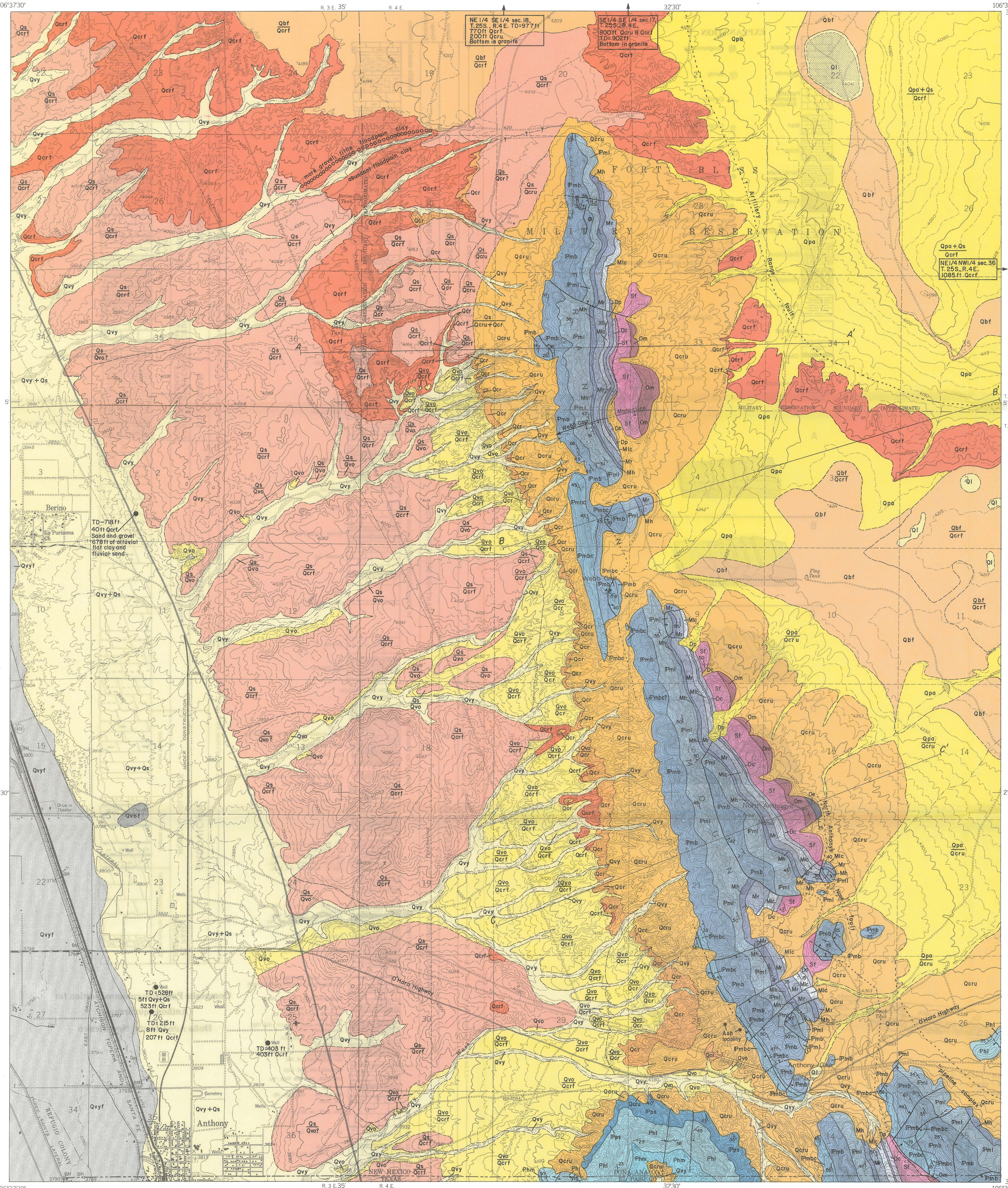


Base from U.S. Geological Survey
Drafting by James Brannon, 1983

Geology by Shari Kelley and J. Paul Matheny, 1979
Bedrock geology south of 32°2'30" after Harbour (1972)
Geology of "pipeline complex" after Figuers (in press)

