

Selected conversion factors*

TO CONVERT	MULTIPLY BY	TO OBTAIN
Length		
inches, in	2.540	centimeters, cm
feet, ft	3.048×10^{-1}	meters, m
yards, yds	9.144×10^{-1}	m
statute miles, mi	1.609	kilometers, km
fathoms	1.829	m
angstroms, Å	1.0×10^{-8}	cm
Å	1.0×10^{-4}	micrometers, µm
Area		
in^2	6.452	cm^2
ft^2	9.29×10^{-2}	m^2
yds^2	8.361×10^{-1}	m^2
mi^2	2.590	km^2
acres	4.047×10^{3}	m^2
acres	4.047×10^{-1}	hectares, ha
Volume (wet and dry)		
in^3	1.639×10^{1}	cm^3
ft^3	2.832×10^{-2}	m^3
yds^3	7.646×10^{-1}	m^3
fluid ounces	2.957×10^{-2}	liters, l *or* L
quarts	9.463×10^{-1}	l
U.S. gallons, gal	3.785	l
U.S. gal	3.785×10^{-3}	m^3
acre-ft	1.234×10^{3}	m^3
barrels (oil), bbl	1.589×10^{-1}	m^3
Weight, mass		
ounces avoirdupois, avdp	2.8349×10^{1}	grams, gr
troy ounces, oz	3.1103×10^{1}	gr
pounds, lb	4.536×10^{-1}	kilograms, kg
long tons	1.016	metric tons, mt
short tons	9.078×10^{-1}	mt
oz mt^{-1}	3.43×10^{1}	parts per million, ppm
Velocity		
ft sec^{-1} (= ft/sec)	3.048×10^{-1}	m sec^{-1} (= m/sec)
mi hr^{-1}	1.6093	km hr^{-1}
mi hr^{-1}	4.470×10^{-1}	m sec^{-1}
Pressure stress		
lb in^{-2} (= lb/in^2), psi	7.03×10^{-2}	kg cm^{-2} (= kg/cm^2)
lb in^{-2}	6.804×10^{-2}	atmospheres, atm
lb in^{-2}	6.895×10^{3}	newtons (N)/m^2, N m^{-2}
atm	1.0333	kg cm^{-2}
atm	7.6×10^{2}	mm of Hg (at 0° C)
inches of Hg (at 0° C)	3.453×10^{-2}	kg cm^{-2}
bars, b	1.020	kg cm^{-2}
b	1.0×10^{6}	dynes cm^{-2}
b	9.869×10^{-1}	atm
b	1.0×10^{-1}	megapascals, MPa
Density		
lb in^{-3} (= lb/in^3)	2.768×10^{1}	gr cm^{-3} (= gr/cm^3)
Viscosity		
poises	1.0	gr cm^{-1} sec^{-1} *or* dynes cm^{-2}
Discharge		
U.S. gal min^{-1}, gpm	6.308×10^{-2}	l sec^{-1}
gpm	6.308×10^{-5}	m^3 sec^{-1}
ft^3 sec^{-1}	2.832×10^{-2}	m^3 sec^{-1}
Hydraulic conductivity		
U.S. gal day^{-1} ft^{-2}	4.720×10^{-7}	m sec^{-1}
Permeability		
darcies	9.870×10^{-13}	m^2
Transmissivity		
U.S. gal day^{-1} ft^{-1}	1.438×10^{-7}	m^2 sec^{-1}
U.S. gal min^{-1} ft^{-1}	2.072×10^{-1}	l sec^{-1} m^{-1}
Magnetic field intensity		
gausses	1.0×10^{5}	gammas
Energy, heat		
British thermal units, BTU	2.52×10^{-1}	calories, cal
BTU	1.0758×10^{2}	kilogram-meters, kgm
BTU lb^{-1}	5.56×10^{-1}	cal kg^{-1}
Temperature		
°C + 273	1.0	°K (Kelvin)
°C + 17.78	1.8	°F (Fahrenheit)
°F – 32	5/9	°C (Celsius)

**Divide by* the factor number to reverse conversions.
Exponents: for example 4.047×10^3 (see acres) = 4,047; 9.29×10^{-2} (see ft^2) = 0.0929.

Editor: Nancy Gilson

Typeface: Palatino

Presswork: Miehle Single Color Offset
Harris Single Color Offset

Binding: Perfect bound with softbound cover

Paper: Cover on 12-pt. Kivar Text
on 70-lb White Matte
Plates on 80-lb LOE Gloss

Ink: Cover—PMS 320, black
Text—Black
Plates 1 color process, black

Quantity: 1,000