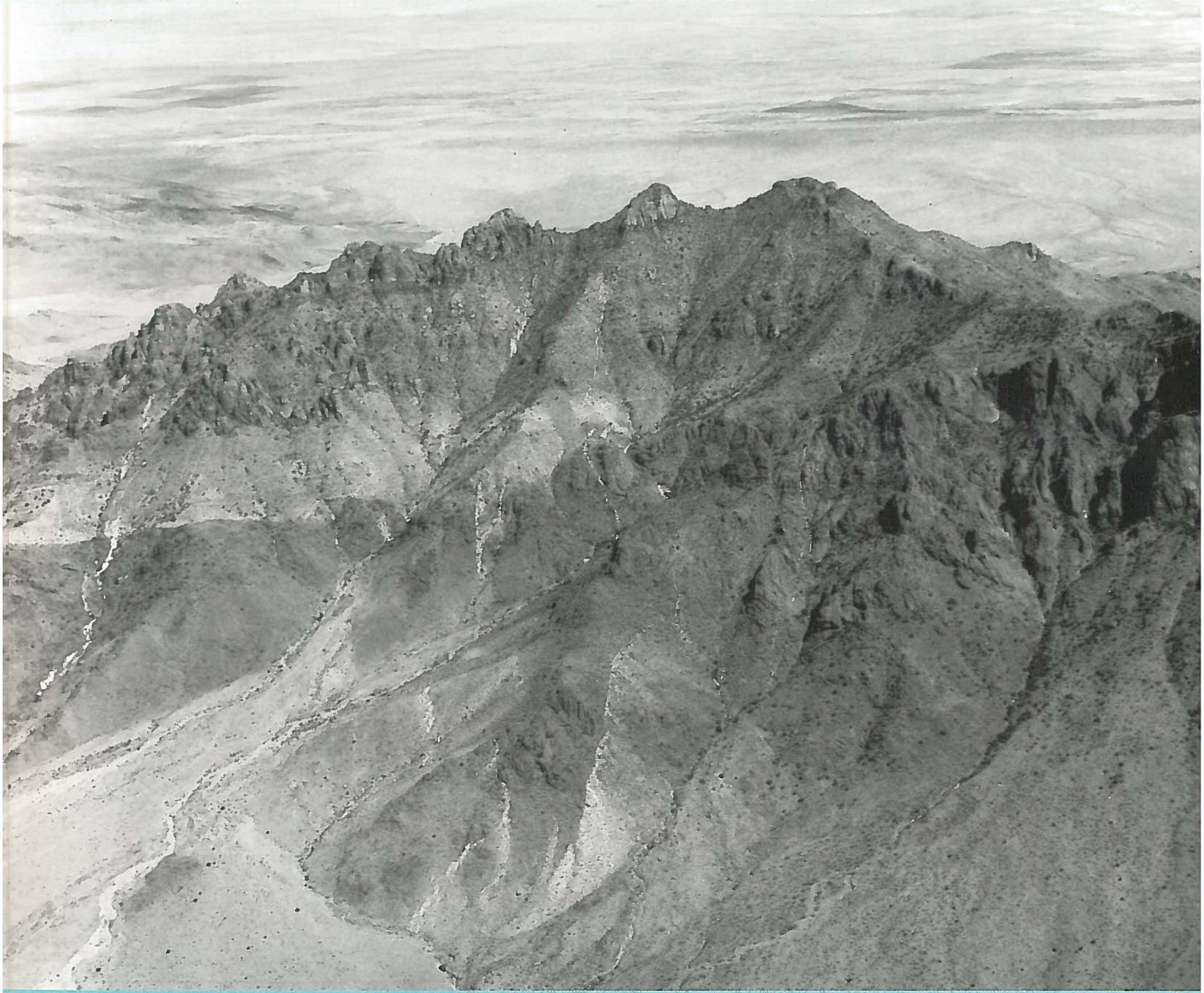
Geology of the Florida Mountains, southwestern New Mexico

by Russell E. Clemons



Memoir 43 New Mexico Bureau of Mines & Mineral Resources 1998

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

COVER—Aerial view of the west side of the Florida Mountains. Florida Gap is on the far left; Florida Peak is to the right of center. (Photo courtesy of Mobil Oil Corp.)

Errata for Memoir 43
Geology of the Florida Mountains, southwestern New Mexico
by Russell E. Clemons

The text on pages 33 and 34 is reversed. When reading from page 32, go to the top of the text on page 34, then to the top of the text on page 33.

Memoir 43

New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

Geology of the Florida Mountains, southwestern New Mexico

by Russell E. Clemons †
New Mexico State University, Las Cruces, New Mexico 88003

SOCORRO 1998

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY
Daniel H. López, *President*

NEW MEXICO BUREAU OF MINES & MINERAL RESOURCES
Charles E. Chapin, *Director and State Geologist*

BOARD OF REGENTS
Ex Officio
Gary Johnson, *Governor of New Mexico*
Michael S. Davis, *Superintendent of Public Instruction*

Appointed
Sidney M. Gutierrez, *President*, 1997–2001, *Albuquerque*
William Gruner, *Student member, Secretary/Treasurer*, 1997–1999, *Socorro*
Ann Murphy Daily, 1997–1999, *Santa Fe*
Randall E. Horn, 1997–2003, *Placitas*
Robert E. Taylor, 1997–2003, *Silver City*

BUREAU STAFF

Bruce Allen, *Field Geologist*
Barry Allred, *Hydrologist*
Ruben Archuleta, *Metallurgical Lab. Tech.*
George S. Austin, *Senior Industrial Minerals Geologist*
Albert Baca, *Maintenance Carpenter II*
James M. Barker, *Assistant Director, Senior Industrial Minerals Geologist, Supervisor, Cartography Section*
Paul W. Bauer, *Field Economic Geologist, Manager, STATEMAP Program*
Lynn A. Brandvold, *Senior Chemist*
Ron Broadhead, *Assistant Director, Senior Petroleum Geologist, Head, Petroleum Section*
Rita Case, *Administrative Secretary (Alb. Office)*
Steven M. Cather, *Senior Field Economic Geologist*
Richard Chamberlin, *Senior Field Economic Geologist*
Sean Connell, *Field Geologist*
Ruben A. Crespin, *Garage Supervisor*
Jeanne Deardorff, *Receptionist/Staff Secretary*
Nelia Dunbar, *Analytical Geochemist*
Richard Esser, *Lab. Technician*
Robert W. Eveleth, *Senior Mining Engineer*
Elizabeth Fleming, *Petroleum Information Specialist*
Tianguang Fang, *Chemical Lab Tech*
Nancy S. Gilson, *Assistant Editor*
Kathryn G. Glesener, *Manager, Cartography Section*
Debbie Goering, *Staff Secretary*
Ibrahim Gundiler, *Senior Metallurgist*
William C. Haneberg, *Assistant Director, Engineering Geologist*
Bruce Hart, *Petroleum Geologist*
Lynn Heizler, *Assistant Curator*
Matt Heizler, *Geochronologist*
Lynne Hemenway, *Geologic Info. Center Coordinator*
Michael Heynekamp, *Geological Lab Associate*
Carol A. Hjellming, *Associate Editor*
Gretchen K. Hoffman, *Senior Coal Geologist*
Peggy Johnson, *Hydrogeologist*
Glen Jones, *Manager, Computer Services*
Philip Kyle, *Geochemist/Petrologist*
Ann Lanning, *Executive Secretary*
Annabelle Lopez, *Petroleum Information Specialist*
David W. Love, *Senior Environmental Geologist*
Jane A. Calvert Love, *Editor*
Virgil Lueth, *Mineralogist/Economic Geologist, Curator, Mineral Museum*
Mark Mansell, *GIS Specialist*
David McCraw, *GIS Cartographer*
William McIntosh, *Volcanologist/Geochronologist*
Christopher G. McKee, *X-ray Facility Manager*
Virginia T. McLemore, *Senior Economic Geologist*
Norma J. Meeks, *Director of Publications Office*
Lisa Peters, *Lab. Technician*
Barbara R. Popp, *Biotechnologist*
Marshall A. Reiter, *Principal Senior Geophysicist*
Gabriella Romero-Silva, *Accounting Technician*
Terry Telles, *Information Specialist*
Jan Thomas, *Cartographer II*
Rebecca J. Titus, *Senior Cartographer*
Judy M. Vaiza, *Business Serv. Coordinator*
Manuel J. Vasquez, *Mechanic II*
Susan J. Welch, *Manager, Geologic Extension Service*
Mike Whitworth, *Hydrogeologist*
Maureen Wilks, *Bibliographer*
Jiri Zidek, *Chief Editor/Senior Geologist*

Robert A. Bieberman, *Emeritus Sr. Petroleum Geologist*
John W. Hawley, *Emeritus Sr. Environmental Geologist*
Jacques R. Renault, *Emeritus Senior Geologist*
Samuel Thompson III, *Emeritus Sr. Petroleum Geologist*
Frank E. Kottlowski, *Emeritus Director/State Geologist*
Robert H. Weber, *Emeritus Senior Geologist*

Research Associates

William L. Chenoweth, *Grand Junction, CO*
Charles A. Ferguson, *AGS*
John W. Geissman, *UNM*
Leland H. Gile, *Las Cruces*
Carol A. Hill, *Albuquerque*
Bob Julyan, *Albuquerque*
Shari A. Kelley, *NMT (adjunct faculty)*
William E. King, *NMSU*
Barry S. Kues, *UNM*
Michael J. Kunk, *USGS*
Timothy F. Lawton, *NMSU*
David V. LeMone, *UTEP*
Spencer G. Lucas, *NMMNH&S*
Greg H. Mack, *NMSU*
Nancy J. McMillan, *NMSU*
Howard B. Nickelson, *Carlsbad*
Glenn R. Osburn, *Washington Univ.*
Allan R. Sanford, *NMT*
William R. Seager, *NMSU*
Edward W. Smith, *Tesuque*
John F. Sutter, *USGS*
Richard H. Tedford, *Amer. Mus. Nat. Hist.*

Graduate Students

Jodi Clark
Vladimir Ispolatov
Robin Pearson
Kristen Coose
William LeFevre
Ron Smith
Andy Dunn
Eric Munroe
Sarah Wilson

Plus about 25 undergraduate assistants

Original Printing

Published by Authority of State of New Mexico, NMSA 1953 Sec. 63–1–4
Printed by University of New Mexico Printing Services, June 1998.

Available from **New Mexico Bureau of Mines & Mineral Resources, 801 Leroy Place, Socorro, NM 87801; phone (505) 835-5410**
Published in public domain, therefore reproducible without permission. Source credit requested.

Preface

The idea of conducting a comprehensive geologic study of the Florida Mountains germinated in 1978 while I was working on road logs in Luna County with Sam Thompson, III. The mountains had been mapped twice (Darton, 1916; Corbitt, 1971), but debates and controversies over interpretations of several aspects of the geology of the Florida Mountains were not settled. Were the plutonic rocks of Precambrian, Ordovician, Mesozoic, or some other age? Were the plutonic rocks related, or were they formed by multiple episodes of plutonism? Were the gabbros and diorites (hornfelses) older or younger than the granites and syenites? Information on the ages and genesis of these rocks appeared critical to conducting mineral exploration. Was the Lobo Formation of Permian, Cretaceous, or Tertiary age? Was it gradational into the overlying Rubio Peak Formation? What was the origin of the south Florida Mountains fault and associated thrust faults? Were they part of the Cordilleran overthrust belt? If not, how could the complex structures be explained? The Florida Mountains seemed to contain the most complete Paleozoic section between the Franklin and Big Hatchet Mountains. Surely, more useful information could be obtained by a thorough stratigraphic and petrographic study, especially with renewed interest in oil and gas exploration in southwestern New Mexico. Where did the volcanic rocks in the Little Florida Mountains come from? Were they related to the mineralization? Enclosed herein are some answers to the above questions and my version of the geology of the Florida and the Little Florida Mountains. By no stretch of the imagination am I naive enough to think it is the final version! Hopefully, reading this report will inspire or incite others to prove or disprove the enclosed interpretations and add to the database. In that way, this report will be a stepping stone to better understanding of the geology of southwestern New Mexico.

While conducting this study, I visited most of the mountains in southwestern New Mexico to gain a better understanding of the various rock units exposed in the Florida Mountains. In so doing, I benefited greatly from use of published information on southwestern New Mexico by many geologists who preceded me in discovering the geologic intrigue of this part of the state. Instead of holding all data until completion of mapping and laboratory studies, progress reports were published as four geologic maps (Clemons, 1982a, 1984, 1985; Clemons and Brown, 1983). Terminology, interpretations, and ideas in this report (phase 5) represent revisions from all my earlier publications on the Florida Mountains.

Acknowledgments—Contributions to this project have been made by many persons and organizations in the form of financial aid, field and laboratory assistance, advice, technical aid, critical readings of texts, and other types of help and cooperation. The New Mexico Bureau of Mines and Mineral Resources provided the bulk of financial assistance for the field work, preparation of petrographic slides, K–Ar age determinations, and drafting of maps and figures. I thank Lynn Brandvold at the Bureau who provided chemical analyses and assays. Thanks also go to Robert North at the Bureau who provided some zircon and apatite separates for age determinations. I am grateful to Charles Thorman, Karl Evans, and Robert Zimmerman with the U.S. Geological Survey for providing U–Pb and fission-track ages. Special thanks are extended to Frank Kottlowski, Director of the New Mexico Bureau of Mines and Mineral Resources, for his continued support and encouragement during the study and for many discussions on the geology of Luna County. I also gratefully acknowledge the major effort provided by Glen Brown through his thesis on the Gym Peak area and our many discussions on the structure of the Florida Mountains. Irene Lemley assisted in unraveling the age of the Lobo Formation with her thesis that was supervised by Greg Mack. The Phillips Petroleum Foundation generously provided fellowships to finance these two theses. Glen Brown, Charles Chapin, Leroy Corbitt, Harold Drewes, Rousseau Flower, John Hawley, Greg Mack, William Seager, Sam Thompson, and Charles Thorman are acknowledged for discussions that aided interpretations. Charles Chapin, Roger Denison, Harold Drewes, Anne Loring, William Seager, Sam Thompson, and Charles Thorman read various parts of manuscripts during the study and made many suggestions for improvement. James Barrick, Alonso Jacka, William King, Keith Rigby, and Donald Toomey willingly provided fossil and allochem identifications for which I am thankful. I am grateful to N. Crawford, W. Greeman, L. Koenig, R. May, D. McDougal, the POL Ranch, and all other landowners for allowing access to their lands. I also thank L. Horton (Deming manager for Barite of America) who provided access to the new adit below the Atir mine and donated core samples for petrographic study. A special thank you goes to Gene Cook for his hospitality to Glen Brown and me, and discussions concerning the Mahoney mines and Anniversary prospect. Robert Cooper and Steve Speer were of considerable assistance in the field and laboratory, and I thank them for their enthusiastic efforts. I also wish to thank Steve Blodgett, Jane Calvert, Mickey Wooldridge, and other members of the New Mexico Bureau of Mines & Mineral Resources' editorial and drafting staff for their assistance and patience during revisions necessitated by amended interpretations and new field data.

Russell E. Clemons
New Mexico State University, 1986

Contents

ABSTRACT **6**
INTRODUCTION **6**
  LOCATION **6**
  ACCESS AND LAND OWNERSHIP **6**
  PHYSIOGRAPHY **8**
  PREVIOUS WORK **10**
STRATIGRAPHY **11**
  PRE-BLISS ROCKS **11**
    Hornblende gneiss and gneissic granite **11**
    Hornfels and related rocks **11**
    Syenites **12**
    Granites **14**
    Age **16**
    Diamictite **16**
  PALEOZOIC ROCKS **16**
    Bliss Sandstone **18**
    El Paso Formation **20**
    Montoya Formation **26**
    Fusselman Dolomite **34**
    Percha Shale **36**
    Rancheria Formation **37**
    Hueco Limestone **39**
    Oncolite beds **39**
  MESOZOIC(?)–CENOZOIC ROCKS **40**
    Lobo Formation **41**
    Rubio Peak Formation **44**
  MIOCENE–OLIGOCENE VOLCANIC ROCKS **45**
    Ash-flow tuff of Little Florida Mountains **46**
    Rhyolite and tuff of Little Florida Mountains **46**
    Basaltic andesite of Little Florida Mountains **47**
    Fanglomerate of Little Florida Mountains **47**
    Dacite of Little Florida Mountains **48**
  MONZONITE OF FLORIDA MOUNTAINS **49**
  MIMBRES FORMATION **49**
  QUATERNARY ALLUVIUM **49**
STRUCTURAL GEOLOGY **50**
  REGIONAL SETTING **50**
  SOUTH FLORIDA MOUNTAINS FAULT **52**
  THRUST FAULTS **54**
    Victorio thrust fault **54**
    Gym Peak thrust fault **55**
    Mahoney thrust fault **55**
    Capitol Dome thrust faults **56**
  MAHONEY PARK AUTOCHTHON **56**
  NORMAL FAULTS **57**
  SYNTHESIS **57**
MINERAL RESOURCES **58**
  METALLIC DEPOSITS **59**
    Mahoney mines **59**
    Silver Cave mine **60**
    Anniversary prospect **60**
    Priser mine **60**
    Atir mine **60**
    Park (Hilltop) mine **61**
    San Antonio mine **61**
    Stensor (Copper Queen) mine **61**
    Bradley mine **62**
    Little Florida Mountains mining district **62**
    Other mines and prospects **62**
  CLAY, SAND, AND GRAVEL **63**
  OIL AND GAS **63**
  GROUND WATER **65**
REFERENCES **65**
APPENDICES **73**
SHEETS **IN POCKET**

Figures

1—Index map of topographic quadrangle maps **7**
2—Location map of Luna County **7**
3—Location map of Florida and Little Florida Mountains **8**
4—Slopes southwest of South Peak and South Peak **9**
5—Eastern slopes from Mahoney Ridge and Gym Peak **9**
6—Northern Florida Mountains and Mimbres Basin **9**
7—West face of Little Florida Mountains **9**
8—Drainage-pattern map **10**
9—Hornfels **12**
10—Pyroxene-hornfels xenoliths in granite **13**
11—Cross section of interlayered granite and hornfels **13**
12—Alkali-feldspar syenite **14**
13—Quartz–potassium feldspar contents of plutonic rocks **14**
14—Granite intruding hornblende gneiss and tectonically brecciated Bliss Sandstone **17**
15—Stratigraphic chart of exposed Precambrian and Paleozoic **17**
16—Tentative correlation of two Bliss Sandstone sections **19**
17—Bliss hematitic arkose, siliceous subarkose, dolomitic pelmicrosparite, and neomorphosed, fossiliferous Bliss limestone **20**
18—Subdivisions of El Paso Formation **21**
19—Dolomitized burrow fillings in McKelligon and Padre Members **22**
20—Allochems in Hitt Canyon Member **23**
21—*Nuia siberica* Maslov **24**
22—Allochems and trilobite pygidia in Jose Member **25**
23—Fossils in McKelligon Member **26**
24—Allochems in McKelligon Member **27**
25—Cherty, burrowed Padre Member **28**
26—Allochems in Padre Member **29**
27—Capitol Dome's west slope, Aleman–Upham contact, and Upham–Cable Canyon contact **30**
28—Allochems in Montoya Formation **31**
29—Dolomitized burrow fillings in Cutter Member **32**
30—Chert nodules in upper Cutter Member and Fusselman–Cutter contact **33**

31—Brachiopod coquina in Cutter Member 33
32—Corals in Fusselman Dolomite 35
33—Laminated dolomite and broken coral fragments in lower Fusselman Dolomite 35
34—Contact and *Syringopora*-like corals in Fusselman Dolomite 36
35—*Tentaculites* 37
36—Allochems in Rancheria Formation 38
37—Ostracods in Hueco Formation 39
38—Oncolite rims exposed in Mahoney Park 40
39—Western flank of Florida Mountains 42
40—Basal Lobo Formation and Lobo sandstones 43
41—Rubio Peak Formation 44
42—Andesite, basaltic andesite, and pyroxene hornfels 47
43—Perlitic obsidian, partially devitrified perlite, and agate nodules 48
44—Rhyolite fanglomerate 49
45—Western U.S. overthrust belt 50
46—Postulated fold-thrust belt 50
47—Major tectonic features 51
48—Bouguer anomaly map 51
49—Gym Peak and South Peak 52
50—South Florida Mountains fault in Mahoney Park 52
51—Cross sections of thrust-faulted rocks 53
52—Southeast flank of Florida Mountains 54
53—Ridge on south side of Mahoney Park 54
54—El Paso and Montoya Formations 55
55—Nonconformity between Bliss Sandstone and syenite 56
56—Tectonic map of Florida Mountains 58
57—Mines and prospects in the Florida Mountains 59
58—Sketch map of Barite of America adit and core 61
59—Sketch of polished section from Barite of America core 61
60—Inactive manganese mines 63
61—Oil and gas exploration wells in Luna County 64

Tables

1—Modes of gneisses 11
2—Chemical analyses and norms of plutonic rocks 15
3—Bliss Sandstone thicknesses 18
4—El Paso Formation thicknesses 21
5—Montoya Formation thicknesses 32
6—Fusselman Dolomite thicknesses 34
7—Lithologic description of oncolite beds in Mahoney Park 40
8—Cenozoic rocks exposed in Florida Mountains 41
9—Chemical analyses and norms of volcanic and hypabyssal rocks 46
10—Partial chemical analyses of selected ore and rock samples 60

Appendices

A–1—Modes of hornfels 73
A–2—Modes of plutonic rocks 74
B–1—El Paso Formation allochems at Capital Dome 76
B–2—El Paso Formation allochems at Victorio Canyon 78
C–1—Montoya Formation allochems at Capitol Dome 80
C–2—Montoya Formation allochems at Mahoney Park 80
C–3—Montoya Formation allochems at Victorio Canyon 81
D–1—Lobo Formation grain size and composition at Capitol Dome 82
D–2—Lobo Formation grain size and composition at Tubb Spring 82
D–3—Lobo Formation grain size and composition at west Florida Mountains 83
D–4—Lobo Formation grain size and composition at Lobo Draw 83
E–1—Capitol Dome (Bliss Sandstone channel) measured section 84
E–2—Capitol Dome (Bliss Sandstone–Montoya Formation) measured section 85
E–3—Mahoney Park (Montoya Formation–Fusselman Dolomite) measured section 93
E–4—Victorio Canyon–Birchfield mine (Bliss Sandstone–Fusselman Dolomite) measured section 96
E–5—Gym Peak–Mine Canyon (Bliss Sandstone–Hueco Formation) measured section 104
E–6—Northwest Capitol Dome (Lobo Formation) measured section 108
E–7—Tubb Spring (Lobo Formation) measured section 109
E–8—West Florida Mountains (Lobo Formation) measured section 110
E–9—Lobo Draw (Lobo Formation type section) measured section 111
E–10—Florida Peak (Rubio Peak Formation) measured section 112

Sheets

1—Geology of the Florida Mountains, Luna County New Mexico (a–north half, b–south half) **in pocket**
2—Geologic map of Mahoney mine–Gym Peak area **in pocket**
3—Geologic maps of Mahoney Park and of Capitol Dome areas **in pocket**
4—Cross sections of the Florida Mountains and explanation **in pocket**

Abstract

The Florida Mountains are an eastward-tilted Basin and Range fault block about 15 mi southeast of Deming. The mountains are surrounded by a broad bajada that slopes gently into the Mimbres Basin and sediments conceal the range-bounding faults except at the northwest end. Ephemeral streams are continuing the erosive processes that have reduced the exposed bedrock area to less than one-half of its initial size.

The oldest rocks exposed in the Florida Mountains are Precambrian hornblende and granitic gneisses exposed only north of Capitol Dome. An Upper Cambrian pluton intruded an andesitic to basaltic volcanic sequence producing the hornblende and pyroxene hornfels common in the western and southern parts of the mountains. The alkali-feldspar plutonic rocks are granite at the northern and southern ends of the range and syenite and quartz syenite in the central part. These shallow plutonic rocks and hornfels were unroofed before deposition of a diamictite that, in turn, was mostly eroded preceding deposition of the Bliss Sandstone in Early Ordovician time (approximately 500 m.y. B.P.). Approximately 4,100 ft of Paleozoic rocks that crop out in the southeastern Florida Mountains include, in ascending order: Bliss Sandstone, El Paso Formation, Montoya Formation, Fusselman Dolomite, Percha Shale, Rancheria Formation, and Hueco Formation. No Mesozoic rocks are present except possibly the basal beds of the Lobo Formation, the bulk of which was deposited penecontemporaneously with Laramide deformation during Paleocene and early to middle Eocene times. Extensive andesitic to rhyolitic volcanism from middle Eocene to early Miocene times accounted for the thick Rubio Peak volcaniclastic section forming Florida Peak, as well as the ash-flow tuff, air-fall tuffs, flow-banded rhyolite, basaltic andesite, and dacite in the Little Florida Mountains. Thick rhyolite fanglomerates in the Little Florida Mountains and alluvial conglomerates forming an apron around the mountains have been deposited as the mountain block was uplifted approximately 7,000 ft since early Miocene time.

The south Florida Mountains fault is a northwest-trending, high-angle reverse fault that places Upper Cambrian granite against rocks as young as basal Lobo Formation. Multiple, small thrust faults cut the Paleozoic rocks northeast of the south Florida Mountains fault. Most of these thrust faults exhibit younger-over-older rock relations and produce tectonic elimination of strata. A few show older-over-younger relations. Current studies demonstrate that Laramide deformation in the Florida Mountains is not a continuation of the Cordilleran overthrust belt. Evidence suggests that the deformation resembles the basement-cored uplifts of the Rocky Mountain foreland, with possibly some strike-slip components.