CORRELATION OF UNITS

Qvy	Qvy—Younger valley-slope alluvium
Qvyf	Qvyf—Younger valley-fill fluvial facies
Qvo	Qvo—Older valley-slope alluvium
Qvof	Qvof—Older valley-fill fluvial facies
Qs	Windblown sand
Qpo	Qpo—Undifferentiated piedmont-slope alluvium
Ql	Ql—Playa-lake sediments
Qbf	Qbf—Basin-floor sediments
Qcrf, Qcr, Qcru	Camp Rice Formation; Qcrf—Fluvial facies; Qcr—Eolian and piedmont toeslope facies; Qcru—Undifferentiated piedmont toeslope facies
IPhm	Middle member of Hueco Formation
IPhl	Lower member of Hueco Formation
IPps	Panther Seep Formation (Magdalena Group)
IPmbc	Bishop Cap Formation (Magdalena Group)
IPmb	Berino Formation (Magdalena Group)
IPml	La Tuna Formation (Magdalena Group)
Mh	Helms Formation
Mr	Rancheria Formation
Mlc	Las Cruces Formation
Dp	Percha Shale
Dc	Canutillo Formation
Sf	Fusselman Dolomite
Om	Montoya Dolomite
Oe	El Paso Limestone

Rio Grande valley — Undissected bolson

SERIES	SYSTEM
MIDDLE PLEISTOCENE–HOLOCENE; UPPER PLIOCENE–MIDDLE PLEISTOCENE	QUATERNARY
WOLFCAMPIAN	PERMIAN
VIRGILIAN; MISSOURIAN; DESMOINESIAN; ATOKAN; MORROWAN	PENNSYLVANIAN
CHESTERIAN; MERAMECIAN	MISSISSIPPIAN
UPPER DEVONIAN; MIDDLE DEVONIAN	DEVONIAN
MIDDLE SILURIAN	SILURIAN
MIDDLE-UPPER ORDOVICIAN; LOWER ORDOVICIAN	ORDOVICIAN