Hydrothermal alteration and low-grade mineralization are widespread in the Florida and Little Florida Mountains. Relatively limited activity has produced manganese, zinc, lead, silver, copper, barite, and fluorite ores. Most production of copper, zinc, lead, and silver ores was from shallow oxidized veins, but small amounts of chalcopyrite accompany fluorite and barite in deeper veins. The age of mineralization is believed to be late Tertiary.

Introduction

Location

The Florida range is one of many small mountain chains in southwestern New Mexico, so named for the profuse flowers that grow on the slopes—*florida* (Spanish; pronounced "floor-eé-dah") = flowery.

The Florida Mountains and Little Florida Mountains, southeast of Deming in south-central Luna County, have a combined area of about 100 mi^2. They occupy the southeastern corner of the Capitol Dome 7½ min quadrangle, western halves of the Florida Gap and Gym Peak 7½ min quadrangles, and eastern half of the South Peak 7½ min quadrangle (Fig. 1). The geologic map (Sheets la and lb) was compiled from these four topographic maps, all of which were published by the U.S. Geological Survey. The Florida Mountains are surrounded by alluvium that fills the Mimbres Basin. The Tres Hermanas Mountains lie 6 mi to the southwest, the Cedar Mountains about 26 mi to the west–southwest, the Snake Hills 12 mi to the west, Cooke's Range 10 mi to the north, the Goodsight Mountains 14 mi to the northeast, and the West Potrillo Mountains 22 mi to the east.

Access and land ownership

NM–11, between Deming and Columbus, borders the area on the west, and NM–549, east of Deming, crosses the northern tip of the Little Florida Mountains (Fig. 2). In addition, paved roads from these highways to Rock Hound State Park provide further access to that area. Many gravel roads and tracks from the highway to water tanks, windmills, and abandoned mines provide access to the perimeter of the range (Fig. 3). A four-wheel-drive road from Florida Gap to the antennas on the Little Florida Mountains, and another from

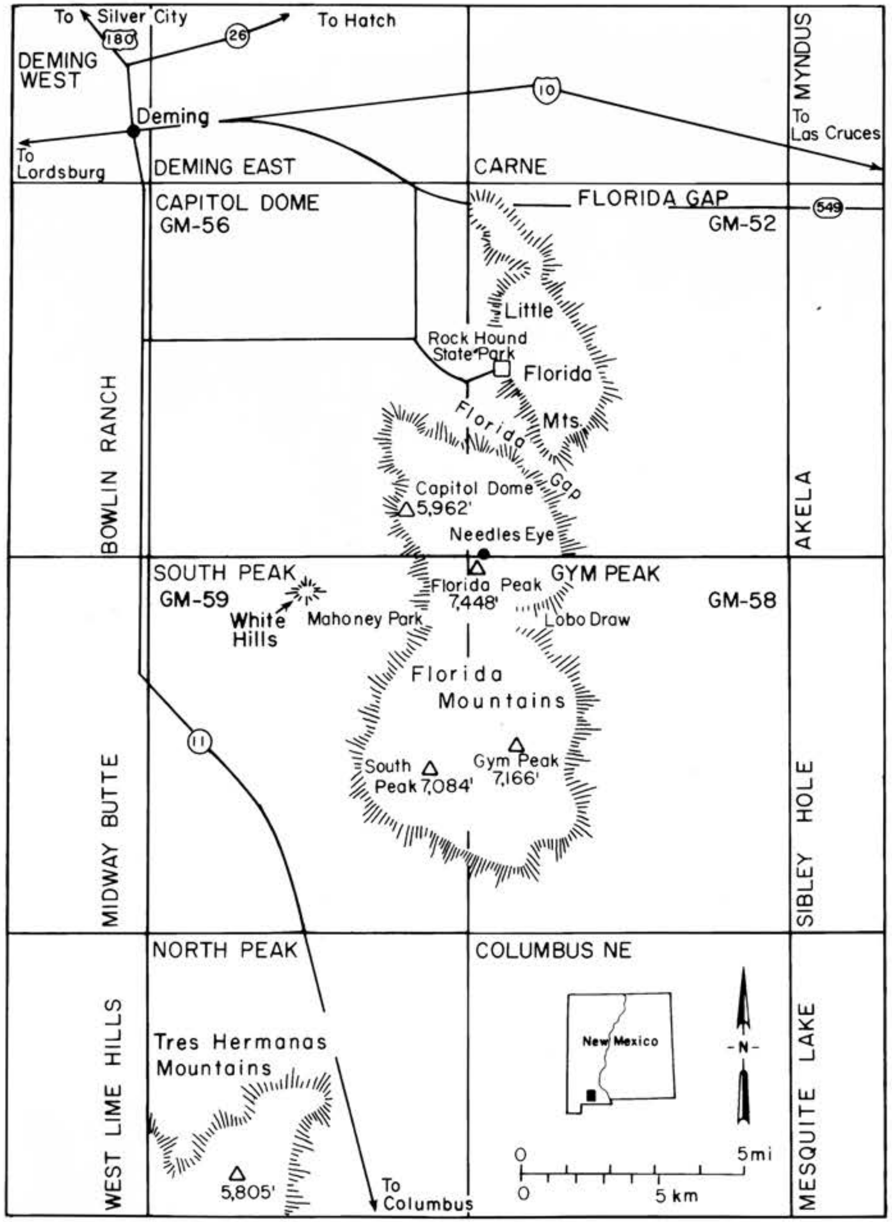


FIGURE 1—Index map showing locations of topographic quadrangles covering the Florida Mountains area. A geologic map of each quadrangle that includes the Florida Mountains has been published under the GM number given.

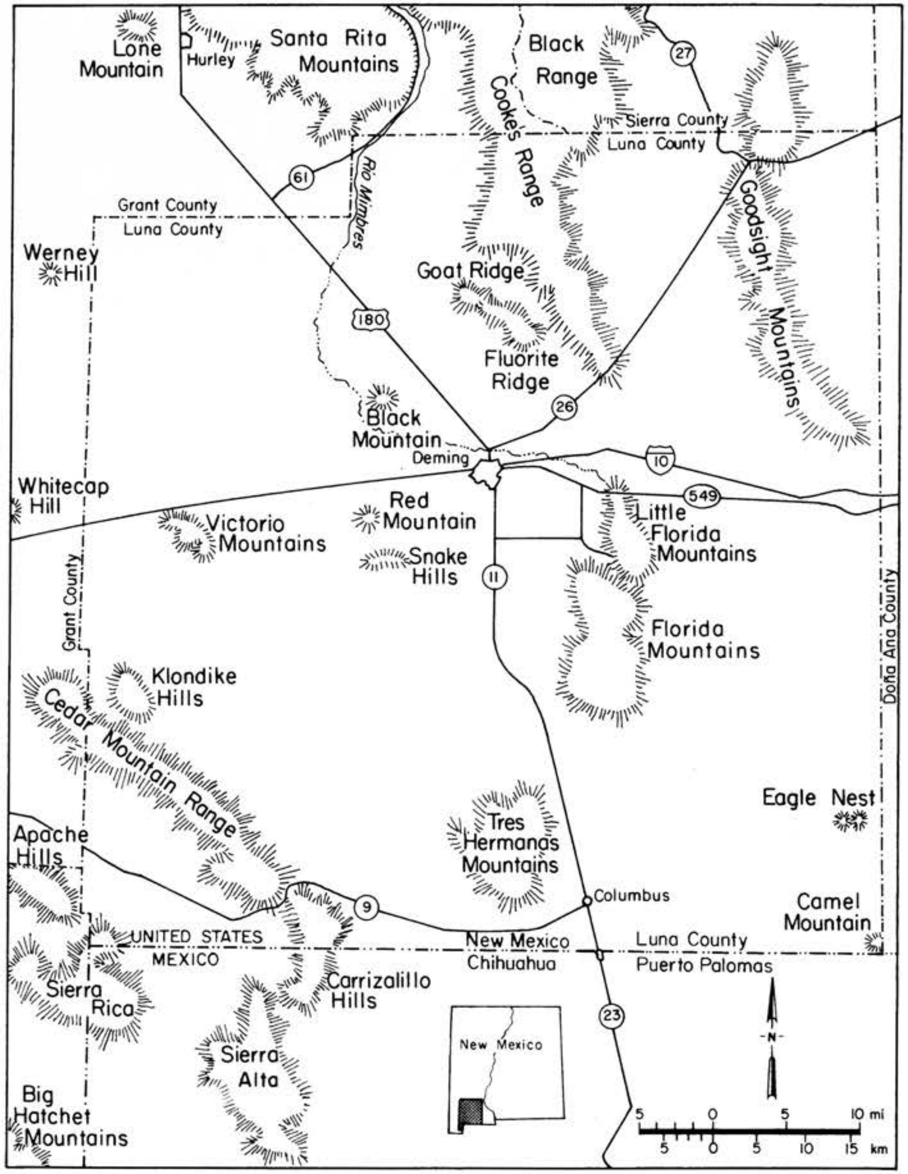


FIGURE 2—Location map of Luna County, New Mexico.

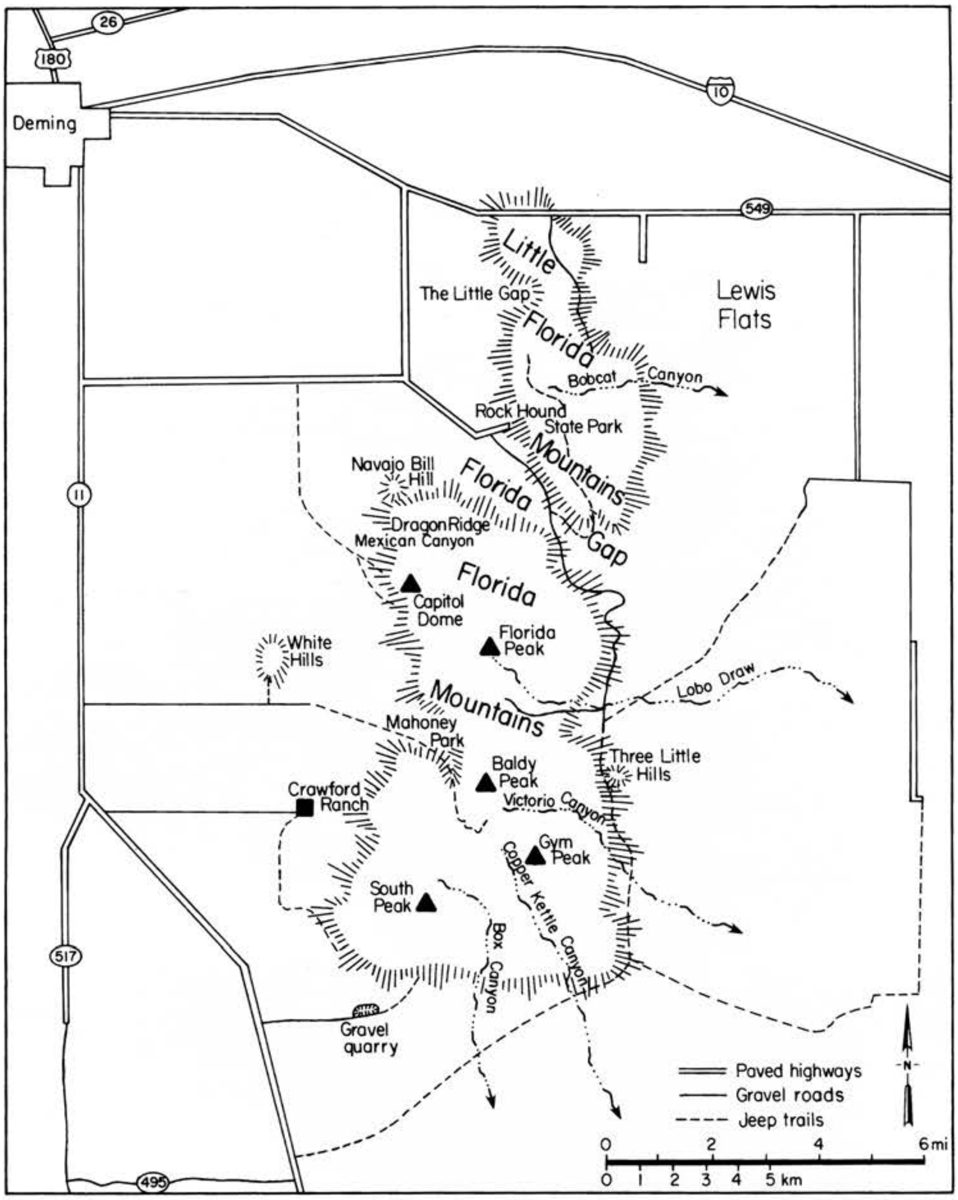


FIGURE 3—Location map of Florida Mountains and Little Florida Mountains.

Mahoney Park to the Mahoney mines area provide relatively easy access to these two crests. There is a locked gate on the Mahoney Park road, and permission for entry should be obtained from Gene Cook in Deming. Access to the remaining high areas is limited to somewhat strenuous footwork. The mountains and contiguous bajada occupy a little more than 100 mi^2. Approximately 73% of this is public domain, 15% is state land, and 12% is private land. The private land consists of patented claims and ranches sporadically distributed over the area. Federal and state land is leased by the local ranchers; although most have open entry, it is recommended that land owners and leasees be contacted for access permission.

Physiography

The Florida Mountains are in the Mexican Highlands section of the Basin and Range Province. The mountains are an east- to northeast-tilted fault block with extensive rugged outcrops of Upper Cambrian plutonic rocks exposed around the southwestern end (Fig. 4). A thick section of lower Paleozoic sedimentary rocks underlies the relatively smooth, brushy slopes (Fig. 5) near the southeast end of the range. The tilted fault-block character is readily apparent in the northern half of the range where Paleocene- to Eocene-age sedimentary and volcanic rocks have average dips of about 20° northeastward from bold cliffs (Fig. 6) on the western side of the big Florida Mountains. Elevations of some of the high peaks include 7,448 ft on Florida Peak, 7,106 ft on Gym Peak, 7,104 ft on an unnamed peak at the head of Box Canyon, and 7,084 ft on South Peak. Elevations at the edge of the main mountains are about 4,400–4,600 ft, and elevations along the lower edge of the bajada are about 4,100–4,200 ft. Therefore, relief in the area is about 3,350 ft.

Florida Gap is largely a pediment cut on middle

FIGURE 4—**A**, Interlayered granite and hornfels in slopes southwest of South Peak; compare with Fig. 11. **B**, South Peak viewed from southeast side.

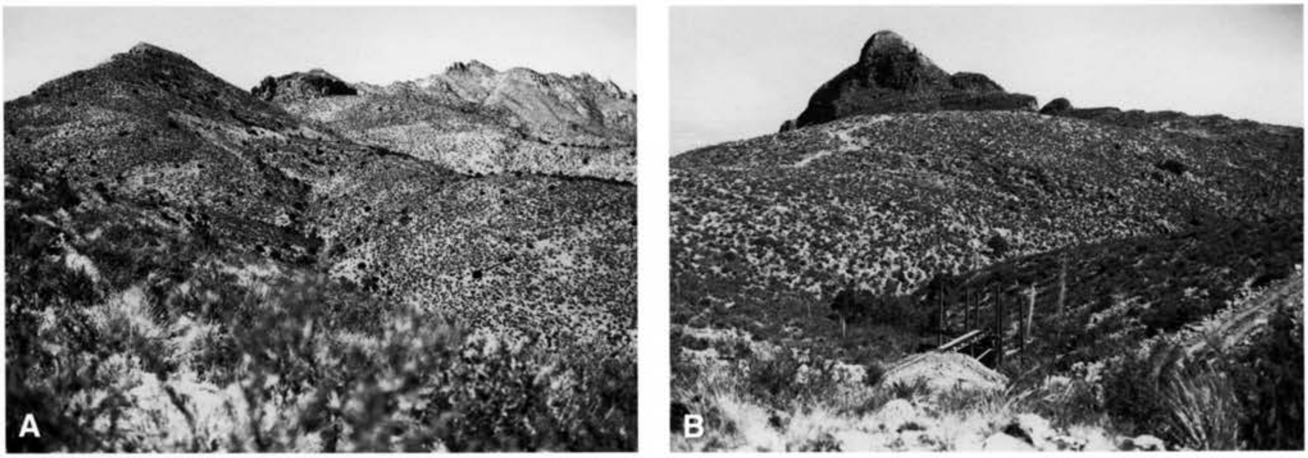


FIGURE 5—**A,** View north from Mahoney Ridge; slopes in foreground underlain by Fusselman Dolomite. **B,** View from Mahoney Ridge, southeast to Gym Peak.

FIGURE 6—View northwest from Florida Peak to Mimbres Basin slope and cliffs formed by Rubio Peak volcaniclastic rocks.

FIGURE 7—West face of Little Florida Mountains at Rock Hound State Park. Cliffs are flow-banded rhyolite intrusions, slopes underlain mostly by air-fall tuffs and breccias.

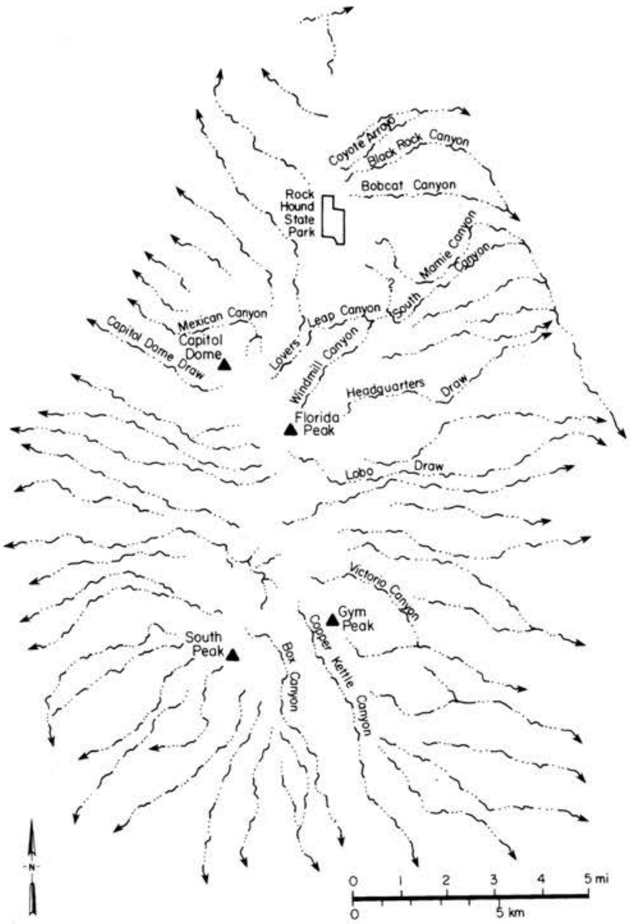


FIGURE 8—Remap of major arroyos forming drainage pattern in Florida and Little Florida Mountains.

Tertiary volcaniclastic strata. The north–northwest trending Little Florida Mountains, northeast of Florida Gap, have a steep western escarpment (Fig. 7) and gentle eastern slopes. The scarp may be fault-controlled, but no faults are exposed and the relief could be entirely due to the resistant nature of the elongate rhyolite intrusions relative to the less resistant volcaniclastic strata in Florida Gap.

There are no permanent streams; only a few small springs flow most of the year. The overall drainage of the Florida Mountains area is radial into the surrounding Mimbres Basin (Fig. 8). As the ephemeral streams flow down the bajada, they incise locally parallel drainage patterns typical of arid climates. At flood stage most of the arroyos empty by a vast network of distributaries and sheet wash into the Mimbres Basin. Some flow north and northeast into the lower reaches of the Mimbres River, and a few flow south into Palomas arroyo, which in turn empties into the basin.

Beveled bedrock surfaces are common at the mouths of the principal canyons. These bedrock surfaces have transitory deposits of alluvium yet to be delivered to the basin fills. The outer margins of the bare-rock pediment are gradational into alluvial fans by thin veneers of sand and gravel. Some of the older fans are close to the mountains, and arroyos now bypass them to form fans basinward from the older fans. The coalescing alluvial-fan part of the piedmont has been formed largely by aggradation. The gently sloping apron-like surface spreading outward from the mountains, including the pediment and coalescing alluvial fans, is known as a bajada. The range-bounding fault(s) west of the Florida Mountains is(are) mostly buried by the toe of the bajada 2–3 mi from the edge of the mountains. Faults related to uplift of the mountains or subsidence of the basin to the east are apparently deeply buried by basin fill beyond the bajada's east margin. Since uplift of the mountains began with the onset of Basin and Range deformation, the exposed bedrock area has decreased to less than one-half of its initial size, and the deeply entrenched canyons seen today represent one stage of the continuing incision process.

Previous work

One of the first publications on the geology of the Florida Mountains was by Becker (1914). The current report includes results of the fourth published geologic-mapping project in the Florida Mountains. Darton (1916, 1917b) included the Florida Mountains area in his geologic maps of Luna County and Deming quadrangle. Lasky (1940) published a generalized geologic map of the Little Florida Mountains in his report on the manganese deposits. Corbitt (1971) mapped the big Florida Mountains, and publications concerning ages of plutonic rocks and structural interpretations based at least in part on this work have been done by Corbitt (1974), Corbitt and Woodward (1970, 1973a, b), Brookins and Corbitt (1974), Brookins (1974a, b, 1980a, b), Brookins et al. (1978), Woodward (1980), Woodward and DuChene (1981), Evans and Clemons (1987, 1988), and Mack and Clemons (1988). Publications resulting from the current project are Brown (1982), Brown and Clemons (1983a, b), Clemons (1982a, b, d, 1984, 1985, 1986b, 1988), and Clemons and Brown (1983). Lindgren et al. (1910) mentioned several mines in the Florida Mountains, and Griswold (1961) included generalized descriptions of the geology and mines in his report on the mineral deposits of Luna County. Elston (1958) and Turner (1962) discussed the position of the Florida Mountains relative to the Burro uplift and Deming axis. Discussions on relations of rocks in the Florida Mountains to surrounding areas also are included in Armstrong and Mamet (1978), Bogart (1953), Darton (1917a, 1928), Flower (1953a, b, 1958, 1964, 1965, 1969), Greenwood et al. (1970), Hawley (1981), Hayes (1970, 1975a), Howe (1959), Jicha (1954), Kelley and Bogart (1952), Kelley and Silver (1952), Kottlowski (1957, 1958b, 1960, 1962, 1963, 1965a, b, 1971a, b, 1973), Kottlowski and Foster (1962), Kottlowski and Pray (1967), Kottlowski, Foster, and Wengerd (1969), Kottlowski, LeMone, and Foster (1969), Lemley (1982), LeMone (1969a, b, c, 1974, 1976a, b), Lochman-Balk (1958, 1974), Loring and Armstrong (1980), Lucia (1969), Lynn (1975), Thompson (1982), Thompson and Potter (1981), Woodward (1970), and Woodward and DuChene (1981, 1982).

Stratigraphy

Pre-Bliss rocks

The most extensively exposed bedrock in the Florida Mountains is plutonic, ranging in age from Precambrian to Cambrian and occupying about 15 mi^2. Names of igneous rocks used in this report follow the I.U.G.S. classification of Streckeisen (1976, 1979). The Precambrian to Cambrian rocks include five distinct map units: 1) a high-grade metamorphic sequence containing hornblende gneisses (amphibolites?) and gneissic granite, 2) hornblende and pyroxene hornfels, 3) syenites and quartz syenites, 4) granites, and 5) diamictite. Xenoliths of the hornfels are abundant in granites at the south end of the mountains and in syenites south of Capitol Dome. In these areas two additional map units are used that denote the mixed rock types.

Hornblende gneiss and gneissic granite

Two small hills on the southwest side of the mouth of Mexican Canyon are underlain mostly by gneissic granite and some hornblende gneiss. Crosscutting relations indicate that the parent material of the hornblende gneiss is older than that of the gneissic granite. Evans and Clemons (1987, 1988) reported Pb207/206 ages of 1,550–1,570 m.y. on zircons from the gneissic granite. Foliation in both rock types generally strikes northeasterly, but locally there are west and northwesterly trends (Sheet 3).

Hornblende gneiss, resembling an amphibolite except for quartz and orthoclase content, crops out on the northern and northeastern slopes of the small hill south of Mexican Canyon. It contains fine-crystalline (0.1–0.5 mm) subhedral hornblende (44%), anhedral sodic plagioclase (27%), quartz (16%), potassium feldspar (7%), biotite (5%), and accessory magnetite and apatite (3%). The feldspars are partly altered to kaolin and sericite. Some hornblende is slightly altered to chlorite and biotite, but most appears fresh and slightly pleochroic, light greenish brown to moderately greenish brown, with extinction angles averaging approximately 15°. Poikiloblastic plagioclase and hornblende are common in samples studied.

The gneissic granite is finely to medium crystalline (0.1–0.6 mm), strongly foliated, and contains approximately 33% potassium feldspar, 33% quartz, 28% sodic plagioclase, 3% biotite, and 3% chlorite, iron oxides, and zircon. The potassium feldspar is chiefly orthoclase with kaolin and sericite alteration. Locally, small quartz augen (1–3 mm) have developed. Several quartz-rich pegmatite veins (Table 1) are probably related to the gneissic granite. Orthoclase in the pegmatite is interstitial to quartz and along boundaries between annealed quartz crystals that are granulated to the extent of resembling orthoquartzite when viewed with a handlens.

Hornfels and related rocks

Dark gray, fine- to medium-crystalline mafic rocks crop out sporadically in the western slopes for about 1.5 mi south of Capitol Dome and extensively in the southwestern part of the Florida Mountains. The northern group of mafic rocks was intruded by syenite and the southwestern group by granite. In many areas outcrops are close to 50% mafic rocks and 50% syenite or granite. The mafic rocks are less resistant to weathering and erosion and form slopes and saddles between granite or syenite ledges and ridges. Lindgren et al. (1910) described the northern group of mafic rocks as andesite; Griswold (1961) referred to the mafic rocks as sheets and masses of diorite and gabbro intruded by granite. Corbitt (1971) described the same rocks as sills and dikes of diabase, gabbro, diorite, and anorthosite intrusive into the syenite and granite. Clemons (1982b, d) and Clemons and Brown (1983) referred to the mafic rocks as meladiorite, diorite, diabase, and norite intruded by granite and syenite. After completing petrographic examinations of more than 32 samples of these mafic rocks (Appendix A–1), I believe they should be called hornblende and pyroxene hornfels.

TABLE 1—Modes of gneisses. **Qz**, quartz; **Kf**, potassium feldspar; **Pl**, plagioclase; **Bi**, biotite; **Hb**, hornblende; **Alt**, alteration products; Acc, accessory minerals.

Sample Number	Qz	Kf	Pl	Bi	Hb	Alt	Acc	Name
231	16	8	25	11	36		4	Hornblende gneiss
232	15	4	25	1	51		4	Hornblende gneiss
233	13	9	30	1	43		4	Hornblende gneiss
234	18		25	9	45		3	Hornblende gneiss
235	17	7	30	1	44		1	Hornblende gneiss
236	33	31	28	7			1	Gneissic granite
237	35	32	29	2			2	Gneissic granite
238	35	33	24	2		5	1	Gneissic granite
239	30	34	29	1		5	1	Gneissic granite
240	92	8						Pegmatite

The hornfels are composed of granoblastic mosaics of plagioclase, hornblende, clinopyroxene (probably diopside), orthopyroxene, biotite, olivine, and accessory magnetite, apatite, and sphene (Fig. 9). A few samples contain traces of anhedral quartz, and one not listed in Appendix A–1 contained 71% sericitized oligoclase, 19% amphibole, 5% quartz, 4% magnetite–sphene–apatite, and 1% alteration products of chlorite and carbonate. Plagioclase commonly ranges in composition from oligoclase to calcic andesine. Most plagioclase xenoblasts are unzoned with clear, light-colored rims and nearly opaque cores possessing felted sericite flakes and less commonly epidote. Few samples, away from intrusive contacts, contain relict phenocrysts of the original intermediate to mafic volcanic rocks. The amphibole in these rocks generally occurs as pale-green to light-brown common hornblende in anhedral crystals that appear to be pseudomorphs of pyroxene, thick prisms with ragged terminations, or small scattered grains. Partial alteration to biotite is common, and exsolved magnetite occurs in, and marginal to, most crystals. A few samples contain fibrous, green uralite pseudomorphs of pyroxene. The clinopyroxene (probably diopside) occurs both as large, colorless to pale-green, subhedral crystals and as tiny, equidimensional grains (Fig. 9). In a few sam-

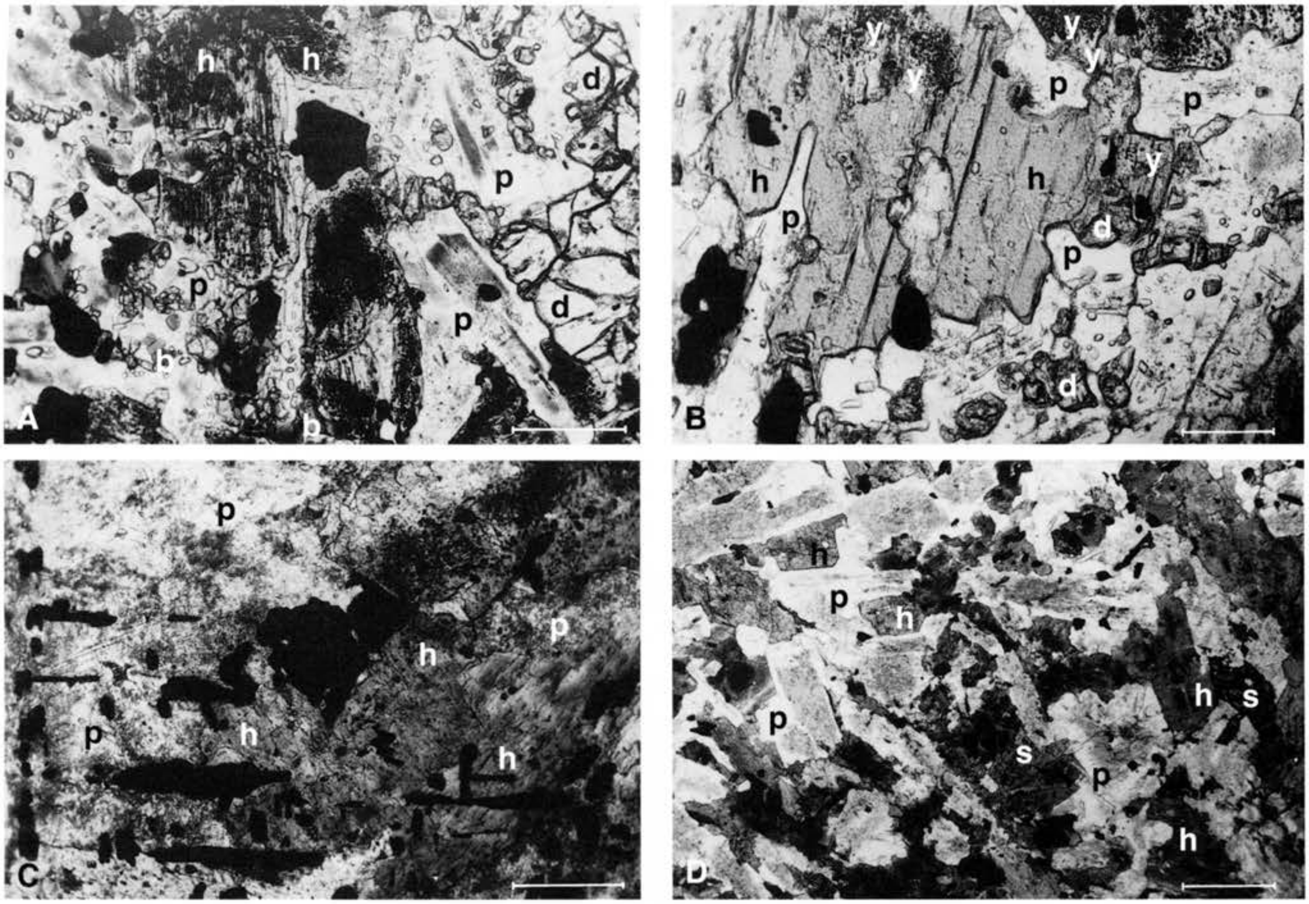


FIGURE 9—Photomicrographs of hornfels. Scale bars = 0.2 mm. **A,** Granoblastic mosaic of plagioclase (**p**), hornblende (**h**) being replaced by hypersthene (**y**), diopside (**d**), biotite (**b**), and magnetite (black); sample from near Stenson mine. **B,** Hornblende (**h**) partly replaced by hypersthene (**y**), plagioclase (**p**), and small anhedral crystals of diopside (**d**); sample from near Copper Queen mine. **C,** Anhedral hornblende (**h**), sericitized plagioclase (**p**), and magnetite (black); sample from southwest slope of South Peak. **D,** Plagioclase (**p**) with sericitized cores, hornblende (**h**), sphene (**a**), and magnetite (black); sample from southwest slope of South Peak.

ples it forms a rim of granules between hornblende and plagioclase. Some of the larger prismatic crystals contain much exsolved magnetite and closely resemble the colorless to faintly pink orthopyroxene (hypersthene or enstatite in various samples). All the orthopyroxene crystals contain schiller structure with abundant associated anhedral magnetite. Biotite typically occurs as pale-brown to reddish-brown ragged books or anhedral masses associated with magnetite or hornblende. Much of the biotite is poikiloblastic, containing small euhedral apatite crystals. A few are bleached and a few are altered to chlorite. Large anhedral (poikiloblastic) olivine crystals are common in only two of the samples studied. These crystals are biaxial negative, contain dark sinuous fractures, and many possess pyroxene–hornblende–biotite haloes. Accessory minerals in order of decreasing abundance are anhedral to subhedral magnetite, anhedral sphene, and euhedral apatite.

Field relations probably indicate that the hornfels were produced by intrusion of syenitic and granitic magmas into older rock (Fig. 10), which probably were andesitic to basaltic flows. Hornfels derived from andesites commonly contain biotite and quartz. The hornfels and granite southwest of South Peak are prominently interlayered with layers dipping 25–35° northeasterly (Fig. 11). Hornblende- and pyroxene-hornfels facies are representative of shallow (low-pressure), high-temperature contact metamorphism. Magmas probably intruded between volcanic flows as well as by crosscutting to produce many sills and dikes, thus accounting for the interlayered character in the syenite and granite terrane. A small lens (a few meters long) of dark-gray to black limestone in the brecciated syenite–hornfels sequence near the top of the ridge north of the Stenson mine is probably a remnant of sedimentary rocks interbedded with flows.

Syenites

Plutonic rock ranging in composition from syenite to quartz syenite crops out from Tubb Spring (on south side of Capitol Dome) to Mahoney Park. Syenite outcrops form a wide, northwest-trending band across the central Florida Mountains. Overlapping alluvium forms most of the eastern and western boundaries. The northern margin is overlain by the Lobo Formation (lower Tertiary). To the southeast the syenite is overlain nonconformably by Bliss Sandstone

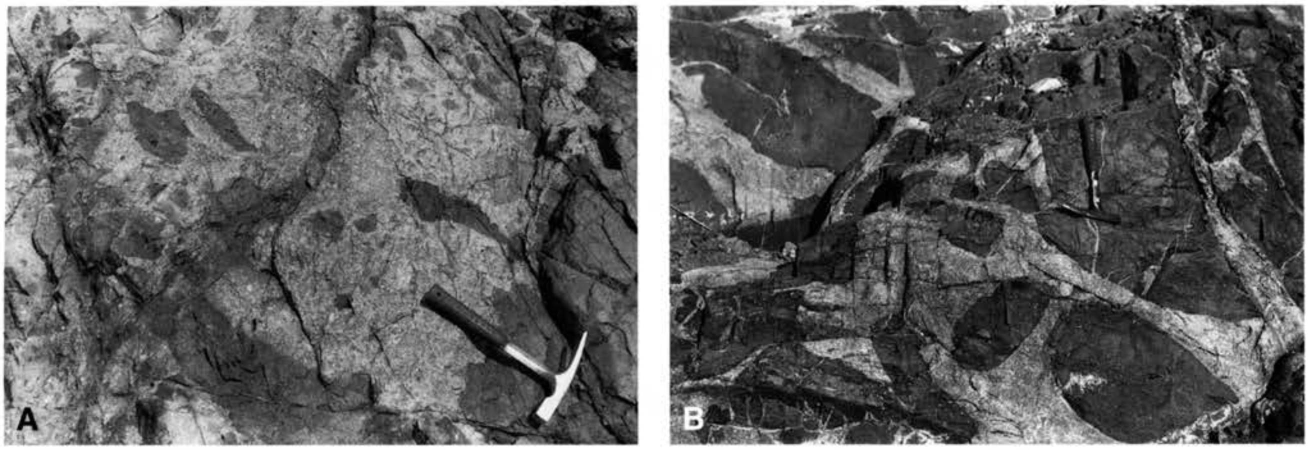


FIGURE 10—Pyroxene-hornfels xenoliths in granite at Box Canyon (**A**) and south of South Peak (**B**).

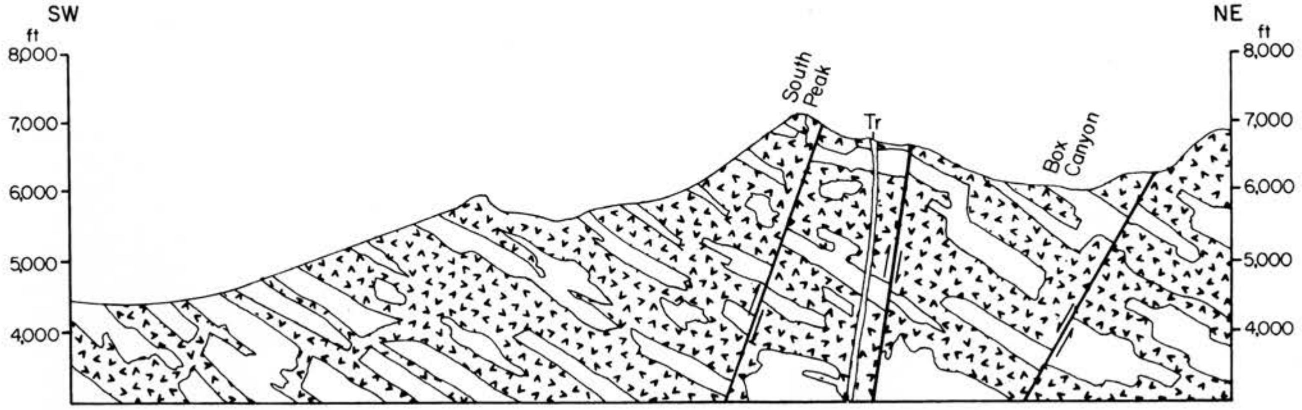


FIGURE 11—Southwest–northeast cross section showing diagrammatically the interlayered relations of granite and hornfels. Horizontal = vertical scale. From Clemons (1985). Compare with Fig. 4A.

(Lower Ordovician) and thrust sheets of lower Paleozoic rocks. The syenite is truncated abruptly south of Mahoney Park by the south Florida Mountains fault. Plutonic rock south of the fault is granite with otherwise similar mineralogy to the syenites, but it contains 20–43% quartz (Appendix A–2). Although six samples of quartz syenite contain as much as 18–19% modal quartz, only the aplite dikes in the central part of the Florida Mountains contained 20% or more quartz.

Unaltered, fresh Florida Mountains syenite is medium light gray (N6) to medium bluish gray (5B5/1), but in fresh exposures throughout most of the range the rock varies from pink to reddish brown and yellowish brown as a result of probable hydrothermal alteration and deep chemical weathering. The texture is predominantly coarse to very coarse (5–40 mm), with some fine- and medium-crystalline (0.5–2.0 mm) rocks. Typically, the syenites are nonporphyritic, but locally rocks tend to be porphyritic with perthite crystals up to 2 cm long.

As might be expected in coarse-crystalline rocks, wide variations exist in the percentages of quartz and alkali feldspars seen in thin sections. The rocks are predominantly alkali-feldspar syenites and quartz–alkali-feldspar syenites. The predominant mineral is braid and string perthite, which commonly contains abundant microlites of biotite, amphibole, apatite, and rutile(?). Patch perthite is less common and microcline and orthoclase are typically subordinate. All are kaolinized, and most show sericitization. The ratio of orthoclase to albite in most of the perthite is close to one. No other plagioclase was observed in the syenites. Moderately to strong undulose quartz is mostly interstitial to the perthite and is distributed unevenly. It is typically dusted with dark inclusions and possesses faint rhombic cleavage. The primary mafic minerals (observed only in the less altered syenites) are predominantly hastingsite with subordinate common hornblende and minor biotite (Fig. 12B). Hastingsite is subhedral to anhedral and pleochroic to dark bluish-green. Hornblende is pleochroic pale brown to medium greenish-brown. Biotite, pleochroic to dark reddish-brown, typically has fringed borders and associated magnetite. The majority of thin sections examined contain secondary alteration products of chlorite, epidote, magnetite, and carbonate that replaced the amphiboles and biotite. Magnetite, zircon, and apatite are common accessory minerals. Most thin sections show cataclastic (brecciation) effects. Fractures are in

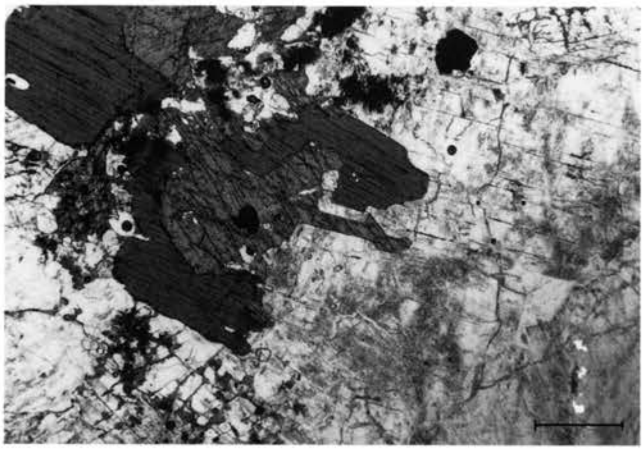


FIGURE 12—Photomicrograph of perthite with biotite and apatite rimming hornblende in alkali-feldspar syenite. Crossed nicols. Scale bar = 0.2 mm.

places marked by microscopic veinlets of quartz, calcite, fluorite, barite, and iron and copper sulfides. Other fractures are conspicuous with iron-oxide fillings.

Aplite dikes and irregular intrusive masses varying in thickness from a few inches to tens of feet are common throughout the syenite and quartz-syenite outcrops. This aplite is regarded as a late differentiate of the syenites because of similar mineral composition, association in space, and gradational contacts with the host syenites, even though it plots mineralogically with the granites (Fig. 13). It is sugary-textured, pale-orange rock with an average grain size of about 0.5 mm. The principal minerals are the same as in the syenites, but quartz content ranges from 19 to 35%.

The age of the Florida Mountains syenites has been the subject of much controversy. Darton (1916, 1917b) mapped all the plutonic rocks as Precambrian, and Griswold (1961) recognized four types of Precambrian rocks. Corbitt (1971) mapped and described the plutonic rocks as Precambrian granite and Mesozoic syenite intruded by gabbro and anorthosite. Corbitt (1974) discussed the possibility of the syenite being Precambrian and having its radiometric clocks reset at some later time. He changed his interpretation (pers. comm. 1980) of intrusive contacts between the syenite and Paleozoic rocks to thrust-fault contacts.

Field evidence shows conclusively that the syenite is older than the Bliss Sandstone (Lower Ordovician). Three well-exposed outcrops in the central part of the Florida Mountains contain depositional contacts of Bliss Sandstone resting nonconformably on coarse-crystalline alkali-feldspar syenite. The basal Bliss at one outcrop is composed largely of well-rounded cobbles and pebbles of alkali-feldspar syenite; thus the syenites were uplifted and partly eroded before deposition of the Bliss Sandstone.

Granites

Medium-crystalline alkali-feldspar granite (herein called informally the Capitol Dome granite) underlies

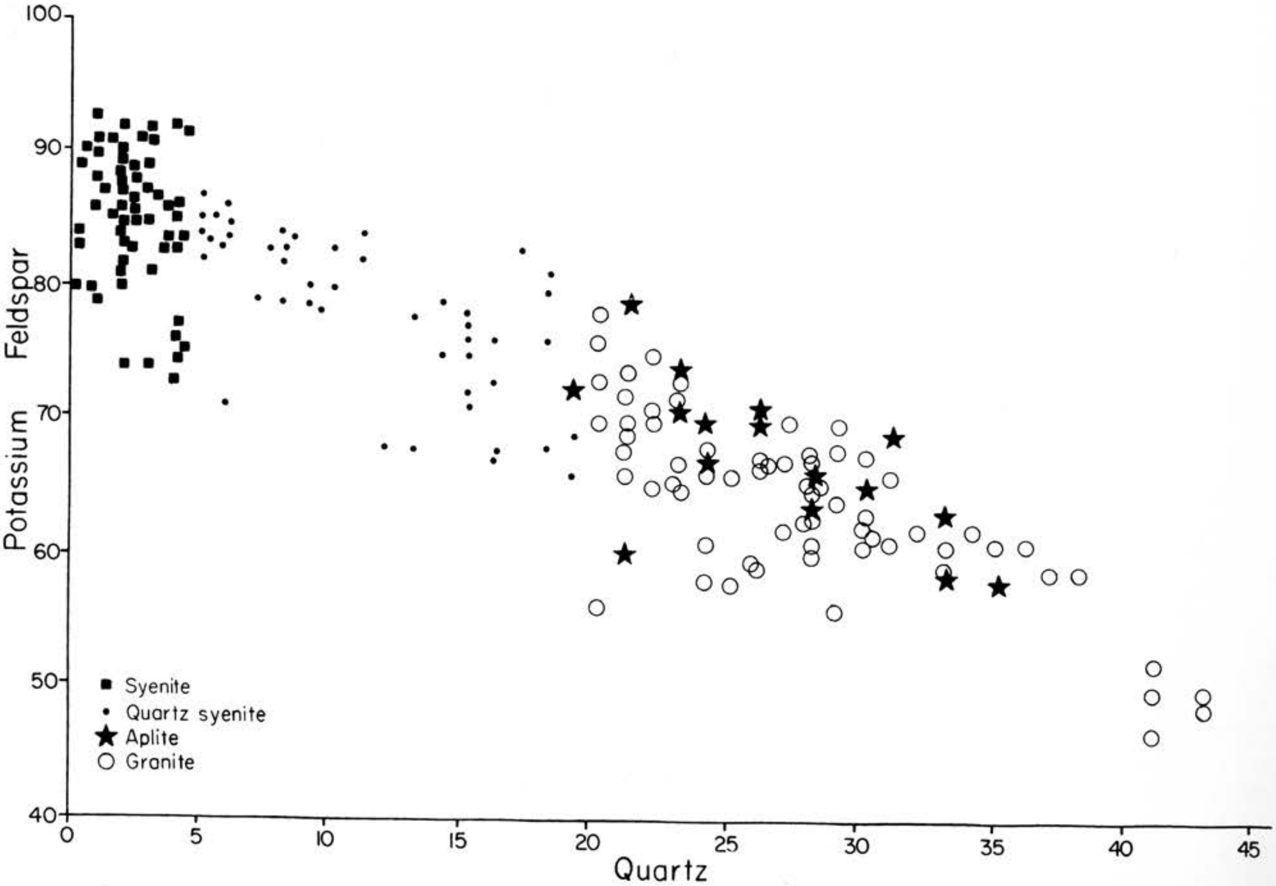


FIGURE 13—Diagram showing quartz–potassium-feldspar contents of syenites, quartz syenites, granites, and aplites. Aplites plot with granites even though the aplite dikes are in syenites.

Bliss Sandstone west and northwest of Capitol Dome and intrudes the hornblende and granitic gneisses north of Capitol Dome. Fine- to medium-crystalline granite (herein called informally the South Peak granite) makes up the bulk of the southwestern Florida Mountains. Overlapping alluvium forms the western boundary and most of the southern boundary of the South Peak granite. Rocks belonging to the Paleocene(?) Lobo Formation rest nonconformably on South Peak granite in several small outcrops near the southeast end of the range. The northern boundary of the South Peak granite is a fault along which the granite is against Florida Mountains syenite and Paleozoic rocks ranging in age from Early Ordovician to Early Permian. The South Peak granite intruded a sequence of probable andesite and basalt flows, which accounts for the abundant hornfels xenoliths similar to those in the Florida Mountains syenite. Xenoliths appear to be lacking in Capitol Dome granite.

K-feldspar is the most abundant mineral in all the granites, typically making up 60–70% of the rocks (Fig. 13). It is chiefly orthoclase and perthitic microcline in the Capitol Dome granite and almost entirely string and braid perthite in the South Peak granite. Traces of oligoclase are present throughout the Capitol Dome granite, but occur only in the fine-crystalline and aplitic varieties (contact facies or border phase) of the South Peak granite. Quartz characteristically forms anhedral, equant crystals with slight to strong undulose extinction. Graphic intergrowths appear to be slightly more common in the Capitol Dome granite, and a faint rhombic cleavage is typical of much quartz in this granite. Biotite is conspicuously absent from the granites. The Capitol Dome granite probably contained 3–7% biotite and amphibole(?), but alteration products of shreddy olive chlorite and magnetite remain in what were probably sites of mafic minerals. Amphibole (up to 11%), pleochroic medium green to deep greenish blue, is commonly interstitial to quartz and perthite in the South Peak granite. A few small crystals are enclosed in quartz and perthite. Several thin sections contain blue needles marginal to greenish-brown amphibole. Overall the amphibole appears to be hastingsite, identical to that in the Florida Mountains syenite. Accessory minerals include magnetite, zircon, and apatite in order of decreasing amounts, generally totaling less than 0.5% (Appendix A–2).