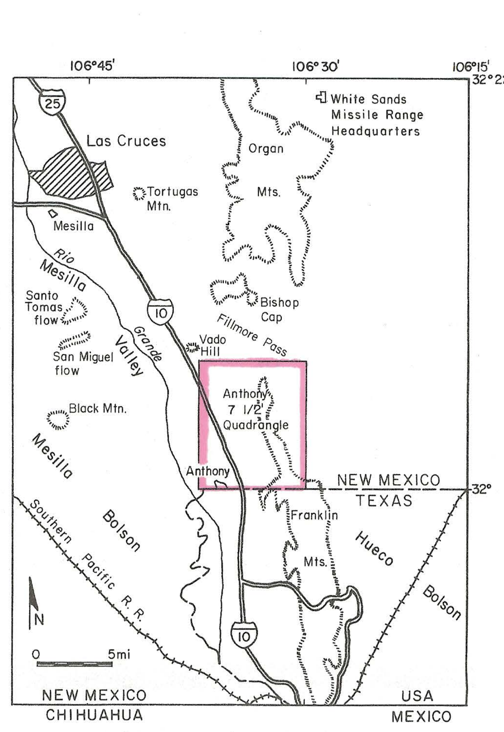
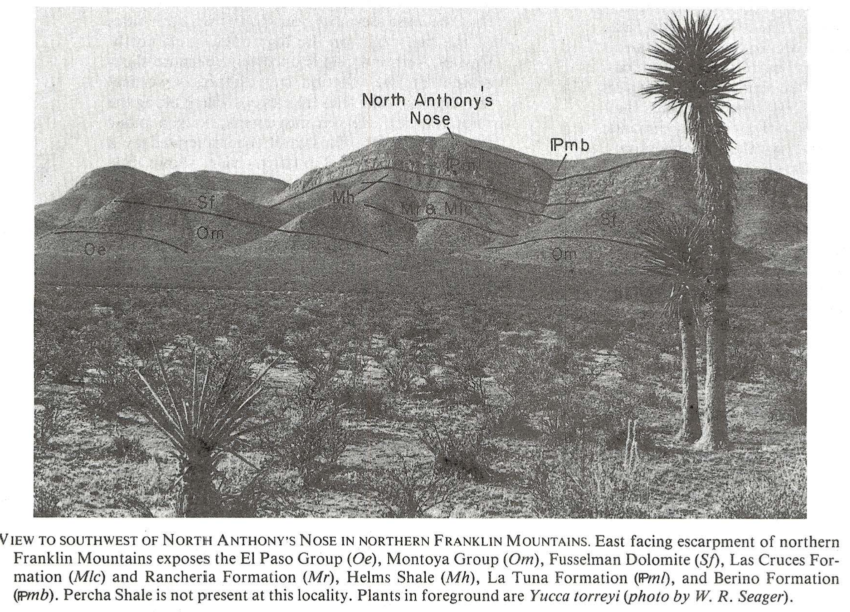
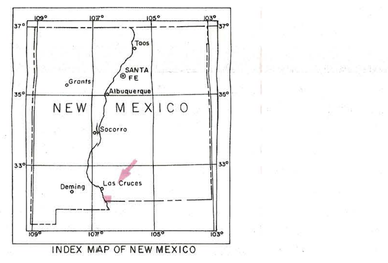
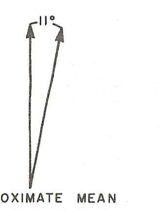


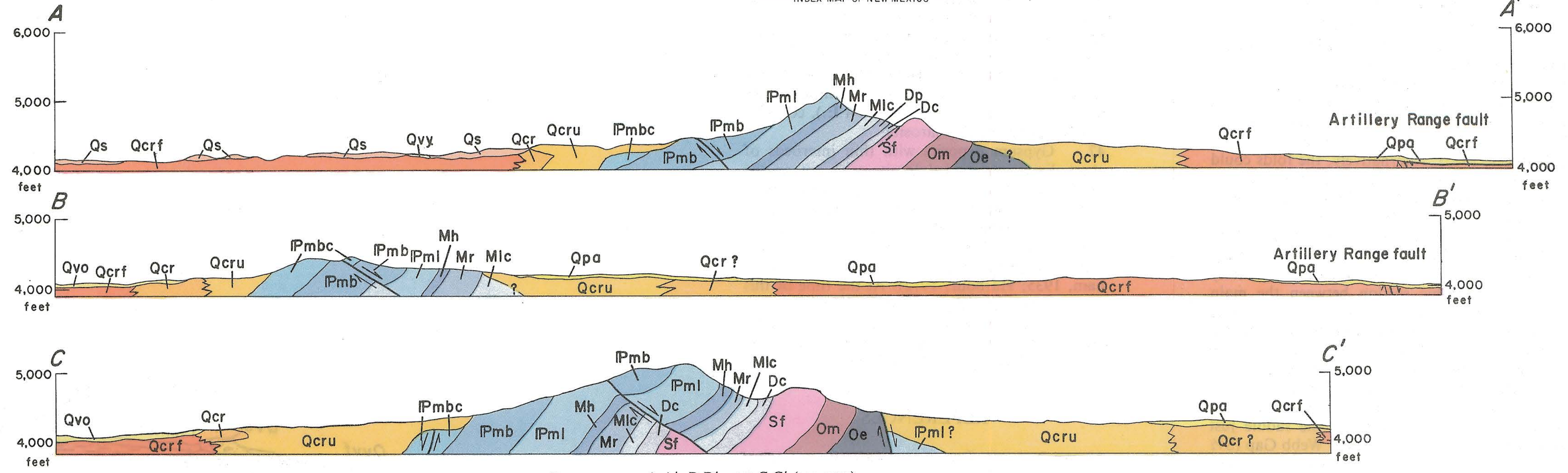
FIGURE 1—Location of Anthony 7½-min quadrangle in Doña Ana County, New Mexico.