The syenites and South Peak granite are mineralogically and chemically very similar (Table 2), and the numerous aplite dikes in the syenites have compositions identical to the South Peak granite (Fig. 13). Therefore, it would seem that these rocks are consanguine and of similar age. The age and genesis relations

TABLE 2—Chemical analyses and norms of selected plutonic rocks in the Florida Mountains. **1**: hornblende hornfels, Box Canyon; **2**: hornblende hornfels, southeast of Crawford Ranch; **3**: pyroxene hornfels, southeast of Crawford Ranch; **4**: metadiorite, Big Burro Mountains; **5**: hornblende hornfels, southeast of Crawford Ranch; **6**: gray granite, southeast of Crawford Ranch; **7**: red granite, southeast of Crawford Ranch; **8**: fine-crystalline red granite, Box Canyon; **9**: syenite, Mahoney Park; **10**: average of eight analyses of FM–1 core of granite, Box Canyon; **11**: average of seven analyses of FM–2 core of granite, Copper Kettle Canyon; **12**: average of six analyses of FM–5 core of granite, Capitol Dome; **13**: average of five analyses of FM–4 core of syenite, Mahoney Park; **14**: average of eight analyses of FM–7 core of syenite, near Victorio Well; **15**: average of two analyses of FM–8 core of syenite, Spring Canyon. Samples **la**, **4a**, **7a**, and **8a** are X-ray fluorescence analyses of samples **1**, **4**, **7**, and **8**, respectively; samples 10 through 15 are averages of data released by Brookins et al. (1978); — = none detected.

Sample	**1**	**la**	**2**	**3**	**4**	**4a**	**5**	**6**	**7**	**7a**	**8**	**8a**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
SiO_2	46.95	47.04	45.76	44.25	45.02	45.99	49.25	70.65	72.41	73.38	72.62	73.03	61.15	71.52	75.48	73.11	60.83	66 21	68.09
TiO_2	1.53	2.57	1.97	2.10	2.66	2.34	2.33	0.37	0.28	0.28	0.38	0.34	1.14	0.30	0.40	0.36	1.23	0.59	0.31
Al_2O_3	15.42	15.92	16.23	10.35	16.42	16.53	14.06	13.27	11.22	10.81	12.28	12.63	17.12	12.72	11.84	12.46	16.73	17.58	14.44
Fe_2O_3	14.79	14.14	11.74	14.92	14.96	14.83	11.07	4.04	4.04	4.32	3.64	3.53	5.54	5.04	4.18	4.56	5.93	2.37	4.20
MnO	0.17	0.19	0.14	0.17	0.16	0.19	0.15	0.09	0.02	0.03	0.03	0.04	0.04	—	—	—	—	—	—
MgO	5.10	5.97	9.85	15.87	6.20	6.89	7.16	0.05	0.04	0.06	0.18	0.34	1.66	0.41	0.16	0.20	1.65	0.37	0.21
CaO	8.37	7.85	8.35	6.44	8.38	8.91	10.67	0.76	1.73	1.45	0.54	0.59	1.90	0.41	nd	0.23	2.12	0.40	0.63
Na_2O	3.64	3.49	2.97	2.37	3.05	2.89	3.10	4.86	2.96	2.69	3.07	3.34	6.82	3.93	2.61	3.78	6.89	6.32	6.09
K_2O	1.93	1.62	1.32	1.22	0.96	0.74	1.54	5.16	5.47	5.64	5.82	5.83	5.77	4.87	5.04	4.60	5.67	6.20	5.44
LOI	1.39	—	0.90	0.61	0.93	—	0.09	0.50	1.48	—	1.75	—	0.41	—	—	—	—	—	—
P_2O_5	0.38	0.40	0.30	0.32	0.31	0.36	0.46	0.03	0.02	0.02	0.03	0.03	0.03	—	—	—	—	—	—
Total	99.67	99.19	99.53	98.62	99.05	99.67	99.88	99.78	99.67	98.68	100.34	99.70	101.58	99.20	99.71	99.30	101.05	100.04	99.41
Qz								21.31	31.43		30.72								
Cor											0.01								
Ru																			
Il	2.95		3.79	4.09	5.16		4.46	0.71	0.53		0.72		2.14						
Hm																			
Mt	4.43		5.07	5.30	6.11		5.58	2.00	2.58		2.72		3.02						
Ap	0.89		0.70	0.76	0.73		1.08	0.07	0.05		0.07		0.07						
An	20.34		27.41	14.36	28.87		20.07		1.16		2.48								
Ab	23.31		22.35	20.34	26.34		26.45	39.67	25.18		25.93		45.04						
Or	11.59		7.91	7.40	5.80		9.19	30.66	32.54		34.37		33.69						
Di	7.97		7.87	10.18	5.92		19.25	0.21	0.22				5.80						
He	8.08		2.20	2.85	3.47		4.95	2.96	3.52				1.48						
Fo	6.45		14.86	25.10	7.93		5.46						0.97						
F	8.26		5.24	8.87	5.88		1.77						0.31						
Wo									1.30										
En					1.69		1.27	0.03			0.45								
Fs					1.14		0.38	0.45			0.78								

of the Capitol Dome granite relative to the syenites and South Peak granite are much less conclusive. The Capitol Dome granite intrudes gneissic rocks but contains no hornfels xenoliths as do the syenite (on south side of Capitol Dome) and the South Peak granite. The Capitol Dome granite contains more orthoclase, microcline, and oligoclase and apparently fewer mafic minerals than do the syenites and South Peak granite. The two granites might be related facies, but it is not known whether the differences are caused by depths of emplacement, reactions with different country rocks, or unrelated magmas.

Age

There have been substantial disagreements concerning the ages of plutonic rocks nonconformably overlain by the Bliss Sandstone (Brooking, 1974a, b, 1980a, b; Brookins and Corbitt, 1974; Brookins et al., 1978; Clemons, 1982b, 1985; Corbitt, 1971, 1974; Corbitt and Woodward, 1970, 1973b; Matheny and Brookins, 1983; Woodward and DuChene, 1981). The lack of agreement on isotopic ages strongly suggests that the Rb–Sr and K–Ar systems have been disturbed irregularly. Field evidence is clear in constraining the relative ages of the plutonic rocks as follows: 1) The gneissic rocks are obviously older than the syenite–granite suite because they have undergone regional metamorphism not recorded in the younger syenites and granites. 2) The mafic and intermediate hornfels are older than the syenites and South Peak granite, and the andesite–basalt precursors of the hornfels were at least partial hosts into which the syenites and granite intruded. 3) The granites and syenites are chemically and petrographically quite similar and are probably of the same age. The syenites and Capitol Dome granite are nonconformably overlain by the Bliss Sandstone. 4) The diamictite is post-gneiss and pre-Bliss. Granite clasts in the diamictite indicate it is younger than the syenites and granite.

Therefore, all these rocks must be older than the Bliss Sandstone. Unfortunately, the exact age of the Bliss in the Florida Mountains has not been determined precisely. Combined paleontological evidence in southwestern and south-central New Mexico (Flower, 1969) indicates a Late Cambrian–Early Ordovician age for the basal Bliss in the Florida Mountains. The Cambrian–Ordovician boundary is shown to be 505 m.y. on the DNAG time scale (Palmer, 1983), but with an uncertainty of 32 m.y.

Evans and Clemons (1987, 1988) reported 1,550–1,570 m.y. Pb 207/206 ages on the gneissic granite. Similar gneissic rocks from the San Andres and Caballo Mountains trend (Muehlberger et al., 1966) yielded Rb/Sr ages in the 1,300–1,400 m.y. range. Zircons from granite, diabase, and biotite gneiss in the Big Burro Mountains gave ages in the 1,440–1,570 m.y. range (Stacey and Hedlund, 1983). The age of formation of the rocks that were converted to gneisses is obviously older by an amount even more uncertain.

There are three ages reported by Brookins (1974b, 1980b) on the mafic hornfels (hornblende gabbro of Brookins). These ranged from 530 to 550 m.y. on amphiboles. These ages should be close to the time of intrusion of the syenite, because the ages (isotope systems) should be reset by the heat of the intrusion and metamorphism. These ages are of uncertain quality because of the disturbed isotopic system.

Ages from the syenite–granite suite have a reported range of 371–1,600 m.y. (Brooking, 1974a, b, 1980a, b; Brookins and Corbitt, 1974; Brookins et al., 1978; Clemons, 1985; Matheny and Brookins, 1983). These results are so erratic that they cast doubt on all of the ages. Most of the data suggested an early to middle Paleozoic time on intrusion. Karl Evans of the U.S. Geological Survey in Denver determined a U–Pb concordia age of 503 ± 10 m.y. on zircons from the South Peak granite, 504 ± 10 m.y. on the hornfels, and U–Pb ages of 409–507 m.y. on the Capitol Dome granite. C. E. Hedge and L. B. Fischer determined U–Pb ages of 460 and 471 m.y. and Pb 207/206 age of 523 m.y. on the syenite (Evans and Clemons, 1988).

Cambrian–Ordovician igneous activity is not common in the southwestern U.S., but alkalic plutonism is recorded in several areas of southern Colorado (Armbrustmacher, 1984; Olson et al., 1977) and east-central Idaho (Evans, 1984). Loring and Armstrong (1980), Loring et al. (1987), and McLemore (1980, 1981, 1987) reported scattered occurrences of rocks yielding early Paleozoic ages from alkalic rocks in New Mexico, and some of these may be equivalent to the major plutonic activity in the Florida Mountains. It might appear that there is too little time to unroof the syenite–granite rocks before transgression of the early Paleozoic seas in which the Bliss Sandstone was deposited, but considering the uncertainty of the precise age of the Bliss and the vagueness of the geologic time scale this is not a problem.

Diamictite

A small exposure of diamictite, located in the NW¼NW¼ sec. 11 T25S R8W, rests nonconformably on hornblende and granitic gneisses intruded by the Capitol Dome granite (Fig. 14A). It is overlain by Bliss Sandstone, but some of the upper contact is complicated by small thrust faults (Fig. 14B) so the diamictite may be a basal unit of the Bliss. The diamictite is approximately 40 ft thick and consists of pebble, cobble, and boulder clasts in a reddish-brown to greenish-black mudstone matrix. The clasts include 45% sandstone, 17% silty hematite breccia, 17% siliceous ironstone, 12% diabase, and 10% granite (Corbitt and Woodward, 1973a). Corbitt (1971) suggested a mudflow origin, and Corbitt and Woodward (1973a) postulated a glacial origin for these beds. Evidence cited in support of glacial deposition includes: 1) sedimentary structures caused by ice-rafted boulders, 2) exotic clasts, and 3) resemblance to Precambrian diamictites from Alaska to California. No conclusive evidence was found during this study.

Paleozoic

Paleozoic sedimentary rocks are well exposed in the Florida Mountains on the western slopes of Capitol Dome and as a broad, southeast-trending belt across the range from Mahoney Park. Their aggregate

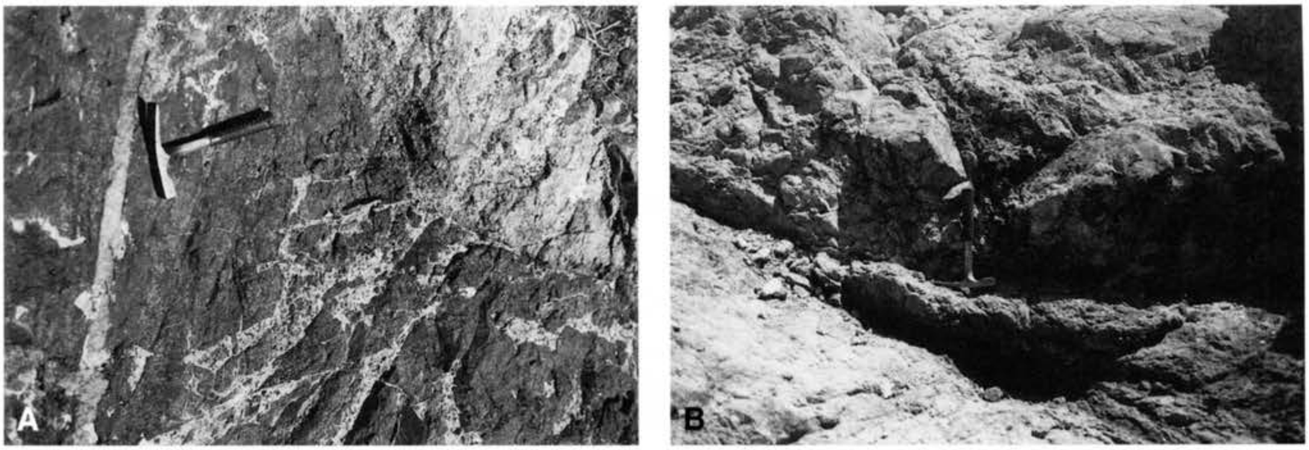


FIGURE 14—**A,** Granite intruding hornblende gneiss, north of Capitol Dome. **B,** Tectonically brecciated Bliss Sandstone thrust-faulted on diamictite. Head of geologic pick at fault contact.

System	Lithostratigraphic units		Thickness ft	General description
Permian	Hueco Limestone		403	Dark-gray, fossiliferous limestone
	— disconformity —			
Mississippian	Rancheria Formation		221	Interbedded limestone, chert, and shale
	— disconformity —			
Devonian	Percha Shale		250	Dark-gray shale; 30-cm-thick limestone; 10 ft (3 m) above base
	— disconformity —			
Silurian	Fusselman Dolomite		1,480	Six alternating dark-light dolomite units
	— disconformity —			
Ordovician	Montoya Fm.	Cutter Member	200	Fossiliferous limestone and dolomite
		Aleman Member	140	Interbedded limestone, dolomite, and chert
		- disconformity -		
		Upham Member	50	Dark-gray, massive dolomite
		Cable Canyon Mbr.	20	Dolomitic sandstone and sandy dolomite
	— disconformity —			
	El Paso Fm.	Padre Member	270	Thin- to medium-bedded limestone with chert nodules and lenses
		McKelligon Mbr.	560	Medium- to thick-bedded, light-gray limestone
		Jose Member	16	Thin-bedded, dark-gray, silty limestone
		Hitt Canyon Mbr.	330	Thin- to medium-bedded, sandy dolomite; limestone in upper part
Cambrian	Bliss Formation		100-240	Arkose and subarkose with minor limestone and dolomite
	— nonconformity —			
	diamictite		40	Massive, red, muddy conglomerate
	— nonconformity —			
Precambrian	syenite, quartz syenite, granite, hornfels, gneiss			

FIGURE 15—Stratigraphic chart of Precambrian and Paleozoic rocks exposed in the Florida Mountains.

thickness is approximately 4,100 ft but because of structural complications no single area has the complete section. These rocks were first mapped and described by Darton (1916, 1917b) as Bliss Sandstone (Cambrian), El Paso and Montoya Formations (Ordovician), Fusselman Dolomite (Silurian), and Gym Limestone (Pennsylvanian). Darton (1928) assigned a Permian age to the Gym Limestone, but Keyes (1940) concluded that the Gym was an outlier of Magdalena Limestone (Pennsylvanian). Kelley and Bogart (1952) and Bogart (1953) recognized that rocks mapped as Gym Limestone by Darton include in ascending order: Fusselman Dolomite (Silurian), Percha Shale (Devonian), Lake Valley Formation (Mississippian), and Hueco Limestone (Permian); therefore, the name Gym Limestone has been abandoned. Interestingly, Pennsylvanian is the only Paleozoic system not represented in the Florida Mountains (Fig. 15). The Florida Mountains are located in the "poorly defined meeting ground" where stratigraphic units bearing western Texas and southern New Mexico terminology (used in this report) mingle with those named from type sections in southeastern Arizona (Kottlowski, 1963). Correlative terms will be discussed under appropriate units.

Bliss Sandstone

The Bliss Sandstone was named by Richardson (1904) for massive sandstone near Fort Bliss, Texas, along the eastern base of the Franklin Mountains. The name was extended by Darton (1916) to the Florida Mountains and other localities in Luna County. Regional thicknesses (Table 3) and facies are included in isopach maps and tables by Hayes (1975a), Kottlowski (1963), Ottensman (1982), and Thompson and Potter (1981).

Exposures—The Bliss Sandstone crops out intermittently for approximately 1 mi along the lower slopes west and northwest of Capitol Dome. These beds were mapped and described in some detail by Lochman-Balk (1958). The Bliss is also well exposed on the north and south slopes of Victorio Canyon, north of Gym Peak. Smaller, less accessible, but significant outcrops of Bliss are located high on the slopes east of Mahoney Park. Some of these latter exposures show the Bliss Sandstone pinching out against topographic highs on the nonconformity, and lower El Paso beds resting nonconformably on the syenite.

TABLE 3—Bliss Sandstone thicknesses. Most of the thicknesses listed are those reported by Hayes (1975a, b) and many differ from those given in the other references.

Location (references)	Thickness ft
1. Wood Canyon, Peloncillo Mountains Gillerman, 1958)	396
2. North Animas Mountains (Soule, 1972)	360
3. Mescal Canyon, Big Hatchet Mountains (Zeller, 1965)	115
4. Klondike Hills (Bromfield and Wrucke, 1961)	103+
5. Wemey Hill (Ballman 1960; Hedlund, 1978)	295
6. Lone Mountain (Pratt, 1967)	188
7. Bear Mountain (Paige, 1916; Cunningham, 1974)	180
8. Cooke's Range (Jicha, 1954)	158
9. Fluorite Ridge (Griswold, 1961)	150+
10. Capitol Dome, Florida Mountains (this report)	200+
11. Gym Peak, Florida Mountains (Clemons and Brown, 1983)	110
12. Sierra Cuchillo (Jahns, 1955)	88
13. San Mateo Mountains (Kelley and Furlow, 1965)	77
14. South Oscura Mountains (Bachman, 1968)	16
15. South San Andres Mountains (Kottlowski et al., 1956)	105
16. Fra Cristobal Mountains (Kelley and Silver, 1952)	65
17 Mud Springs Mountains (Kelley and Silver, 1952)	125
18. Caballo Mountains (Kelley and Silver, 1952)	119
19. San Diego Mountain (Seager, 1975)	125
20. Robledo Mountains (Kottlowski, 1958b)	125
21. South Sacramento Mountains (Pray, 1953)	100
22. Hitt Canyon, Franklin Mountains (Harbour, 1972)	210
23. Scenic Drive, Franklin Mountains (Cloud and Barnes, 1948)	250
24. Padre mine, Hueco Mountains (King et al., 1945)	373

Lithology and thickness—Basal Bliss beds are typically arkosic. At places northwest of Capitol Dome and on the north side of Victorio Canyon close scrutiny of the lowermost beds is required to determine which material is in-situ granite or syenite and which is reworked detritus. On the south side of Victorio Canyon the Bliss consists of a 4-ft-thick basal syenite cobble conglomerate overlain by 75 ft of coarse- to medium-grained, hematitic arkose and subarkose, 13 ft of dolomitic pelmicrosparite (wackestone) and interbedded, medium-grained, calcitic subarkose, and an upper 4 ft of coarse-grained, calcitic, feldspathic quartz arenite. Two measured sections near Capitol Dome are compared in Fig. 16. Section A is apparently complete and undisturbed. The middle limestone beds contain abundant peloids, *Nuia* (a tubular microorganism of uncertain affinity), and fragments of trilobites, cephalopods, gastropods, echinoderms, brachiopods, and algae (Fig. 17). There is a general decrease in sand size and feldspar content and increase in dolomite content upward. Section B is a channel fill 0.3 mi south of section A; it is incomplete because a small thrust fault cuts out some of the upper beds. There is little variation in grain size in section B; feldspar content and hematite cement appear to decrease slightly upward, and calcite cement and silica overgrowths increase. If the massive, light-gray, coarse sandstones 56 ft above the base of section A and 160 ft above the base of section B are correlative, an aggregate thickness of approximately 240 ft of the Bliss is represented in the channel fill and overlying beds.

Depositional environment—The lower beds of coarse- to very coarse-grained, fining-upward sandstone in the Bliss Sandstone at Capitol Dome are transgressive deposits on beach and adjoining shallow-sublittoral sites (channels?). Abundance of clay (sericite) matrix and poor sorting indicate a low-energy environment for the channel-fill(?) deposits. Basal cobble conglomerate in the southeastern Florida Mountains has well-rounded syenite clasts and was probably deposited near local sea cliffs. Flower (1969), Hayes (1975a), Kottlowski (1963), LeMone (1969a), Lochman-Balk (1970, 1971), and other workers have indicated clearly that open sea lay to the west and south during this time. Interbedded limestone and sandstone beds that make up the middle part of the Bliss at Capitol Dome probably were laid down on tidal flats with small pools and channels. Some of the sands appear to be bioturbated, but fossil fragments are mostly restricted to the 12-18-inch-thick limestone lenses. The flats, channels, and shallow-marine pools were heavily populated by *Nuia*, trilobites, gastropods, echino-

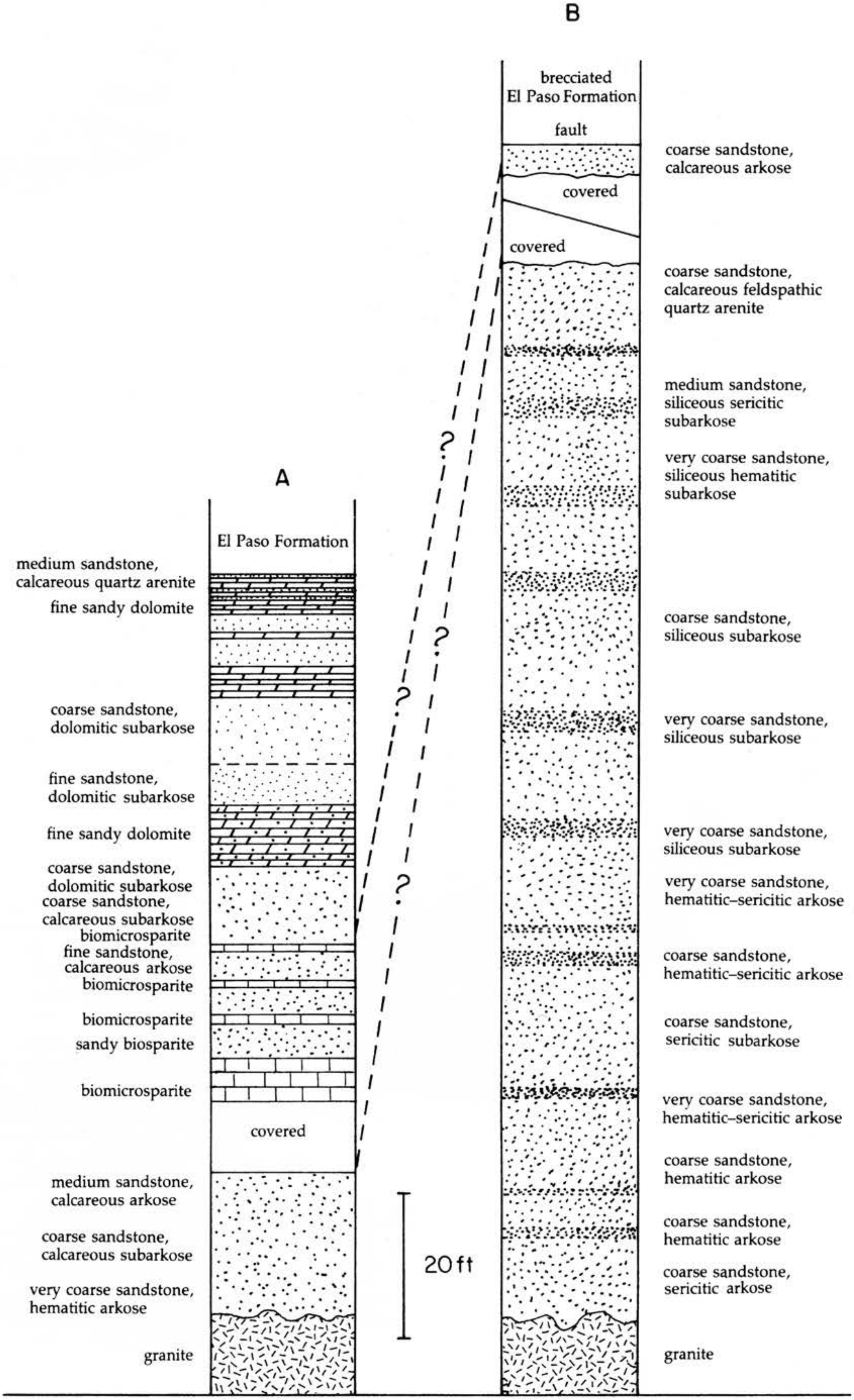


FIGURE 16—Tentative correlation of two Bliss Sandstone sections west of Capitol Dome. See Sheet 3 (in pocket) for section locations.