View to southwest of North Anthony's Nose in northern Franklin Mountains. East facing escarpment of northern Franklin Mountains exposes the El Paso Group (Oe), Montoya Group (Om), Fusselman Dolomite (Sf), Las Cruces Formation (Mlc) and Rancheria Formation (Mr), Helms Shale (Mh), La Tuna Formation (IPml), and Berino Formation (IPmb). Percha Shale is not present at this locality. Plants in foreground are *Yucca torreyi* (photo by W. R. Seager).





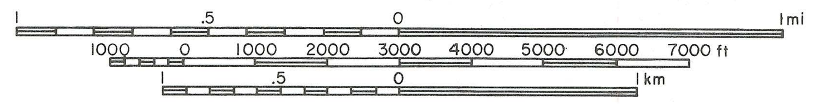


Cross sections A-A', B-B', and C-C' (see map).

Geology of Anthony quadrangle, Doña Ana County, New Mexico

by Shari Kelley and J. Paul Matheny, 1983

scale 1:24,000



Abstract

The northernmost extension of the Franklin Mountains, a tilted block of Paleozoic (Ordovician–Permian) carbonates and shales, is the dominant topographic feature of the Anthony 7½-min quadrangle in southeast Doña Ana County, New Mexico. Rocks of the northern Franklin Mountains have been subjected to early Tertiary (?) folding, possibly related to the Laramide orogeny, and late Tertiary to Quaternary faulting associated with the Rio Grande rift. The most unusual structures in the quadrangle are north-trending, low-angle, normal faults. Apparently, these low-angle fault planes originally were steep fractures that rotated to low-angle attitudes as the Franklin Mountains block tilted west. As rotation continued, movement along the low-angle faults became inefficient; consequently, high-angle, normal faults developed in the Hueco Bolson, east of the Franklin Mountains. The Camp Rice Formation (late Tertiary to early Quaternary) and middle to late Quaternary fan and eolian deposits cover large portions of the map area. Three distinct facies of the Camp Rice Formation are present in the Anthony quadrangle: 1) a fluvial facies composed of channel sand and floodplain clay, 2) an eolian facies consisting of loamy sand, and 3) a piedmont-slope facies composed of fan material from the adjacent mountains. These Quaternary deposits indicate that during the Pleistocene a substantial amount of water from the ancestral Rio Grande flowed east through Fillmore Pass into the Hueco Bolson. Less water flowing west of the mountains into the Mesilla Valley led to the development of a relatively stagnant, deltaic environment, southwest of Fillmore Pass. During the Pleistocene, the prevailing westerly wind blew across the broad floodplain in the Mesilla Valley and piled fluvial sand into eolian dunes against alluvial fans that were forming adjacent to the rising Franklin Mountains.

INTRODUCTION

1 The Anthony 7½-min quadrangle is in southeast Doña Ana County, New Mexico, just north of the New Mexico–Texas state line (fig. 1). A tilted block of folded and faulted Paleozoic carbonates and shales forms a low mountain ridge in the central portion of the map area. This block, which is the northernmost extension of the Franklin Mountains, is part of the continuous, north-trending San Andres–Organ–Franklin fault block of south-central New Mexico and west Texas. The mountains are flanked on the east by the Hueco Bolson and on the west by the Mesilla Valley. Although large portions of the valley are covered by recent eolian and alluvial-colluvial sediments, entrenchment of the Mesilla Valley by the Rio Grande and Quaternary movement along the Artillery Range fault in the Hueco Bolson have provided good exposures of Pleistocene to Holocene deposits in the area.

2 Previous workers in this quadrangle were concerned with either bedrock geology or ground water and geomorphic studies. A geologic map of the southern third of the Anthony quadrangle was published by Harbour (1972) as part of his map of the northern Franklin Mountains in Texas and New Mexico. Several minor modifications of his map are made in this report. The stratigraphy and microfacies of the Pennsylvanian formations exposed south and west of Anthony Gap have been described by Allouani (1976), El Foul (1976), and Hair (1976, 1977). Figuers (personal communication, 1979) is currently analyzing the structural geology of the "pipeline complex" southeast of Anthony Gap. Knowles and Kennedy (1958), Leggat and others (1962), and King and others (1971) discussed the lithology and groundwater conditions surrounding several wells located in or near the map area. In addition, Hawley (unpublished data, 1969) has done detailed work on the soils and geomorphic surfaces near Anthony Gap in the southern part of the area. In this report, we have combined the results of previous efforts with our own observations in describing the geology of the Anthony 7½-min quadrangle.

Acknowledgments—This map is the result of work done for our undergraduate field geology class project at New Mexico State University under the direction of Dr. William R. Seager. We would like to thank Dr. Seager and Dr. John W. Hawley of the New Mexico Bureau of Mines and Mineral Resources for suggesting this project, spending time with us in the field, answering questions concerning the structural and Quaternary geology of the area, and reviewing the map and text. We also thank Sandy Figuers of the University of Texas at El Paso for allowing us to use a simplified version of his geologic map of the "pipeline complex" in our report. We greatly appreciate Richard E. Kelley's assistance in the field.

DESCRIPTION OF ROCK UNITS

3 A composite section of the Paleozoic rocks exposed in the Anthony quadrangle is presented on the back of this sheet. Harbour's (1972) measured sections of the Ordovician, Silurian, and upper Mississippian rocks at North Anthony's Nose have been incorporated into this section. Hair's (1977) section of the Panther Seep and Harbour's (1972) section of the Hueco, measured at the southern boundary of the map area, have also been included in the composite section. The remainder of the section is the result of work done during this study.

4 Paleozoic rocks—The *El Paso Limestone* (Lower Ordovician) is the oldest rock unit exposed in the northern Franklin Mountains. This formation, originally named by Richardson (1904) from exposures in the Franklin and Hueco Mountains, has been divided into three unnamed members by Harbour (1972). Only a portion of Harbour's upper dolomite and sandy limestone member is found in the Anthony quadrangle in a poorly-exposed outcrop just east of North Anthony's Nose. The outcrop consists of approximately 30 m (98 ft) of gray, cherty dolomite that weathers to light tan. The most common fossils in the El Paso Limestone (Lower Ordovician) are snails, brachiopods, trilobites, and conodonts (Harbour, 1972). Because the El Paso thins northward due to post-depositional, pre-Montoya erosion (Harbour, 1972), the outcrop exposed in the Anthony quadrangle is far below the depositional top of the El Paso section. The El Paso is approximately 369 m (1,210 ft) thick farther south in the Franklin Mountains (Harbour, 1972).

5 The El Paso Limestone unconformably underlies the *Montoya Dolomite*, which was differentiated from the El Paso by Richardson (1908). Although many workers in southern New Mexico (Kelley and Silver, 1952; Pray, 1958; Kottlowski, 1975) divide the Montoya into the Upham, Aleman, and Cutter Formations, Harbour (1972) considers the Upham, Aleman, and Cutter to be members within the Montoya Dolomite. For mapping purposes, we have chosen to follow Harbour's definition of the Montoya Dolomite. A fourth member of the Montoya, the *Cable Canyon Sandstone Member*, is absent in the Franklin Mountains, but is present at the base of the formation in the mountains farther north.