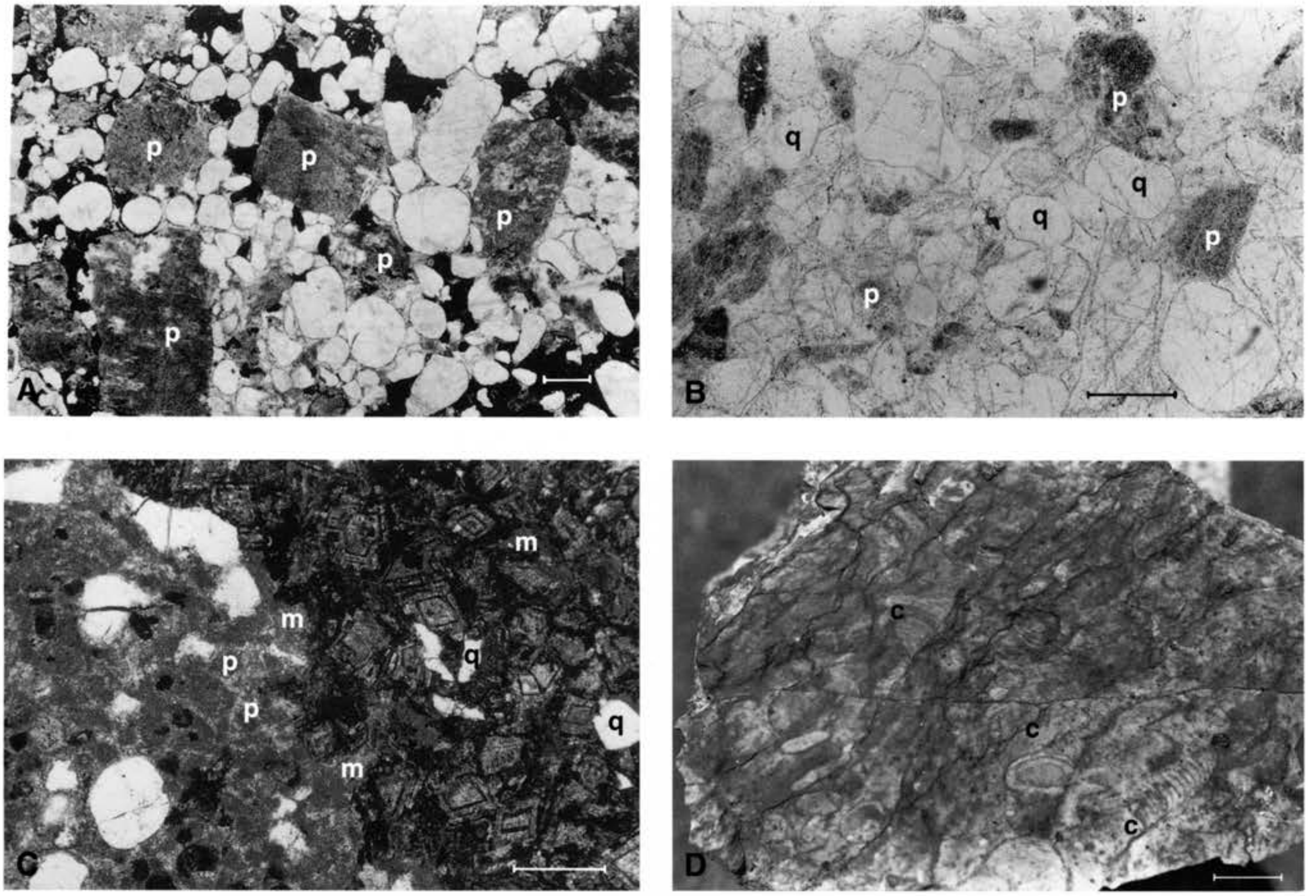


FIGURE 17—**A,** Photomicrograph of Bliss hematitic arkose. Well-rounded quartz with overgrowths and subangular perthite (**p**) grains, all probably derived from nearby granites and syenites. Sample from 30 ft above base of Bliss on north slope of Gym Peak. Scale bar = 0.2 mm. **B,** Photomicrograph of Bliss siliceous subarkose. Well-rounded quartz (**q**) and perthite (**p**). Sample from 28 ft above base on north slopes of Gym Peak. Scale bar = 0.2 mm. **C,** Photomicrograph of Bliss dolomitic pelmicrosparite. Coarse dolomite rhombs replace peloids (**p**), neomorphosed micrite matrix (**m**), and few quartz-sand grains (**q**). Sample from 70 ft above base on north slope of Gym Peak. Scale bar = 0.2 mm. **D,** Photo of neomorphosed, fossiliferous Bliss limestone containing abundant cephalopods? (**c**). Scale bar = 2 cm.

derms, cephalopods, and brachiopods. The increase in dolomite cement and neomorphosed dolomite beds in the upper Bliss probably indicate an intertidal to subtidal environment.

Age and correlation—The Bliss Sandstone is diachronous; it is younger to the east because regionally it onlaps the Precambrian. In southwestern New Mexico it is believed to be Late Cambrian (Dresbachian–Trempealeauan)–Early Ordovician (Canadian) in age (Lochman-Balk, 1971; Flower, 1969). Hayes (1975a) showed the Bliss Sandstone to be correlative to the upper part of the Coronado Sandstone and lower part of the El Paso Limestone along the New Mexico–Arizona border. Farther west, the Bliss is correlative to upper part (upper sandy member and Copper Queen Member) of the Abrigo Formation. To the east (Marathon, Texas), the Bliss is probably correlative to upper Dagger Flat Sandstone and lower Marathon Limestone beds.

El Paso Formation

The El Paso Limestone was named by Richardson (1904) for all exposures of Ordovician limestone near El Paso in the southern Franklin Mountains. He later redefined it (Richardson, 1909) to include only the lower 1,000 ft of Ordovician-age limestone. Darton (1916, 1917b) extended the usage of El Paso Limestone into Luna County and specifically into the Florida Mountains. Kelley and Silver (1952) raised the El Paso to group status, with Sierrite (below) and Bat Cave (above) Formations. Flower (1958, 1964, 1969) and LeMone (1969a, b, c) adopted the group status and assigned formational names to about 10 faunal zones and lithologic units. Lucia (1969) regarded the El Paso as a group and divided it into six formations. Harbour (1972) maintained El Paso Formation, but used six informal subdivisions that closely coincide with Lucia's formations. Hayes (1975a) retained El Paso Group but subdivided it into three formations (Fig. 18). No author has really mapped subdivisions of the El Paso, and numerous explanations have been presented against regarding the El Paso as a group (Bachman and Myers, 1969; Jicha, 1954; Harbour, 1972; Jones et al., 1967; Pratt, 1967; Zeller, 1965, 1975). Pray (1961) used El Paso Formation when he mapped the Sacramento Mountains. Locally, where it is steeply inclined, the El Paso can be mapped as two or three separate units that roughly correspond to Kelley and

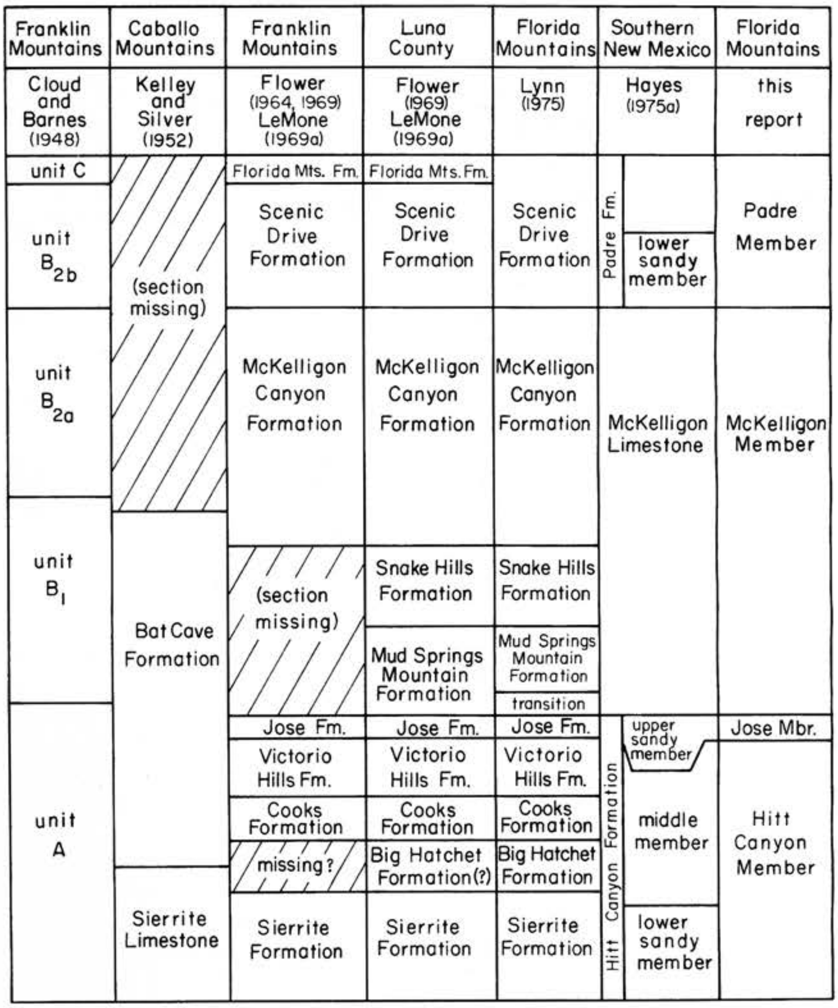


FIGURE 18—Chart showing subdivisions used by various workers for the El Paso Formation in southern New Mexico and westernmost Texas.

TABLE 4—El Paso Formation thicknesses. Only Hayes (1975a, b) and this report use Hitt Canyon, McKelligon, and Padre Members as formal units. [e]Measured section, estimating amounts of section repeated and eliminated by faulting.

Location (reference)	Hitt Canyon ft	McKelligon ft	Padre ft	Total ft
1. Mescal Canyon (Hayes, 1975b)	568	130	106	804
2. Victorio Mountains (Lynn, 1975)				506+
3. Snake Hills (Lynn, 1975)				371+
4. Fluorite Ridge (this report)	215	185+		400+
5. Capitol Dome (this report)	275	550	130	955[e]
6. Gym Peak (Clemons and Brown, 1983)	162	905	193	1,260
7. Victorio Canyon (this report)	270+	560	270	1,100+
8. Robledo Mountains (Kottlowski, 1958b)				700
9. Bishop Cap (Seager, 1973)				800
10. North Franklin Mountains (Harbour 1972)				1,590
11. South Franklin Mountains (Le Mone, 1969c)				1,594
12. Bear Mountain (Paige, 1916; Kelley and Silver, 1952)				330
13. Lone Mountain (Paige, 1916; Kelley and Silver, 1952)				519
14. Cooke's Range (Hayes, 1975b)	295	230		525
15. San Mateo Mountains (Kelley and Furlow, 1965)				75
16. Sierra Cuchillo (Hayes, 1975b)	272			272
17. Mud Springs Mountains (Hayes, 1975b)	427	137		564
18. Caballo Mountains (Hayes, 1975b)	385	170		555
19. Ash Canyon (Kottlowski et al., 1956)				760
20. South Sacramento Mountains (Pray, 1953)				370
21. San Andres Canyon (Hayes, 1975b)	349	329	7	685

Silvers' (1952) or Hayes' (1975a) formations. For areal mapping and stratigraphic studies, however, it is more convenient to consider the El Paso a single, complex lithic unit (Kottlowski, 1963). The (North) American Commission on Stratigraphic Nomenclature (1961, 1983) recommends that formations be mappable at a scale of approximately 1:24,000. Subdivisions of the El Paso are not mappable at this scale in southern New Mexico. Thus the El Paso Formation designation is used in the Florida Mountains, and it is subdivided into members as shown in Fig. 18 and Table 4 (for discussion and more detailed mapping see Sheets 2, 3, 4). The Hitt Canyon, McKelligon, and Padre Members correlate with Hayes' (1975a) formations of the same names, except that I have separated the Jose Member from the top of the Hitt Canyon because the Jose is a distinctive lithologic unit throughout southern New Mexico.

Exposures—The El Paso Formation conformably overlies the Bliss Sandstone west of Capitol Dome, east of Mahoney Park, and northeast of Gym Peak. Very locally, east of Mahoney Park, there are several spots where the Bliss is absent because of nondeposition and the lower El Paso beds rest nonconformably on syenite. Elsewhere in the central Florida Mountains the base of the El Paso either is not exposed or El Paso beds are in thrust-fault contact with syenite. The best exposed, complete El Paso section is on the eastern and southern slopes of Gym Peak (Appendix E–5). A more easily accessible section is well exposed along the northern side of Victorio Canyon (Appendix 4), but the basal 60-ft interval of the Hitt Canyon Member Is covered and probably faulted. The well-exposed section at Capitol Dome (Appendix E–2) described by Lochman-Balk (1958, 1974) and Lynn (1975) is cut by normal faults through the upper McKelligon Canyon and Padre Members; a thrust fault probably eliminates a small amount of section in the Hitt Canyon Member (Sheet 4; Appendix B–1).

Lithology and thickness—The Hitt Canyon Member of the El Paso Formation in the Florida Mountains contains 160–175 ft of thin- to medium-bedded dolomite overlain by 145 ft of thin- to medium-bedded limestone. The basal beds contain up to 5% of very fine quartz sand, which gradually diminishes up through the lower 55 ft of the member. The medium- to dark-gray dolomite is medium to coarsely crystalline and contains only sparse allochem ghosts in thin section. Some of these may be crinoids, trilobites, and *Nuia*. Oncolites (0.5–1.5 cm in diameter) are abundant in the middle and upper parts of the Hitt Canyon at most exposures. These oncolites are referred to as *Girvanella* algal spheres by Lochman-Balk (1958) and Lynn (1975). A graded bedding appearance is produced at Capitol Dome by repeated sequences of coarse-crystalline, yellowish-brown dolomite separated by sharp contact from overlying medium-crystalline, medium-gray, oncolite-bearing dolomite. Minor chert fills interstices between dolomite rhombs, and porosity seen in thin sections is essentially zero.

The upper part of the Hitt Canyon Member contains 145 ft of thin- to medium-bedded limestones on the northeast side of Victorio Canyon and 74 ft of similar rocks at Capitol Dome. The thinner section at Capitol Dome is attributed in part to a thrust fault in a 20 ft thick covered zone between the dolomites and limestones of the Hitt Canyon. Also the basal Hitt Canyon dolomites may include beds that are limestone elsewhere. Mottled colorations and "twiggy" features prominent on bedding surfaces are the result of bioturbation and iron-bearing dolomite preferentially replacing (*Thalassinoides*?) burrow fillings. Burrows typically stand out in relief on weathered surfaces (Fig. 19). The limestones are interbedded biomicrites, biosparites, and intrasparites (wackestones, packstones, and grainstones). Allochems present in approximate order of decreasing abundance are echinoderms, trilobites, intraclasts, *Nuia*, gastropods, sponge spicules and some larger sponge fragments, brachiopods, and cephalopods (Fig. 20). Minor ostracods are in sparse biomicrite near the top of the member. The upper 20 ft of the Hitt Canyon Member are typically silty to finely sandy. *Nuia* is a straight to slightly curved, tubular microorganism with a conspicuous dark central canal and distinctive radial-hyaline wall structure. Multilayered-wall forms are as abundant as singlelayered-wall forms. Many transverse sections are circular (Fig. 21A). *Nuia* is regarded as a problematic microorganism by Toomey and

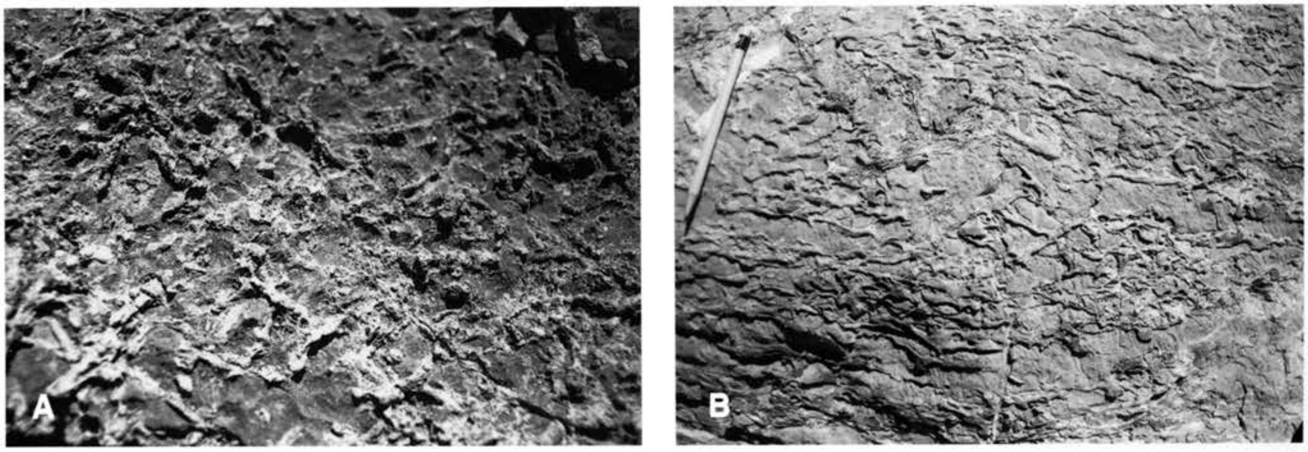


FIGURE 19—Dolomitized burrow fillings (*Thalassinoides*?) on bedding surfaces in the McKelligon (**A**) and Padre (**B**) Members.

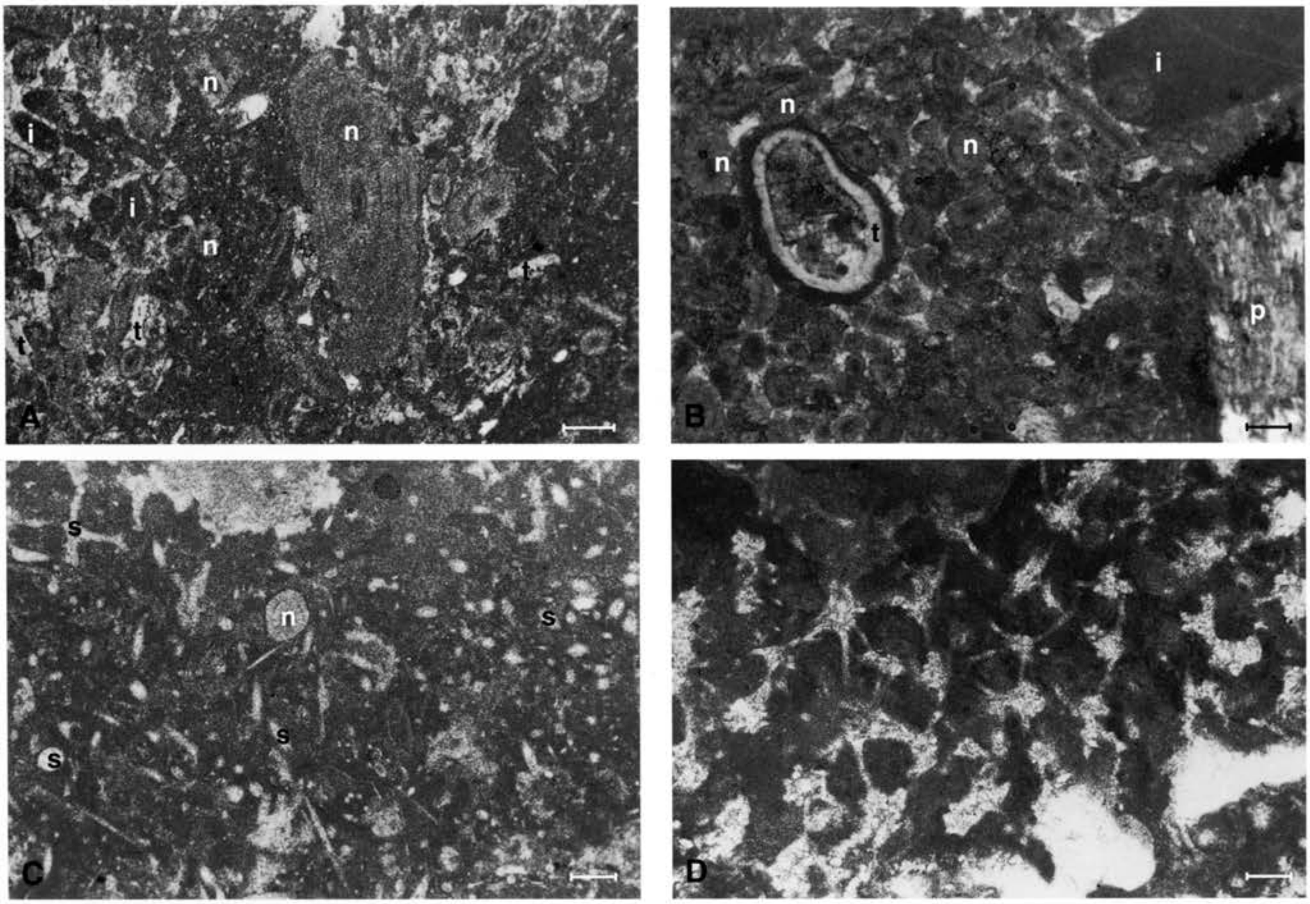


FIGURE 20—Photomicrographs of allochems in Hitt Canyon Member. Scale bar in A = 0.2 mm and applies to B–D as well. **A,** Abundant *Nuia* (**n**), intraclasts (**i**), and few trilobite fragments (**t**) in slightly silty (white quartz grains), bioturbated, poorly washed biosparite. Sample from near top of Hitt Canyon Member on northeast slope of Gym Peak. **B,** *Nuia* (**n**), micritized trilobite (**t**), intraclast (**i**), and perthite grains (**p**) in biosparite from near base of arkosic Hitt Canyon on northeast slope of Gym Peak. **C,** Small *Nuia* (**n**) and micrite-filled sponge fragment in upper Hitt Canyon at Capitol Dome. Sponge spicules (**s**) replaced by spar calcite. **D,** Sponge filled with micrite in upper part of Hitt Canyon Member at Victorio Canyon.

Klement (1966). Maslov (1956) and Johnson (1966) consider it a type of algae. I believe some previous workers have confused *Nuia*, especially some partly micritized *Nuia* (Fig. 21C) in the El Paso Formation, with oolites.

The Jose Member is only 10–15 ft thick in the Florida Mountains, but is very distinctive in southern New Mexico and west Texas. One-half to two-thirds of the Jose consists of thin- to medium-bedded, medium-gray, bioturbated limestone. Interbeds of biomicrite, biosparite, and intrasparite contain abundant fragments of trilobites, echinoderms, intraclasts and a few sponge spicules, and gastropods. Traces of cubic hematite pseudomorphs after pyrite(?) are in some beds, and up to 4% of medium-grained quartz sand is in others. Beds that make the Jose a distinctive lithologic unit compose about one-third to one-half of the member in the Florida Mountains. These interbedded dark-gray limestones and dolomitic limestones contain abundant tiny (less than 1 mm), spherical to subspherical, orange and dark-gray particles (Fig. 22A) easily visible under a handlens. In thin section these rounded particles are seen to be coarse, dolomitized micrite lithoclasts, partly micritized fossil fragments, and micritized *Nuia*. One of the dark-gray beds 3 ft above the base of the Jose northeast of Victorio Canyon is composed chiefly of black trilobite fragments with some pygidia that are up to 2.5 cm across (Fig. 22D).

The McKelligon Member (McKelligon Limestone of Hayes, 1975a) contains approximately 560 ft of medium- to thick-bedded, light- to medium-gray limestones and dolomitic limestones. Dolomitized, branching burrow fillings cause many weathered surfaces to attain a "twiggy" appearance typical of the El Paso Formation. Sparse, silicified cephalopod siphuncles (Fig. 23A), sponges (Fig. 23B), and gastropods may be seen on some bedding surfaces. Thin yellowish-brown laminae that resemble chert are identified in thin section to be insoluble dolomitic residue concentrated in stylolites. These are conspicuous in most of the El Paso Formation. Abundant stromatolite mounds 3–5 inches wide and up to 12 inches high are present about 30 ft above the base of the McKelligon Member (Fig. 23D). The limestones are interbedded biomicrites, biosparites, poorly washed biosparites, intrasparites, intrasparrudites, and a few fossiliferous micrites and dismicrites (wackestones, packstones, grainstones, and few lime mudstones). Many beds are partly dolomitized, but none sampled have been com-

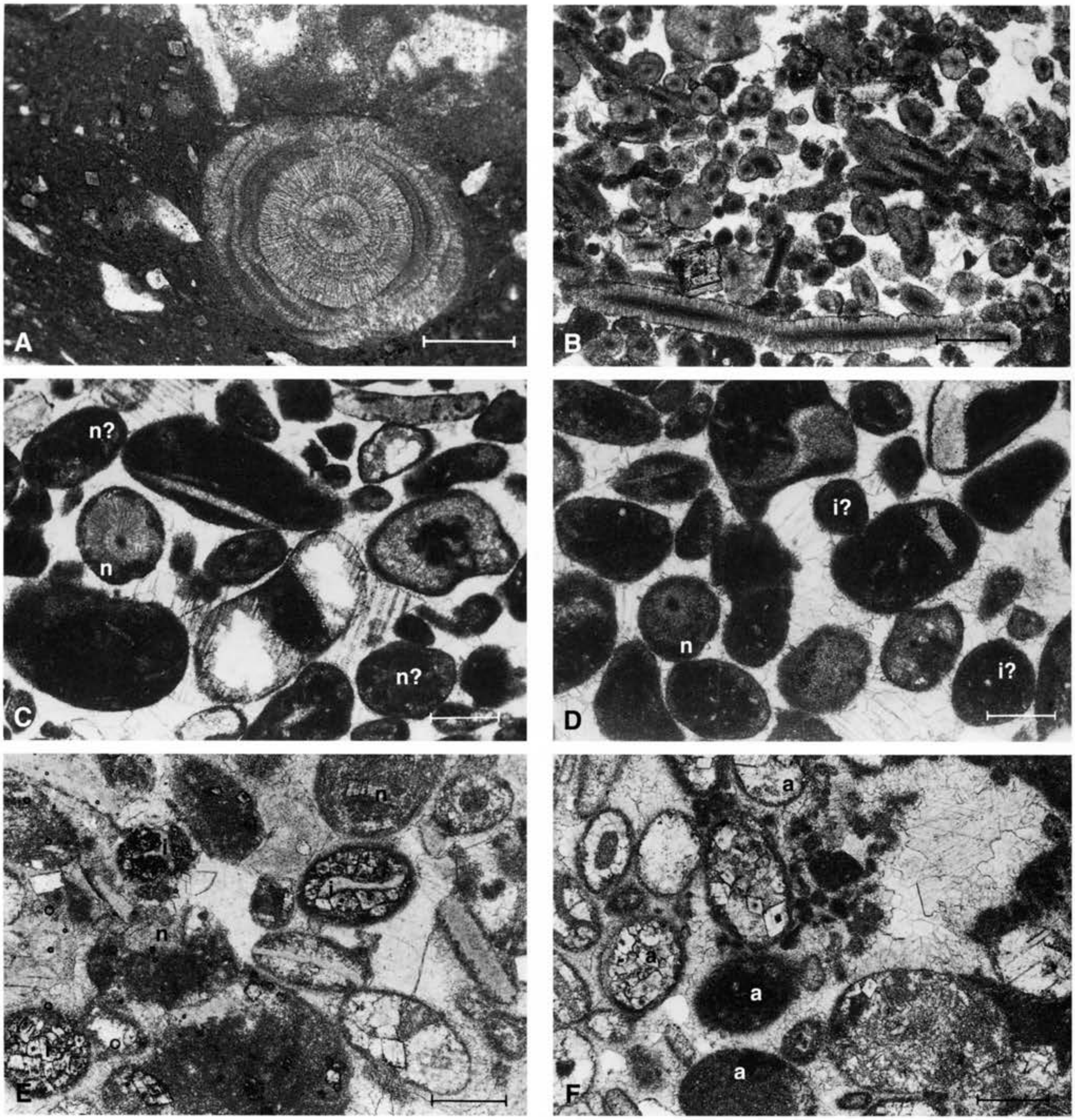


FIGURE 21—Photomicrographs of *Nuia siberica* Maslov. Scale bars = 0.2 mm. **A,** *Nuia* in slightly dolomitized micrite matrix of lower McKelligon Member at Capitol Dome. **B,** *Nuia* grainstone from McKelligon Member north of Victorio Canyon. Some *Nuia* have thin, micritized rims. **C,** Intraclast grainstone from McKelligon Member north of Victorio Canyon. *Nuia* (**n**) gradually being micritized and losing its identity. **D,** Intraclast grainstone as in C. The grains are intraclasts(?) or micritized *Nuia* (**n**). **E,** Partly dolomitized, fossil-bearing lithiclast grainstone from basal Jose Member north of Victorio Canyon. Dolomitized intraclasts (**i**) and micritized *Nuia* (**n**) like these have probably been called oolites. **F,** Same slide as E. The allochems (**a**) may be altered *Nuia*.

pletely replaced. The dolomitic limestones have a conspicuous grayish-orange color. Fossil allochems, in order of decreasing abundance, are: gastropods, sponges and spicules, trilobites, echinoderms, *Nuia*, brachiopods, and cephalopods (Fig. 24). *Nuia* is scarce or absent in the interval containing stromatolite mounds. Traces of quartz silt and fine sand occur in some of the upper beds at Capitol Dome, but not in the vicinity of Victorio Canyon.