6 The Montoya weathers to a gray to light-gray, ledgy slope along the east front of the northern Franklin Mountains. The lowermost unit of the Montoya, the *Upham Dolomite Member*, is a medium-grained, gray dolomite that weathers gray to dark gray. Above the Upham is the *Aleman Dolomite Member*, a fine-grained, dark-gray dolomite with conspicuous, abundant lenses and nodules of medium- to light-gray chert. Overlying the Aleman is the *Cutter Dolomite Member*, a fine-grained, dark-gray dolomite that weathers to light gray. The Upham Member (Middle Ordovician) and the Aleman and Cutter Members (Upper Ordovician) (Kottlowski and others, 1956; Howe, 1959) contain a few brachiopods, corals, and gastropods and abundant, dolomitized fossil debris. Thickness of the Montoya ranges from 116 m (380 ft), at a point 4.8 km (3.0 mi) south of the New Mexico–Texas state line (Harbour, 1972), to 130 m (426 ft) at Bishop Cap (Kramer, 1970). The Upham, Aleman, and Cutter Members of the Montoya are 27 m (89 ft), 44 m (144 ft), and 52 m (170 ft) thick, respectively (Harbour, 1972); total thickness of the Montoya Dolomite in this area is 123 m (403 ft).

7 The *Fusselman Dolomite* (Silurian), which was defined by Richardson (1908), disconformably overlies the Montoya Dolomite. Rugged, complexly jointed, light-gray cliffs formed by the Fusselman crop out along the entire east side of the northern Franklin Mountains, except at the extreme northern end. The Fusselman is a pure, thick-bedded, light-gray dolomite with minor amounts of chert and limestone. Richardson (1909) and Pray (1958) both assigned a Middle Silurian age to the Fusselman on the basis of brachiopods, corals, and gastropods found within the formation. Erosion prior to the Middle Devonian caused the formation to thin from 185 m (607 ft) in the southern part of the area to 150 m (492 ft) at the north end of the Franklin Mountains (Harbour, 1972). Silicified zones containing barite, fluorite, and limonite mineralization are common in the Fusselman near its unconformable upper contact with the Canutillo Formation. Mineralizing fluids probably migrated upward through extensive fractures in the Fusselman and spread laterally along the unconformity upon encountering the impermeable Canutillo Formation and Percha Shale.

8 The *Canutillo Formation* overlies the Fusselman with slight angular discordance caused by minor erosion following tilting of the Fusselman and older rocks. Nelson (1940) included all Devonian rocks in the Franklin Mountains in the Canutillo Formation; however, Laudon and Bowsher (1949) later realized that the upper part of Nelson's Canutillo Formation is actually correlative with the Percha Shale farther north. As a result, the name "Canutillo Formation" is applied to only the lower portion of Nelson's Canutillo Formation.

9 The Canutillo crops out in talus-covered slopes along the eastern escarpment of the range, except at the north end of the Franklin Mountains. The lower two-thirds of the formation is primarily lenses of chert and marl; the upper third consists of interbedded, dark-gray shale and siltstone. Because the Canutillo is composed of incompetent strata, small, local, disharmonic folds are common within the formation. The only significant fossils found in the Canutillo Formation (late Middle Devonian) are brachiopods and conodonts (Harbour, 1972). This formation thins northward from at least 30 m (97 ft) at North Anthony's Nose (Harbour, 1972) to approximately 15 m (49 ft) near Webb Gap.

10 Conformably overlying the Canutillo Formation is the *Percha Shale*, a fissile, black shale, distinguished mainly by its stratigraphic position between thick limestone or dolomite units. This shale was correlated by Laudon and Bowsher (1949) with the Percha Shale of southwest New Mexico. Like the Canutillo, the Percha forms a talus-covered slope on the east face of the northern Franklin Mountains. The Percha pinches out just north of North Anthony's Nose and appears to be absent between North Anthony's Nose and Anthony Gap. A relatively thin (12–15 m; 39–49 ft) Percha section crops out in the mountains south of Anthony Gap. The exact age and correlation of the Percha in this area are uncertain, because no fossils have been found in this shale. The average thickness of the Percha in the Franklin Mountains north of North Anthony's Nose is approximately 18–21 m (60–70 ft).

11 The *Las Cruces Limestone* (Mississippian), named by Laudon and Bowsher (1949) for exposures in Vinton Canyon, 3.5 km (2.1 mi) south of the New Mexico–Texas state line, unconformably overlies Devonian rocks. The Las Cruces forms distinctive, light-gray, evenly bedded (0.3–0.6-m-thick beds), ledgy cliffs along the east side of the Franklin Mountains. In general, the Las Cruces is a dense, brittle, primarily chert-free micrite. Small chert lenses and thin (0.5–1.0 cm), bioturbated, sandy layers are interbedded with limestone in the upper 4 m (13 ft) of the section, north of Webb Gap. Small chert lenses are more common throughout the Las Cruces section, south of Webb Gap. Although the Las Cruces contains very few fossils, Laudon and Bowsher (1949) considered the formation to be of Meramecian age on the basis of a few ostracod valves and lithologic resemblance to the overlying Rancheria Formation. Conodonts found in the Las Cruces at Vinton Canyon indicate that the formation is of late Osage to early Meramecian age (Lane, 1974). The Las Cruces is approximately 27 m (90 ft) thick throughout the area.

12 The *Rancheria Formation*, also named by Laudon and Bowsher (1949), apparently lies conformably on the Las Cruces. The Rancheria crops out in orange-brown to light-gray slopes with few cliffs or ledges along the east face of the range. This formation is divided into three unnamed members: a lower member composed of cherty, black micrite with some siltstone and shale; a middle member characterized by chert-free black micrite that weathers to a light-gray band; and an upper member composed of cherty, sandy, black micrite. The lower member includes a 3-m (10-ft) thick basal bed of crossbedded, crinoidal limestone. The Rancheria, which was assigned a Meramecian age by Laudon and Bowsher (1949), contains abundant crinoid debris, bryozoa, brachiopods, and gastropods. The crinoidal bed near the base of the Rancheria at Vinton Canyon yields a few conodonts that also indicate a Meramecian age (Lane, 1974). The lower, middle, and upper members of the Rancheria are 45, 11, and 61 m (150, 35, and 200 ft) thick, respectively.

13 The upper member of the Rancheria grades into the overlying *Helms Formation*. The Helms, named by Beede (1920) and more clearly defined by Laudon and Bowsher (1949), forms greenish-gray slopes below the Pennsylvanian limestone cliffs along most of the east flank of the Franklin Mountains. This formation is composed of calcareous, gray shale, fossiliferous, olive-green micrite, and some oolitic, olive-green micrite. A 6-m-thick quartzite lens containing a *Lepidodendron* impression (Harbour, 1972) crops out at the top of the Helms, south of North Anthony's Nose. Fossils found in the Helms Formation (Chesterian) include brachiopods, gastropods, ostracods, crinoids, and bryozoa. The Helms is approximately 30 m (100 ft) thick in the Anthony quadrangle.

14 The *Magdalena Group* (Pennsylvanian) conformably overlies the Helms. Originally, Richardson (1904, 1908, 1909) described the Magdalena Group as part of the Hueco Formation, which at that time included all rocks between the Silurian and Cretaceous. Nelson (1940) restricted the term "Magdalena Group" to Pennsylvanian rocks in the Franklin Mountains. Harbour (1972) called the Magdalena a formation and divided the formation into four members: the La Tuna, Berino, Bishop Cap, and unnamed transitional members. Because many workers in New Mexico and Texas (Kelley and Silver, 1952; LeMone, 1976) consider the Magdalena to be a group, we have assigned formation status to Harbour's

(text continued on back)