The Padre Member (Padre Formation of Hayes, 1975a) is made up of thin- to medium-bedded limestones and dolomitic limestones in the Florida Mountains. The base of the Padre in the Capitol Dome area is mapped at the base of a 6-ft-thick black limestone bed. In the southeastern Florida Mountains, the base of the Padre is placed at the lowest of several thick black limestone beds above the uniformly light- to medium-gray McKelligon beds. The Padre Member

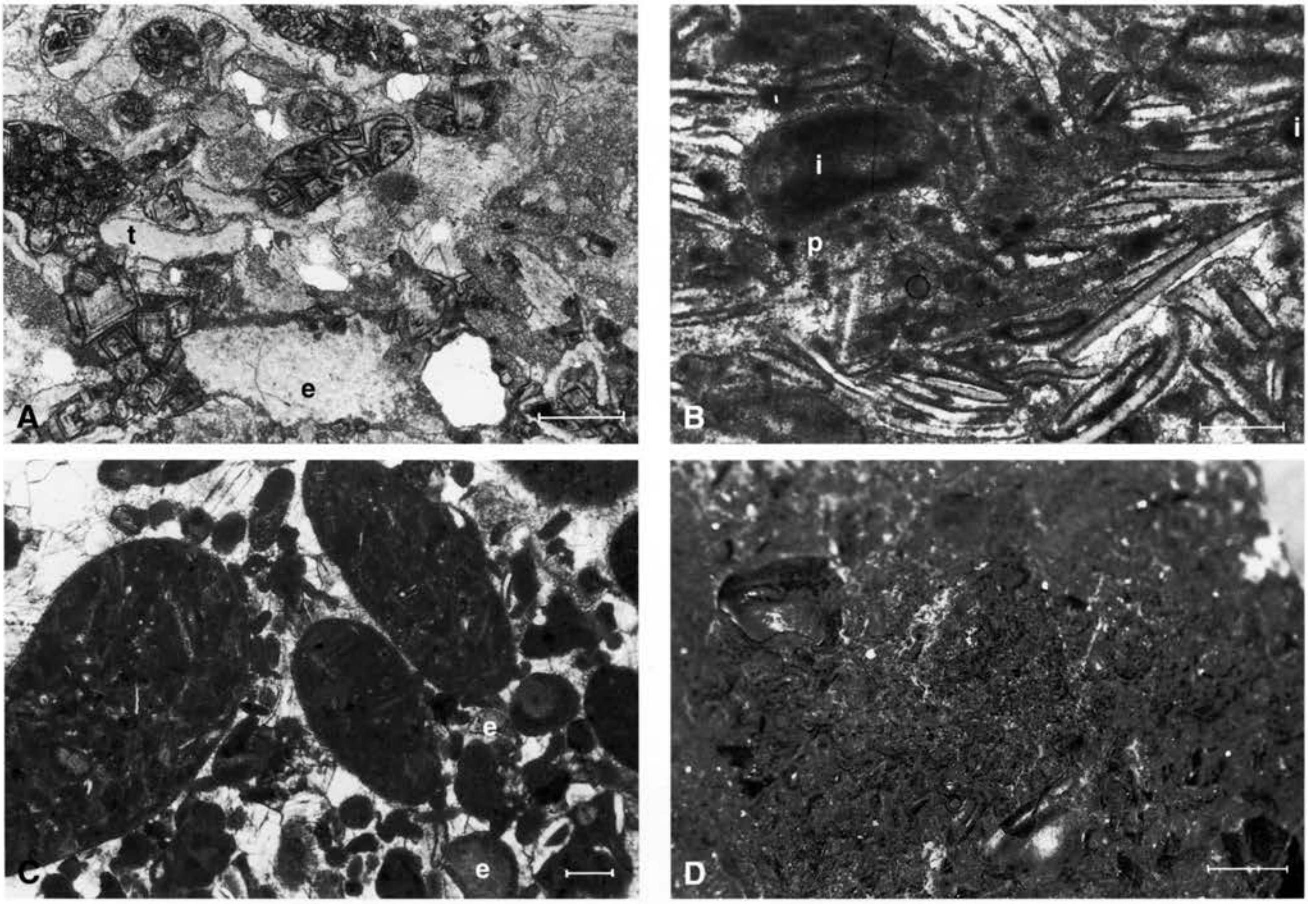


FIGURE 22—Photomicrographs of allochems in Jose Member at Capitol Dome. Scale bars are 0.2 mm in A–C and 2 cm in D. **A,** Partly dolomitized, fossil-bearing intraclast packstone. Large dolomite rhombs have replaced micrite in intraclasts. Abundant fragments of trilobites (**t**) and echinoderms (**e**) with scattered quartz silt (white). **B,** Trilobite grainstone with few peloids (**p**) and intraclast (**i**). Trilobite fragments have micritized rims. **C,** Intraclast grainstone; mostly sponge-spicule–packstone intraclasts with few echinoderm (**e**) fragments. **D,** Trilobite pygidia in sample of Jose Member from Victorio Canyon.

is 270 ft thick at Victorio Canyon and more than 130 ft at Capitol Dome; some of the section is faulted out at Capitol Dome. Small chert nodules are common, and locally chert may form thin lenses and interbeds in the Padre Member (Fig. 25). In general, the limestones are similar to those in the McKelligon Member. The lower beds are typically silty and finely sandy (Appendix B). Fossil allochem content differs from lower beds in that *Nuia* is usually missing in the Padre; brachiopods are more abundant and traces of ostracods occur in many beds (Fig. 26).

Depositional environment—The prolific *Girvanella*(?) oncolites, dolomitization of the wavy, thin-bedded lower Hitt Canyon beds, and regionally southward thickening of the El Paso Formation indicate a period of intertidal to shallow-subtidal deposition along an east-trending shoreline in early El Paso time. Many repetitions of oncolite layers on bedding surfaces apparently cut on non-oncolite beds indicate cyclic conditions in the area.

The pervasive bioturbation of El Paso beds and fauna consisting of digitate algal stromatolites, abundant sponges, gastropods, trilobites, *Nuia*, and cephalopods indicate fluctuating shallow-subtidal depositional environments. Quiet, low-energy environments in which the large volume of micritic muds accumulated were disturbed hundreds or perhaps thousands of times by storms or strong winds producing the great abundance of thin, poorly washed biosparites, intrasparite, and intrasparrudite lenses and local scour-and-fill structures. Some of these may also represent ephemeral tidal channels. LeMone (1969c, 1976b), Lucia (1969), and Toomey and Klement (1966) considered the El Paso rocks to have been deposited under shallow subtidal–intertidal–supratidal conditions, and LeMone (1976a) described 17 cycles in the Jose Member. Much of the silt and fine, rounded, and frosted sand (Lynn, 1975) is in micrite and was probably wind-blown detritus. Sparse sandy intercalations associated with biosparites and intrasparites probably represent storm or tidal channel deposits.

Age and correlation—Subdivisions of the El Paso Formation as used in this report coincide with previously assigned subdivisions of the El Paso Group as shown in Fig. 18. The El Paso is diachronous and younger from west to east (LeMone, 1974). The age of the El Paso Formation has been well established as Early Ordovician (Canadian) by Flower (1953b, 1965, 1969), LeMone (1969a), Hayes (1975a), and other workers. The El Paso Limestone of southeastern Arizona is correlative to the Copper Queen Member of

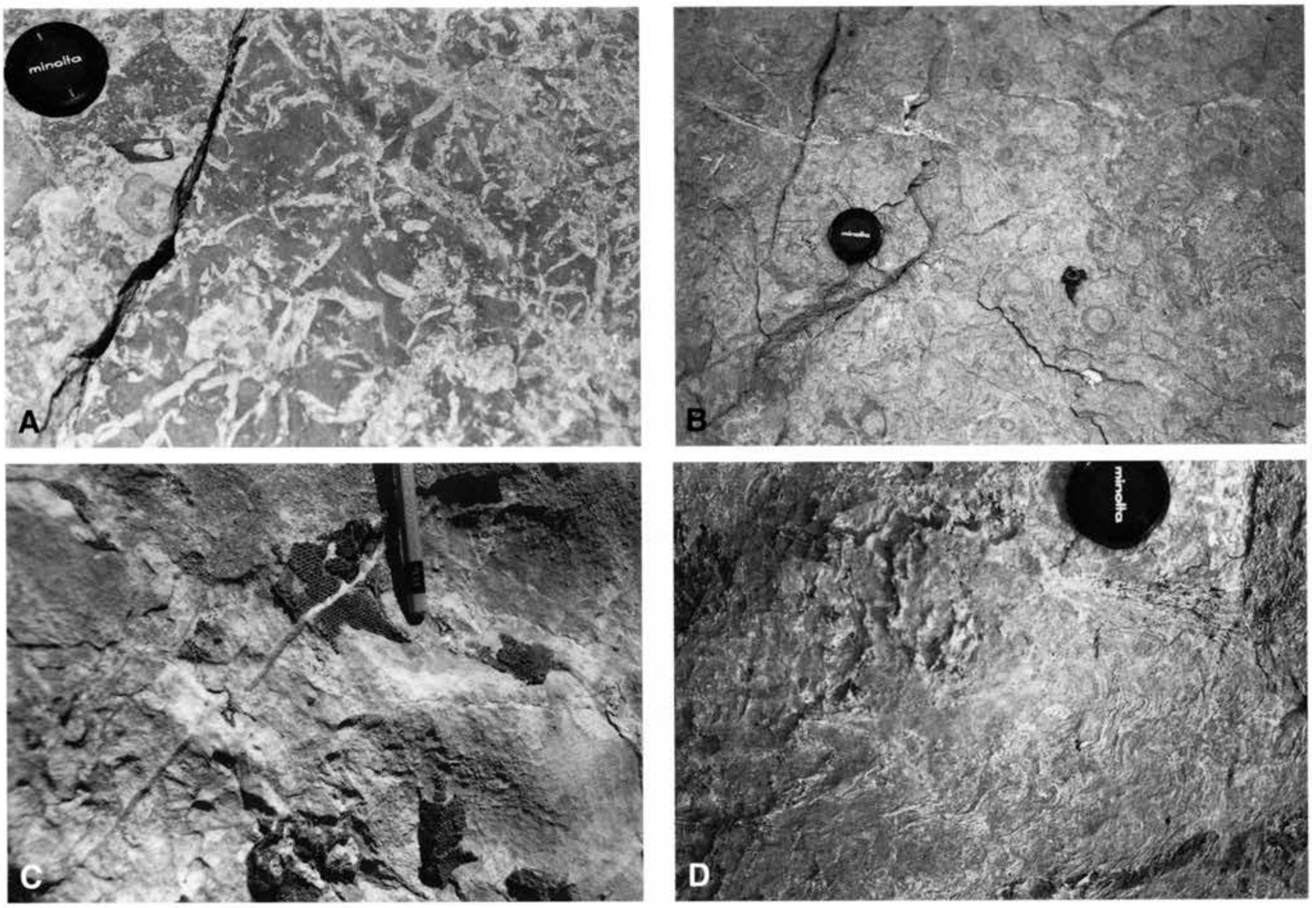


FIGURE 23—**A,** Part of silicified cephalopod siphuncle (below and right of lens cover) in bioturbated McKelligon Member at Capitol Dome. **B,** Abundant sponges in upper McKelligon Member at Capitol Dome. **C,** Silicified sponge fragments and cephalopod siphuncle (**c**) in lower McKelligon Member at Capitol Dome. **D,** Stromatolite in lower McKelligon Member [Mud Springs Mountain Formation of Flower (1969) and LeMone (1969a)].

the Abrigo Formation farther west. In west Texas the El Paso Formation is correlative to the Marathon Limestone and Ellenburger Group.

Montoya Formation

The Montoya Limestone was named by Richardson (1908) for exposures in the southern Franklin Mountains, and Darton (1916, 1917a, 1917b) extended the name throughout southern New Mexico. Entwistle (1944) subdivided the Montoya in the Silver City area into three members, in ascending order the Second Value, Par Value, and Raven. Kelley and Silver (1952) recognized the same members in the Caballo Mountains, but believed that Entwistle's type sections were not satisfactory. They raised Montoya to group rank and named four formations, in ascending order the Cable Canyon, Upham, Aleman, and Cutter. The Cable Canyon and Upham are equivalent to the Second Value Member, and the Aleman and Cutter are equivalent to the Par Value and Raven Members, respectively. Working in the Sacramento Mountains, Pray (1953) applied the name Valmont Dolomite to beds equivalent to the Raven and Cutter units. Subsequently, the name Valmont has been abandoned. Hayes (1975a) believed Entwistle's subdivisions were adequate, but, because Kelley and Silver's units were firmly established by then, Pratt and Hayes considered the Montoya Group to consist of the Second Value Dolomite, Aleman Formation, and Cutter Dolomite. In some areas the Second Value was subdivided into the lower Cable Canyon Sandstone and upper Upham Dolomite Members.

Reasoning similar to that used for the El Paso Formation can be applied to consideration of the Montoya as a Formation. The subdivisions of the Montoya cannot be mapped at 1:24,000 scale and thus do not qualify for formational rank. I prefer to use Montoya Formation rather than Montoya Dolomite in the Florida Mountains because the Cable Canyon Member contains much sand, the Aleman Member consists of about equal amounts of dolomite, limestone, and chert, and the Cutter Member is at least one-half limestone.

Exposures—The Montoya Formation crops out in the western slopes of Capitol Dome, south of Mahoney Park, northeast of Victorio Canyon, and in the Mahoney Ridge-Gym Peak area. A well-exposed, easily accessible, complete section is in NW¼NW¼ sec. 35 T25S R8W (Appendix E–3).

The section northeast of Victorio Canyon (Appendix E–4) is easily accessible but poorly exposed and may contain faults not recognized during mapping. The best exposed but least accessible sections are in sec. 7 T26S R7W, high on the slopes of Gym Peak

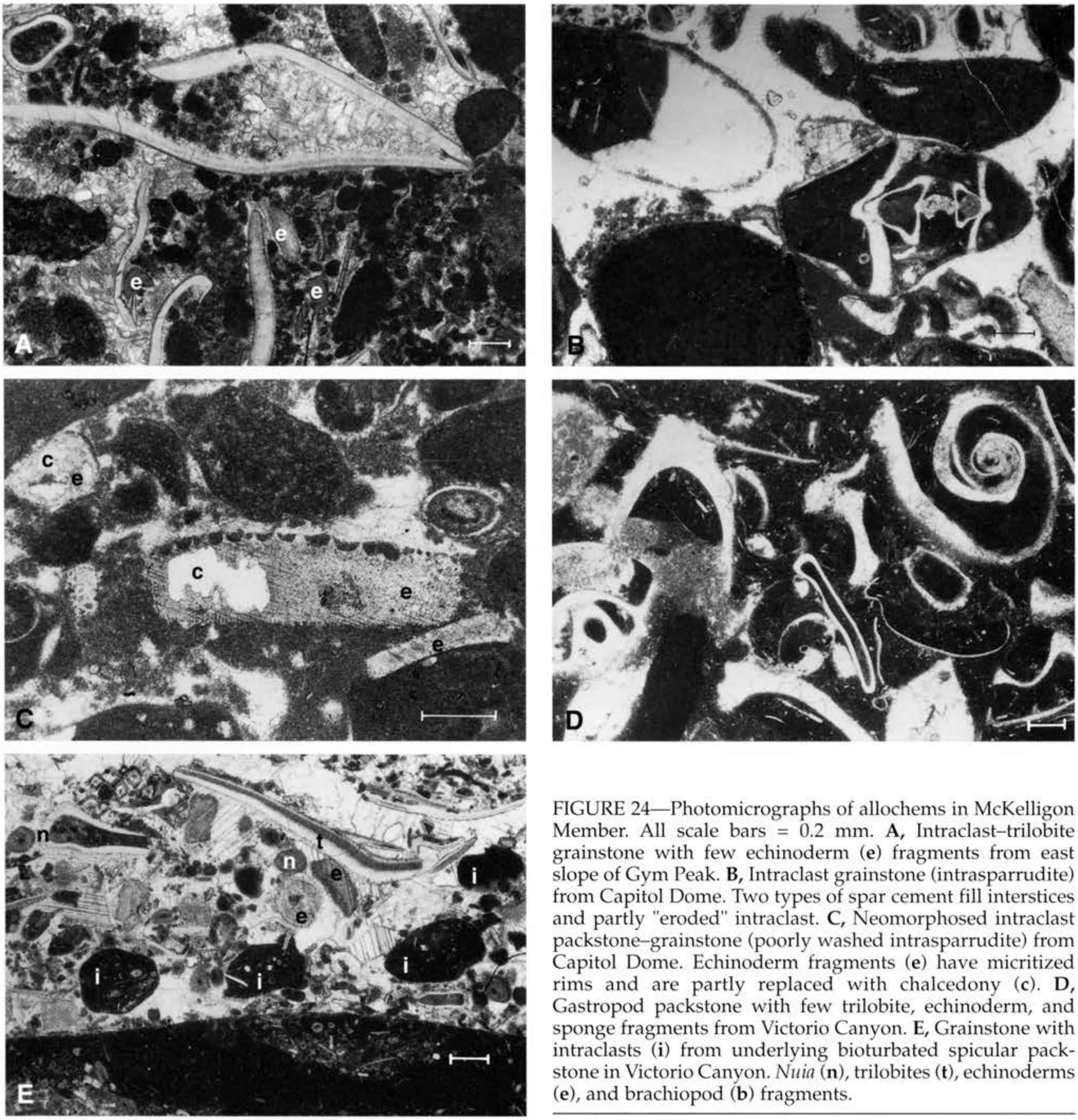


FIGURE 24—Photomicrographs of allochems in McKelligon Member. All scale bars = 0.2 mm. **A,** Intraclast–trilobite grainstone with few echinoderm (**e**) fragments from east slope of Gym Peak. **B,** Intraclast grainstone (intrasparrudite) from Capitol Dome. Two types of spar cement fill interstices and partly "eroded" intraclast. **C,** Neomorphosed intraclast packstone–grainstone (poorly washed intrasparrudite) from Capitol Dome. Echinoderm fragments (**e**) have micritized rims and are partly replaced with chalcedony (**c**). **D,** Gastropod packstone with few trilobite, echinoderm, and sponge fragments from Victorio Canyon. **E,** Grainstone with intraclasts (**i**) from underlying bioturbated spicular packstone in Victorio Canyon. *Nuia* (**n**), trilobites (**t**), echinoderms (**e**), and brachiopod (**b**) fragments.

(Appendix E–5). The Capitol Dome section (Appendix E–2) does not contain the upper part of the Cutter Member (Fig. 27A), and there is probably a small thrust between the Upham and Aleman Members (Fig. 27B).

Lithology and thickness—The Cable Canyon Member in the Florida Mountains generally consists of 15–28 ft of massive, medium brownish-gray, sandy dolomite (Table 5). Poorly sorted, fine to coarse, subrounded to well-rounded quartz grains are embedded in medium-crystalline dolomite. Quartz content ranges from 10 to 60%, generally decreasing upward and grading into slightly sandy basal Upham Dolomite. Examination of the quartz grains with a handlens reveals that approximately 1% of the grains are distinctively pale blue. Lynn (1975) separated clean, rounded, and frosted grains as insoluble residue from the Cable Canyon at Capitol Dome. Flower (1969) believed that a 3 ft thick basal crinoidal dolomite without any quartz sand at Capitol Dome could belong to the Padre Member (Florida Mountains Formation) of the El Paso Formation. Insufficient exposures prevent obtaining conclusive evidence. The lower 7 ft of Cable Canyon at Mahoney Park are limestone and dolomitic limestone with fragments of echinoderms, brachiopods, trilobites, and ostracods.

The Upham Member is a massive, dark-gray, medium-crystalline dolomite that weathers dark brownish gray. Locally, mottled colorations of medium to dark gray and dark yellowish brown indicate probable bioturbated sediments that were dolomitized. Echinoderm(?) ghosts are common throughout the Upham at Mahoney Park. The lower 7 ft at this locality are less dolomitized and also contain ghosts of trilobites, gastropods(?), and brachiopods. The lower few feet contain minor amounts of quartz sand, which diminish upward. Upham exposed in the Florida Mountains ranges in thickness from 36 to 50 ft.

The Aleman Member in the Florida Mountains ranges in thickness from 85 to 148 ft and possesses the same distinctive lithology common throughout southern New Mexico. Thin dolomite (or locally limestone) alternates in rhythmic succession with thin beds and elongated nodules of dark-gray chert that weather dark brown to black. The dolomite and limestone are typically dark gray and weather light to medium gray; limestone is less abundant in the Capitol Dome section than elsewhere in the Florida Mountains. The limestone–dolomite to chert ratio ranges from 1 to 3. The upper 20 ft at Capitol Dome are massive dolomite with lensoid chert nodules. Stylolites are common in all sections. Undisturbed microlaminations can be seen in thin sections of many samples. Dolomitization obliterated all fossils in the dolomites, but fragments of echinoderms, brachiopods, trilobites, bryozoa, ostracods, and spicules can be seen in many of the limestones (Fig. 28). A few silicified brachiopods weather in relief on limestone interbeds, and some brown-weathering chert beds on the southeast slope of Gym Peak are silicified brachiopod coquinas.

The Cutter Member consists of 90–220 ft of dolomite and limestone. The variations in thickness are believed to be due to differential erosion of the upper Cutter before it was covered by Fusselman Dolomite. Typically, the lower Cutter is limestone and dolomitic limestone and the upper Cutter is dolomite

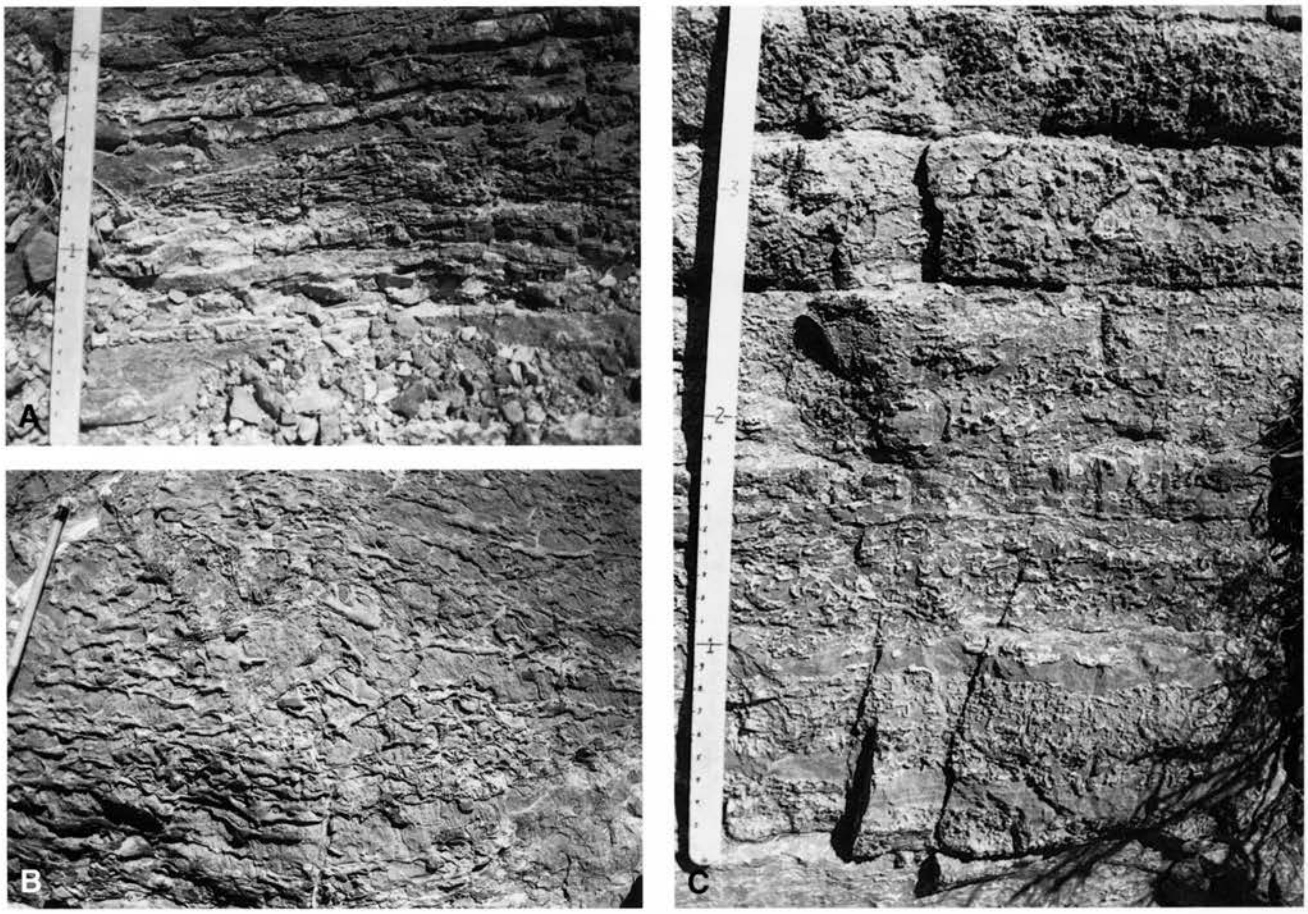
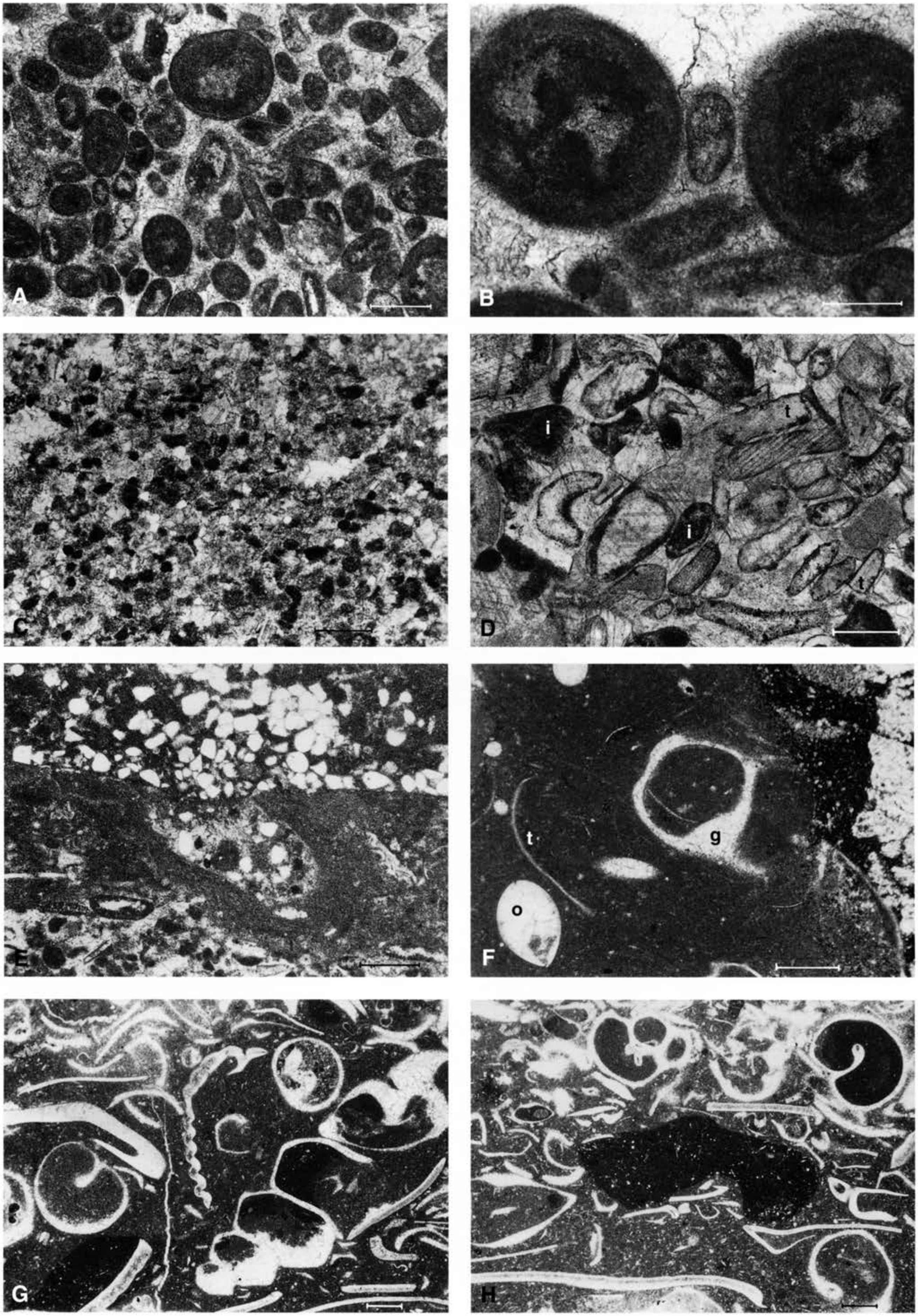


FIGURE 25—**A,** Cherty, thin-bedded Padre Member at Capitol Dome. **B,** Dolomitized burrow fillings (*Thalassinoides*?) on bedding surfaces of Padre Member at Capitol Dome. **C,** Dolomitized burrow fillings in lower part of Padre Member at Capitol Dome.

FIGURE 26—Photomicrographs of allochems in Padre Member. All scale bars = 0.2 mm. **A,** *Nuia* grainstone from Capitol Dome. *Nuia* are so intensely micritized that they resemble ooids. Two types of spar cement fill interstices. **B,** Enlarged views of *Nuia* in same slide as A. Faint tangential rings and radially oriented crystals are present in left *Nuia*. Compare with Fig. 21A. **C,** Neomorphosed peloid packstone from Victorio Canyon. Peloids may be micritized *Nuia* or small intraclasts. Quartz silt grains (white) are characteristic of the Padre. **D,** Echinoderm grainstone from Victorio Canyon. Minor micritization of fragments preceded syntaxial overgrowths that form cement. Few trilobite fragments (**t**) and intraclasts (**i**). **E,** Very fine sandy wackestone overlying burrowed wackestone and grainstone from Victorio Canyon. **F,** Packstone with gastropod (**g**), ostracod (**o**), trilobite fragments (**t**), and sponge spicules (**s**) from Victorio Canyon. Right side is dolomitized burrow filling. **G,** Gastropod–trilobite packstone from Victorio Canyon. Spar fill in top of large, high-spired gastropod forms geopetal feature. **H,** Gastropod–trilobite packstone with intraclast of spicular wackestone identical to bed immediately below. Sample taken 7 ft below G.


A
B
C
i
t
i
t
D
E
t
g
o
F
G
H

and cherty dolomite. Thick and massive beds occur locally in the otherwise thin- to medium-bedded sections. The fine- to medium-crystalline dolomite is medium gray and weathers light gray. Mottled-gray, yellowish-brown, and brownish-gray colorations are abundant on weathered surfaces of the limestones. Abundant branching burrows (*Thalassinoides*?) have been dolomitized selectively and stand out in relief to provide the twig-like structures on weathered surfaces (Fig. 29) similar to those noted in the El Paso Formation. Insoluble residues and ferroan dolomite concentrated in the abundant stylolites weather yellowish brown and resemble thin chert laminae. The Cutter is relatively chert-free except for large, irregular nodules that weather reddish brown or medium gray in the upper beds of thicker sections (Fig. 30). Several brachiopod-coquina zones (Fig. 31) occur in the lower Cutter, and scattered silicified brachiopods and solitary horn corals weather in relief on the upper dolomite beds. Dolomitization destroyed many fossils in the upper Cutter, but ghosts of echinoderm(?) and brachiopod(?) allochems can be seen in thin sections of the dolomites. The limestones contain abundant fragments of brachiopods, bryozoa, echinoderms, gastropods, ostracods, sponge spicules, and trilobites (Appendix C).

An erosional disconformity is present between the Cutter and overlying Fusselman Dolomite. The precise contact is difficult to locate in some sections, as noted by Darton (1916), Bogart (1953), and Corbitt (1971). This problem is attributed to a slight relief of the disconformity, similar lithologies above and below the contact, local tectonic complications. However, the boundary is recognizable if exposures are fair to good. The dolomite at the top of the Cutter Member is lighter gray and finer crystalline than Fusselman Dolomite; the upper Cutter contains many irregular and lensoid chert nodules, whereas the Fusselman does not; and the Cutter dolomitic beds rarely contain fossils, whereas the basal Fusselman strata commonly contain silicified corals. The 90-ft section at Capitol Dome contains no chert and is correlative to the basal part of Cutter sections in the southern Florida Mountains. The 173 ft section in Mahoney Park con-

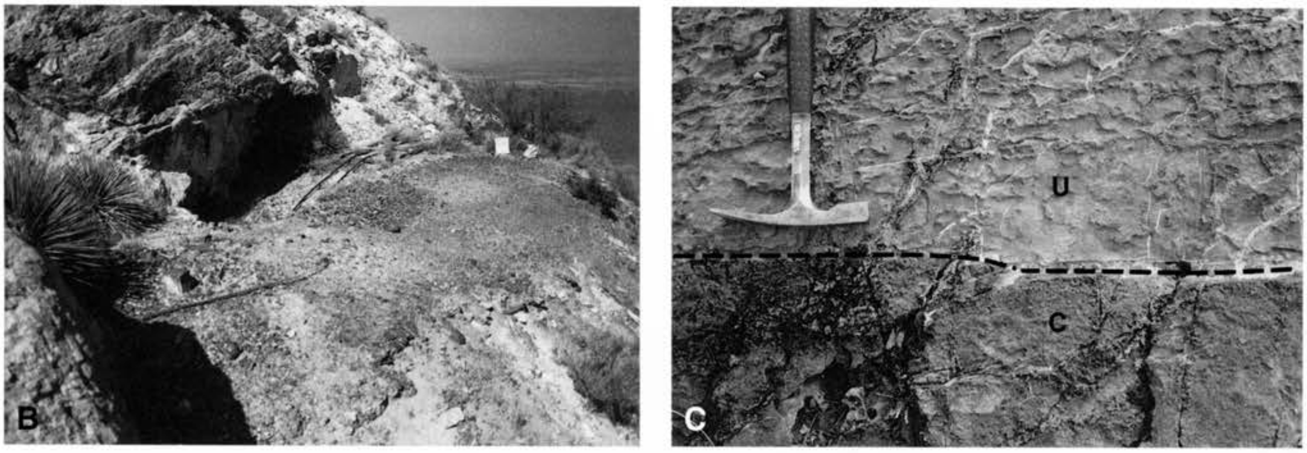
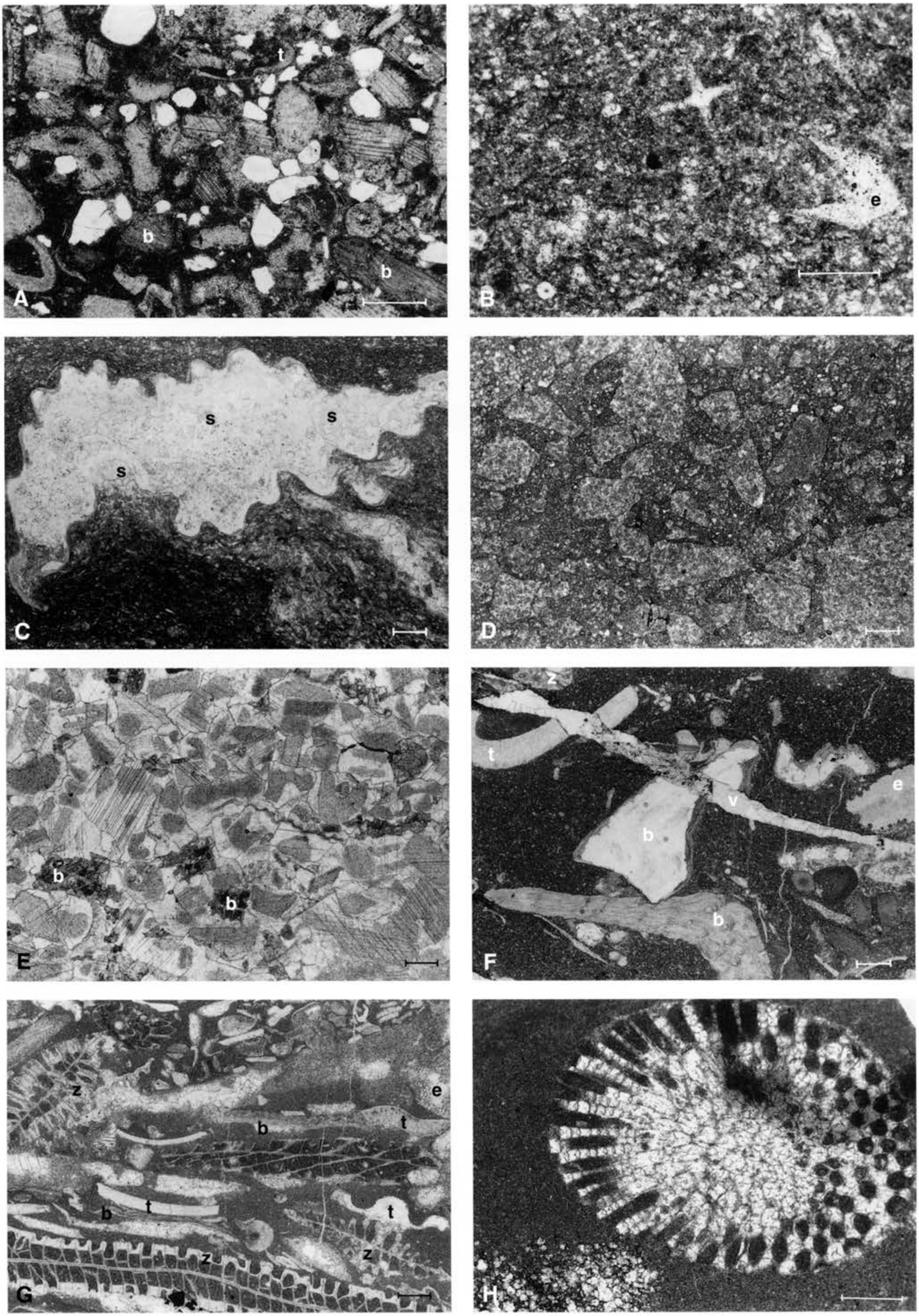


FIGURE 27—**A,** Padre Member of El Paso Formation (**P**) overlain by Cable Canyon Sandstone (**C**), Upham Dolomite (**U**), and Aleman Member (**A**) of Montoya Formation, Lobo Formation (**L**), and Rubio Peak Formation (**R**) on west slope of Capitol Dome. **B,** Entrance of inclined adit along thrust-faulted contact of Aleman and Upham Members on west slope of Capitol Dome. **C,** Cable Canyon Sandstone (**C**)–Upham Dolomite (**U**) contact on lower east slope of Gym Peak. Bioturbation of Upham marked by etched relief of burrow fillings.

FIGURE 28—Photomicrographs of allochems in Montoya Formation. All scale bars = 0.2 mm. **A,** Echinoderm fragments with quartz grains (white) and a few trilobite (**t**) and brachiopod (**b**) fragments; basal Upham Member in Mahoney Park. **B,** Spicular–peloid packstone with a few recognizable echinoderm fragments (**e**) from Aleman Member at Victorio Canyon. **C,** Brachiopod in compacted wackestone. Spar filling (**s**) mostly replaced by chert; near top of Aleman Member at Victorio Canyon. **D,** Dolomite breccia at base of upper dolomite unit of Cutter Member in Mahoney Park. **E,** Echinoderm grainstone with few bryozoan fragments (z) at base of Cutter Member in Victorio Canyon. **F,** Bioclastic packstone (biomicrudite) containing brachiopods (**b**), trilobites (**t**), bryozoa (**z**), and echinoderms (**e**) from Cutter at Victorio Canyon. Large brachiopod fragment in center was filled and replaced with chalcedony before fracturing and spar filling of the vein (**v**). **G,** Bioclastic packstone (biomicrudite) containing brachiopod (**b**), trilobite (**t**), bryozoan (**z**), and echinoderm (**e**) fragments from 46 ft above sample shown in F. Black crystals in lower center are hematite pseudomorphs after pyrite. **H,** Bryozoan in partly dolomitized micrite matrix; Cutter Member on south slope of Gym Peak.

→


t
b
b
A
e
B
s
s
s
C
D
b
b
E
z
t
e
v
b
b
F
z
e
b
t
b
t
t
z
z
G
H

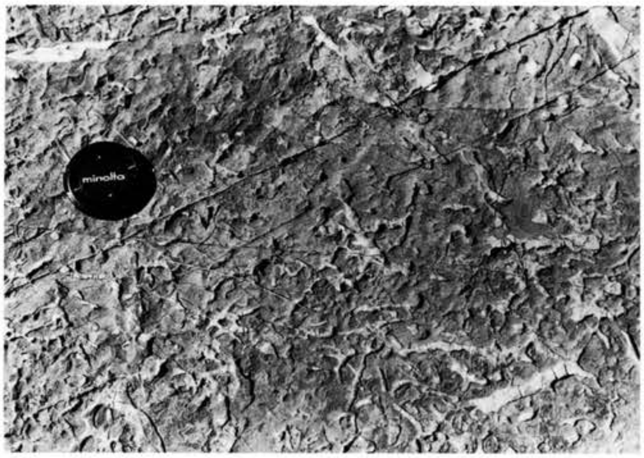


FIGURE 29—Bedding surface of lower part of Cutter Member in Mahoney Park showing dolomitized burrow fillings (*Thalassinoides*?).

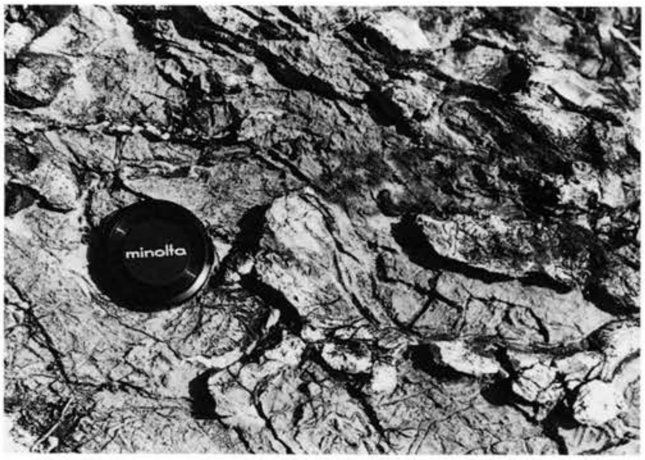
tains in its upper part some chert nodules (Fig. 30), which are stratigraphically above the Capitol Dome section, and the 181 ft Gym Peak section is topped by 3 ft of sublithographic dolomite above the chert-nodule horizon. The Victorio Canyon section contains 220 ft of Cutter, which includes all the lithologies present at Capitol Dome, Mahoney Park, and Gym Peak, and additional upper beds of medium-crystalline dolomite similar to Fusselman Dolomite. It is at this locality that the Fusselman–Cutter contact is more difficult to locate precisely.

Depositional environment—A significant environmental change is indicated by the basal Montoya strata. The sharp contact with the underlying El Paso Formation and thickening of the Cable Canyon Member to the north and west (Kottlowski, 1963) represent deposition and reworking of clastics on an erosional surface in a shoreline to very shallow, nearshore environment. The poorly sorted, rounded, and frosted quartz grains were blown or washed into a low-energy resting place. The Upham strata have been thoroughly neomorphosed, but allochem ghosts and bioturbated beds indicate that the Upham probably was deposited in a shallow-subtidal environment. Its relatively uniform regional thickness (Table 5) implies that the Cable Canyon Member had smoothed out most pre-Montoya relief. The lithology, fossil content, and sedimentary structures of the Aleman Member suggest deposition in quiet, shallow-subtidal marine conditions as noted by Hayes (1975a). The Cutter Member contains less chert than the Aleman, is more bioturbated, and contains corals and more bryozoa and gastropods. These characteristics indicate that possibly water depth increased slightly, although warm, shallow, and quiet, but aerated, subtidal conditions existed in the Florida Mountains through the end of Montoya deposition.

Age and correlation—The Montoya Formation is assigned a late Middle Ordovician (Red River) to Late Ordovician (late Richmondian) age by Flower (1957, 1965) and Hayes (1975a). It lies disconformably on a widespread Middle Ordovician erosional surface rep-

TABLE 5—Montoya Formation thicknesses. *Howe's measured section must be in section 11 or 14 because there is no Montoya section 13.

Location (reference)	Cable Canyon Sandstone	Upham Dolomite	Aleman Member	Cutter Member	Total ft
1. Mescal Canyon (Zeller, 1965)	16	56	76	237	385
2. Mescal Canyon (Hayes, 1975b)	9	48	47	293	397
3. Victorio Mountains (Lynn, 1975)	16	57	223	93	389
4. Victorio Mountains (Thorman and Drewes, 1980)	15	50	150	115	330
5. Snake Hills (Lynn, 1975)	26	54	124+	—	204+
6. Fluorite Ridge (this report)	40	30	90	30+	190+
7. Capitol Dome (this report)	15	50	90	90+	245+
8. Mahoney Park (this report)	28	36	85	173	322
9. Gym Peak (Clemons and Brown, 1983)	20	36	148	181	385
10. Victorio Canyon (this report)	25	40	111	220	396
11. Robledo Mountains (Kottlowski, 1958b)	15	75	90	155	335
12. Bishop Cap (Howe, 1959)	10	93	200	143	446
13. North Franklin Mountains (Pray, 1958)	1	103	163	162	429
14. North Franklin Mountains (Harbour, 1972)	30	70	150	155	405
15. Bear Mountain (Jones et al., 1967)	11	74	72	196	353
16. Lone Mountain (Pratt, 1967)	16	52	77	207	352
17. Georgetown (Jones et al., 1967)	28	91	74	57+	250+
18. Cooke's Range (Howe, 1959)*	43	70	120	224	457
19. Cooke's Range (Jicha, 1954)	33	47	190	51	321
20. Cooke's Range (Hayes, 1975b)	33	44	85	133	295
21. San Mateo Mountains (Kelley and Furlow, 1965)	14	63	—	—	77
22. Sierra Cuchillo (Hayes, 1975b)	13	36	60	35	144
23. Mud Springs Mountains (Kelley and Silver, 1952)	25	51	128	125	329
24. Mud Springs Mountains (Hayes, 1975b)	25	53	121	98	297
25. Caballo Mountains (Kelley and Silver, 1952)	35	77	108	129	349
26. Ash Canyon (Kottlowski et al., 1956)	20	105	130	170	425
27. South Sacramento Mountains (Pray, 1953)	10	100	90	215	415
28. South Sacramento Mountains (Howe, 1959)	8	98	123	167	396



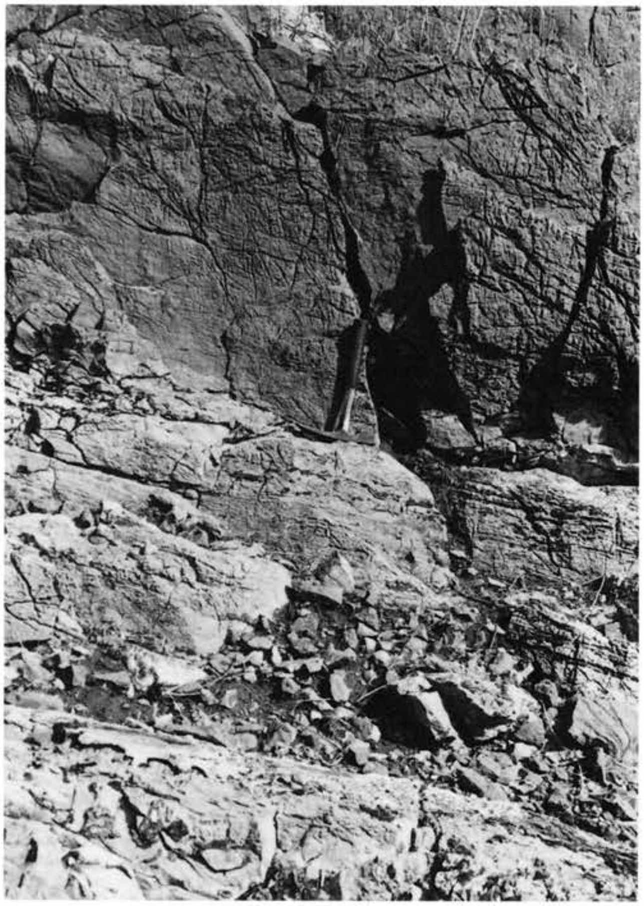


FIGURE 30—**A,** Uppermost part of Cutter Member preserved in the Florida Mountains, consisting of abundant chert nodules in dolomite; west edge of Mahoney Park. **B,** Contact of dark-gray Fusselman Dolomite resting disconformably on medium-gray, cherty Cutter Dolomite.

unit is extensively involved in thrust faulting in the Mahoney Park area; a minimum thickness of 100 ft is estimated. A thickness of 160 ft was measured in an apparently unfaulted section on the south slope of Gym Peak (Appendix E–5).

The middle light-gray member is medium- to massive-bedded, mostly light- to medium-gray, coarse-crystalline dolomite with up to 10% of the total thickness consisting of sporadically interbedded medium-gray dolomite. It contains few scattered silicified *Halysites* and closely resembles the lower light-gray member except that it weathers slightly lighter gray than the lower member. A maximum thickness of unfaulted section in Mahoney Park is about 280 ft, which is less than half of the 610 ft measured south of Gym Peak.

The upper dark-gray member is slightly silty, thin- to medium-bedded, fine- to coarse-crystalline dolomite . The lower 60 ft are dark gray, with the top 10m ft laminated like the middle part of the lower dark-gray member. This is overlain by about 100 ft of medium- to dark-gray dolomite with a distinctive bed of *Syringopora*-like corals (Fig. 34B) at its base. The member is 160 ft thick in Mahoney Park and 165 ft south of Gym Peak.

Depositional environment—Pervasive dolomitization of the Fusselman in southern New Mexico has discouraged, if not prevented, any detailed study of its lithology and fauna. Kottlowski and Pray (1967) indicated a general shallow-platform depositional environment that probably had subtidal, intertidal, and supratidal phases. Reported fossils include pentamerid brachiopods (*Virginia decussata*), solitary and colonial corals, stromatoporoids, gastropods, cephalopods, bryozoans, crinoids, algae, and conodonts (Flower, 1969; Kottlowski and Pray, 1967; Pratt and Jones, 1961; Pray, 1953, 1958; Pray and Bowsher, 1952). The poorly preserved fossils are typical of shallow-marine deposition. The varve-like laminated beds in the lower and upper dark-gray members of the Fusselman in the Florida Mountains may represent intertidal algal mats. Abundant small, irregular vugs in the lower and middle light-gray members in the Florida Mountains resemble "bird's eye" structure typical of supratidal dolomitization, but they may be anhydrite molds and unrelated to supratidal deposition.

Age and correlation—Poor preservation of fossils because of dolomitization has greatly hindered precise age determinations on the Fusselman Dolomite. However, it generally has been established that the Fusselman is of Silurian age. Early Silurian (Alexandrian) ages have been reported for the lower Fusselman in the Sacramento Mountains (Pray, 1953;

FIGURE 31—Bedding surface of brachiopod coquina in lower Cutter Member in Mahoney Park.

resenting a hiatus that resulted from gentle uplift and erosion of pre-Montoya strata. The Montoya is disconformably overlain by Fusselman Dolomite (Silurian) in the Florida Mountains. To the east, the Montoya is correlative to the Maravillas Formation in the Marathon–Big Bend area of Texas.

Fusselman Dolomite

The Fusselman Dolomite was named by Richardson (1908) for Fusselman Canyon in the southeastern Franklin Mountains. Darton (1916, 1917b) extended usage of the name to Silurian rocks in Luna County, but misinterpreted Fusselman Dolomite in the Florida Mountains and included it within his Gym Limestone, which was named for exposures at Gym Peak. Kelley and Bogart (1952) and Bogart (1953) reassigned most of the Gym Limestone as Fusselman Dolomite. Pray (1958) noted that the Fusselman sequence at Fusselman Canyon is complexly faulted and less complete than it is a few miles to the north. Therefore, he proposed a type section located 6 mi north of Fusselman Canyon and informally subdivided the Fusselman exposed there into three members. Kottlowski and Pray (1967) named these members, in ascending order: Chamberino, Flag Hill, and Crazycat.

Exposures—A complete Fusselman section is well exposed on the southeast slope of Gym Peak and in the north-facing lower slope in the SE¼SW¼SE¼ sec. 7 T26S R7W (Appendix E–5). Well-exposed but incomplete and faulted Fusselman sections compose much of the hills south of Mahoney Park. Breccia zones along some thrust faults are up to 100 ft thick and contain chaotic mixtures of several Fusselman and Montoya rock types. Two slabs of the Cutter Member up to 60 ft thick and several hundred ft long appear to be interbedded with the Fusselman Dolomite because of tectonic emplacement. Other faulted and thoroughly brecciated Fusselman Dolomite crops out between Gym Peak and Baldy Peak along the crest of the southern Florida Mountains. The Fusselman was eroded from the northern end of the mountains before the Lobo Formation was deposited in Paleocene(?) time.

Lithology and thickness—The 1,480 ft of Fusselman Dolomite in the Florida Mountains may be subdivided into six distinctive, alternating light and dark units (Table 6). In ascending order, these informal units and their approximate thicknesses are: 1) lower dark-gray member, 160 ft; 2) lower light-gray member, 305 ft; 3) middle dark-gray member, 160 ft; 4) middle light-gray member, 610 ft; 5) upper dark-gray member, 165 ft; and 6) upper light-gray member, 80 ft.

The basal part of the lower dark-gray member consists of about 65 ft of massive, dark-gray, medium-crystalline dolomite with scattered silicified solitary-cup corals and *Halysites* chain corals (Fig. 32A). Locally one to three zones of long, thin solitary corals have not been silicified, but dolomitization has obliterated internal structure (Fig. 32D). The middle part of the lower dark-gray member is a distinctive, laminated dolomite with alternating light and dark layers resembling varves (Fig. 33A), and one or two zones of light-gray, long, narrow auloporid-like coral fragments near the base of the laminated sequence (Fig. 33B). The upper 65–75 ft are medium- to thick-bedded, dark-gray to black dolomite. The uppermost beds form a unit consisting of medium- to dark-gray dolomite with abundant silicified *Favosites* and *Halysites* colonial corals (Fig. 32B). Chert nodules and lenses in this top unit are mostly masses of these corals.

The lower light-gray member is thick- to massive-bedded, medium-gray, medium- to coarse-crystalline dolomite. Locally, small vugs are common and are elongated parallel to the bedding. A thickness of 120 ft was measured in sec. 34 T25S R8W, but the top is eliminated by a thrust fault. A thickness of 235 ft was measured in the southeast corner of sec. 27 T25S R8W; the top is faulted. A thickness of 305 ft was measured in an unfaulted section on the south slope of Gym Peak.

The middle dark-gray member is thick- to massive-bedded, dark-gray to black, medium- to coarse-crystalline dolomite. A zone of abundant long, slender, silicified solitary corals is present near the base in Mahoney Park, just northeast of the intersection of secs. 3 and 4 T26S R8W and sec. 34 T25S R8W. This

TABLE 6—Fusselman Dolomite thicknesses. *I believe Kottlowski's lower-gray unit belongs in the Cutter Member of the Montoya Formation.

Location (reference)	lower dark unit	lower light unit	middle dark unit	middle light unit	upper dark unit	upper light unit	Total ft
1. Victorio Mountains (Kottlowski, 1960)*	240	340	90+				670+
2. Victorio Mountains (this report)	175	320	100+				595+
3. Mahoney Park Clemons 1985)	150	235+	100+	280+	160	50+	975+
4. Gym Peak (Clemons and Brown, 1983)	160	305	160	610	165	80	1,480
5. Robledo Mountains (Kottlowski, 1958b)							250
6. Bishop Cap (Howe, 1959)							260
7. North Franklin Mountains (Pray, 1958)							608
8. Bear Mountain (Cunningham, 1974)							100
9. Lone Mountain (Pratt, 1967)							300+
10. Black Range (Kuellmer, 1954)							85
11. Cooke's Range (Jicha, 1954)							212
12. Cooke's Range (this report)	180	60+					240+
13. Fluorite Ridge (this report)	310	100+					410+
14. Sierra Cuchillo (Hayes, 1975b)							15
15. Ash Canyon (Kottlowski, et al., 1956)							95
16. South Sacramento Mountains (Pray, 1953)							85

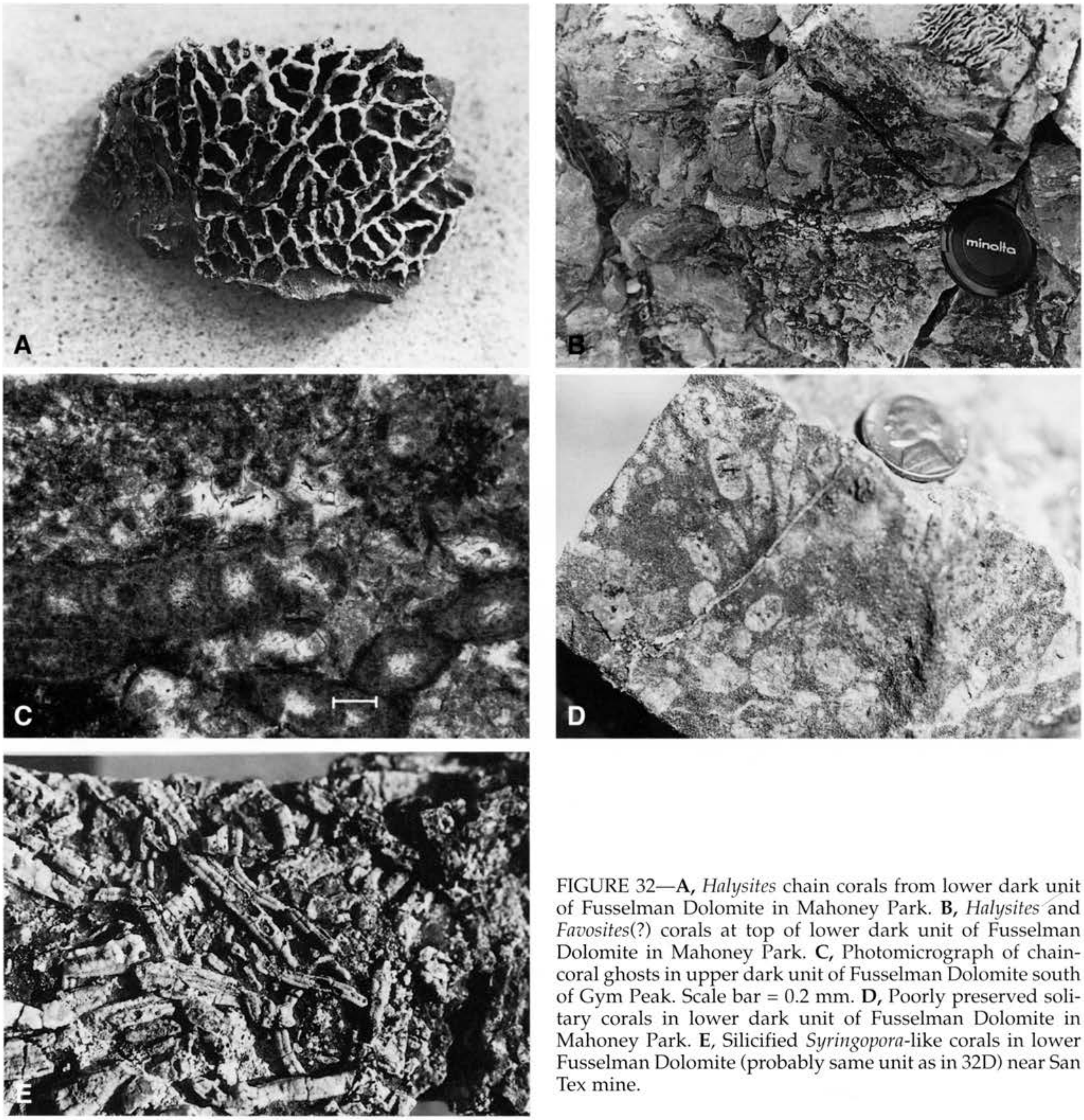


FIGURE 32—**A,** *Halysites* chain corals from lower dark unit of Fusselman Dolomite in Mahoney Park. **B,** *Halysites* and *Favosites*(?) corals at top of lower dark unit of Fusselman Dolomite in Mahoney Park. **C,** Photomicrograph of chain-coral ghosts in upper dark unit of Fusselman Dolomite south of Gym Peak. Scale bar = 0.2 mm. **D,** Poorly preserved solitary corals in lower dark unit of Fusselman Dolomite in Mahoney Park. **E,** Silicified *Syringopora*-like corals in lower Fusselman Dolomite (probably same unit as in 32D) near San Tex mine.

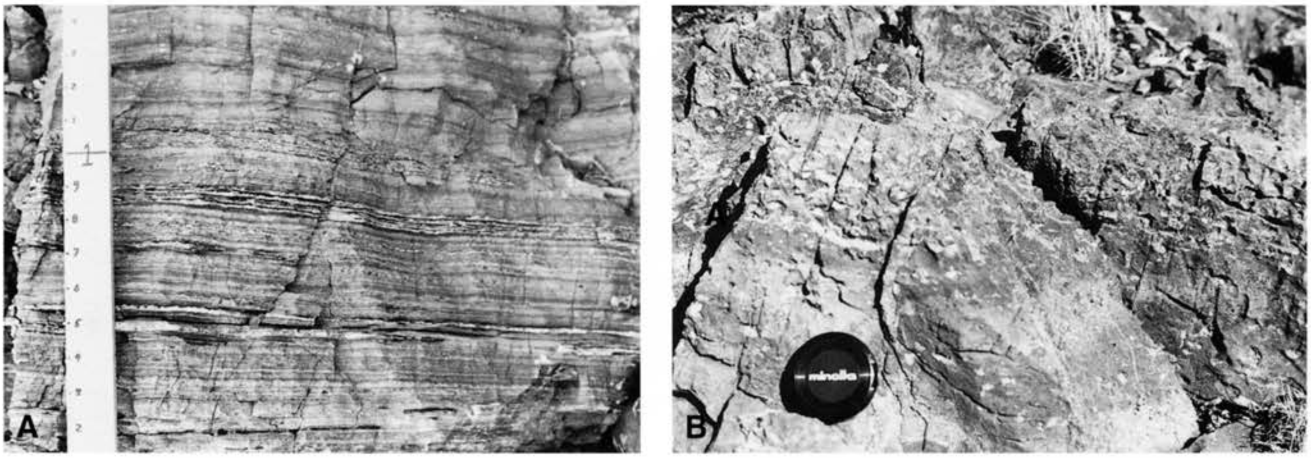


FIGURE 33—**A,** Laminated dolomite probably representing algal mats typical of a zone in upper part of lower dark-gray unit of Fusselman Dolomite in Florida Mountains. Scale in tenths of ft. **B,** Poorly preserved, broken coral fragments in zone just below laminated sequence shown in 33A.

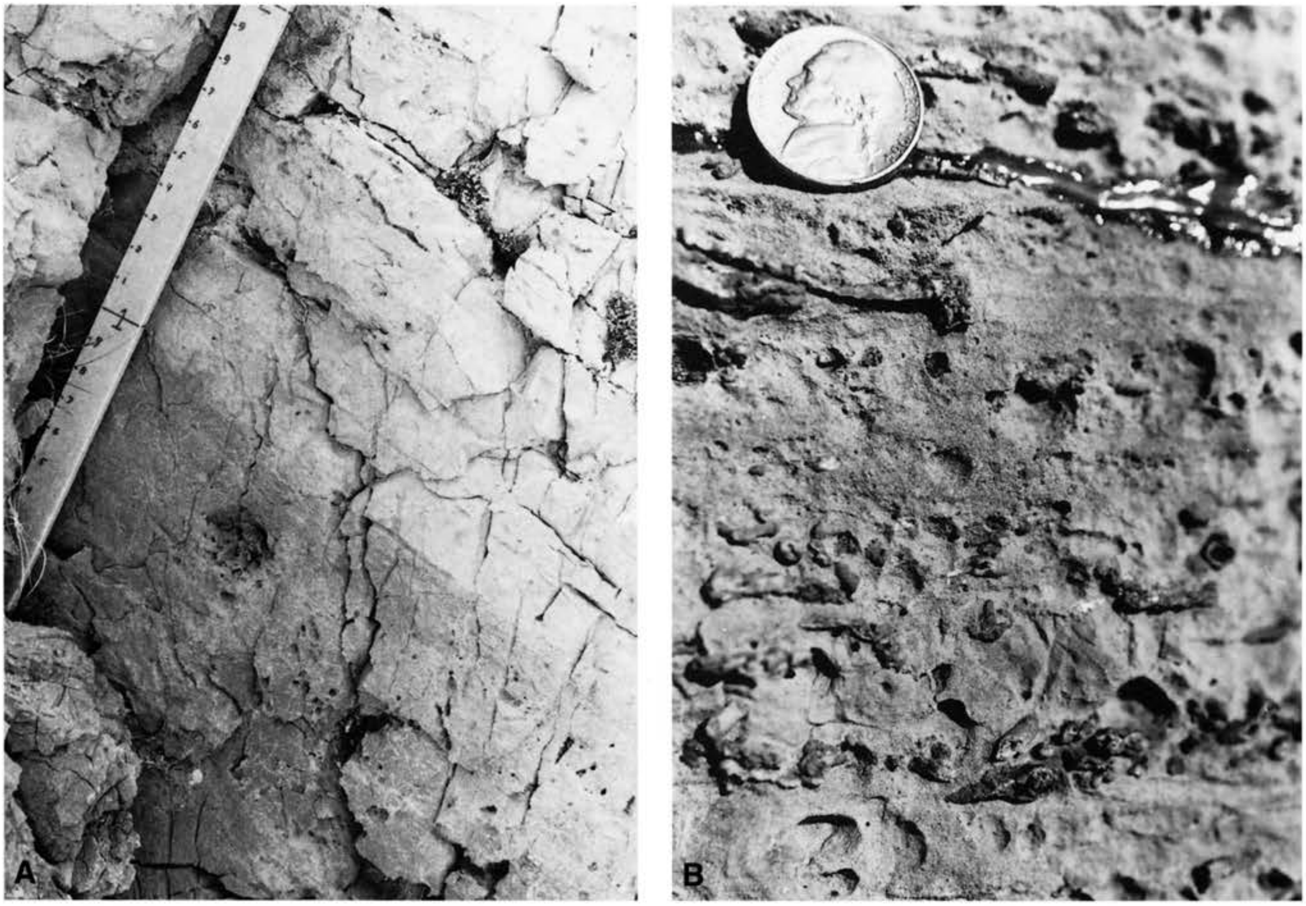


FIGURE 34—**A,** Contact between middle dark-gray and middle light-gray units of Fusselman Dolomite south of Gym Peak. Scale is in tenths of ft. **B,** Silicified *Syringopora*-like corals near top of upper dark-gray unit of Fusselman Dolomite south of Gym Peak.

Fusselman in the Sacramento Mountains (Pray, 1953; Pray and Bowsher, 1952), and Middle Silurian (Niagaran) ages have been reported for the Fusselman in the Franklin Mountains (Pray, 1958, Kottlowski and Pray, 1967). Pratt and Jones (1961) indicated that the Fusselman at Lone Mountain, near Hurley, is Silurian. James Barrick at Texas Tech University reported Early to Middle Devonian conodonts *Belodella* and *Icriodus* from the top 1.3 m of the Fusselman Dolomite south of Gym Peak and an Early to Middle Devonian conodont fauna of *Icriodus*, *Polygnathus*, and *Panderodus* from the upper 40 ft of the Fusselman Dolomite north of Cooke's Peak (written comm. 1983). Barrick further stated that the fauna from the top of the Fusselman is like those characteristic of Early and Middle Devonian shallow-water carbonate environments. It is unlike typical Percha (Late Devonian) faunas. The similar-age conodonts from two different stratigraphic horizons of the Fusselman (but both near the tops of present outcrops) most likely represent stratigraphic leaking.

The distinctive zones of pentamerid brachiopods noted at Lone Mountain and in the Hueco, Sacramento, and Franklin Mountains are not present in the Florida Mountains. The Chamberino Member in the north Franklin Mountains contains pentamerid brachiopods and a wavy-laminated lithology (Kottlowski and Pray, 1967; McEvers et al., 1983). This member may be correlative, at least in part, to the lower dark-gray member in the Florida and Victorio Mountains. Kottlowski and Pray (1967) noted that the Fusselman in Cooke's Range resembles the Chamberino and Flag Hill Members in the Franklin Mountains. The Fusselman lithology in Cooke's Range also closely resembles the lower dark-gray and lower light-gray members in the Florida Mountains.

Percha Shale

The name Percha Shale was first assigned to rocks of Devonian age by Gordon and Graton (1906). Stevenson (1945) designated the type section near Percha Creek, 2.5 mi southeast of Hillsboro, New Mexico. Darton (1916, 1917b) used the term for Devonian strata in mapping the Deming folio, but he did not recognize Percha in the Florida Mountains; Darton included Percha as part of his Gym Limestone. Bogart (1953) redefined Darton's Gym Limestone and assigned to the Percha the shale that crops out in the canyon southeast of Gym Peak. Bowsher (1968) reported that in southwestern New Mexico thin stratigraphic units at the base of the Ready Pay Member, the lower black-shale member of the Percha Shale, may be correlatives of the Oñate Formation. Stevenson (1945) proposed the term Oñate Formation for shale, siltstone, fine-grained sandstone, and limestone in San Andres Canyon, San Andres Mountains. The basal

10–15 ft of shale southeast of Gym Peak may belong to the Oñate Formation.

Exposures—The Percha is poorly exposed. It was mapped about 1 mi southeast of Gym Peak by relying on stratigraphic position, characteristically weathered slopes, exposures in scattered prospect pits, and presence of shale detritus in colluvium. Percha Shale also crops out sporadically northwestward over the crest of the range to Mahoney Park, along the northeast side of the south Florida Mountains fault.

Lithology and thickness—The Percha Shale is composed of extremely fissile, olive- to dark-gray shale. The upper member—Box Member—of the Percha, composed of greenish dark-gray shale with calcareous nodules and argillaceous fossiliferous beds, is not present in the Florida Mountains. A 30 cm thick, dark-gray, packed biomicrite bed 10 ft above the base of the Percha contains abundant *Tentaculites* (Fig. 35). Clemons and Brown (1983) measured 249 ft of Percha (including basal Oñate? beds) southeast of Gym Peak. This measurement is in close agreement with the 236 ft reported by Bogart (1953) for the same locale.

Depositional environment—The Florida Mountains area was part of an east- to southeast-trending shelf during Devonian time (Bowsher, 1968; Kottlowski, 1963). The southern margin of the foreland was probably less than 100 mi to the north, and the northern margin of the geosyncline was in Mexico, less than 50 mi to the south. Rosado (1971) shows the Percha Basin and Percha Channel covering this area with the Oñate Shelf to the north and Canutillo Shelf to the south. The sparse, restricted fauna in the Florida Mountains strata probably indicates a harsh environment (possibly stagnant basin), whereas abundant bryozoa, brachiopods, corals, and sponges are found with *Tentaculites* to the northwest, north, and east (Bowsher, 1968).

Age and correlation—The Oñate Formation generally is assigned a latest Middle Devonian (Taghanic) age (Bowsher, 1968; Cooper and Dutro, 1982; Sorauf, 1984). The Ready Pay Member of the Percha Shale ranges in age from latest Middle Devonian (Taghanican) to Late Devonian (Cassadagan). The Percha–Oñate strata in the Florida Mountains are believed to be correlative to the Portal and Swisshelm Formations in southeastern Arizona and to the Canutillo Formation, Woodford Shale, and Caballos Novaculite in west Texas.

Rancheria Formation

Laudon and Bowsher (1949) proposed the name Rancheria Formation for Rancheria Peak in the Hueco Mountains of west Texas and designated a type section in the Franklin Mountains, east of Vinton, Texas. Darton (1916, 1917b) used the name Lake Valley for Mississippian strata in mapping the Deming folio, but did not recognize their occurrence in the Florida Mountains; instead, he included the Mississippian beds as part of his Gym Limestone. Bogart (1953) recognized the occurrence of Mississippian rocks that he assigned, based on Mississippian-age fossils and lithologic similarity, to the Andrecito Member of the Lake Valley Formation. Kottlowski (1958, 1963) noted that the Mississippian in the Florida Mountains is similar lithologically to the Rancheria Formation. Some later workers in the Florida Mountains accepted the usage of the Lake Valley Formation (Griswold, 1961; Corbitt, 1971). Armstrong (1962) indicated that the Florida Mountains section was part of the Hachita Formation (a shelf equivalent of the basinal Rancheria). Yurewicz (1977) located the Florida Mountains section on the Hachita–Rancheria (shelf–basin) boundary, and Armstrong and Mamet (1978) placed the shelf–basin

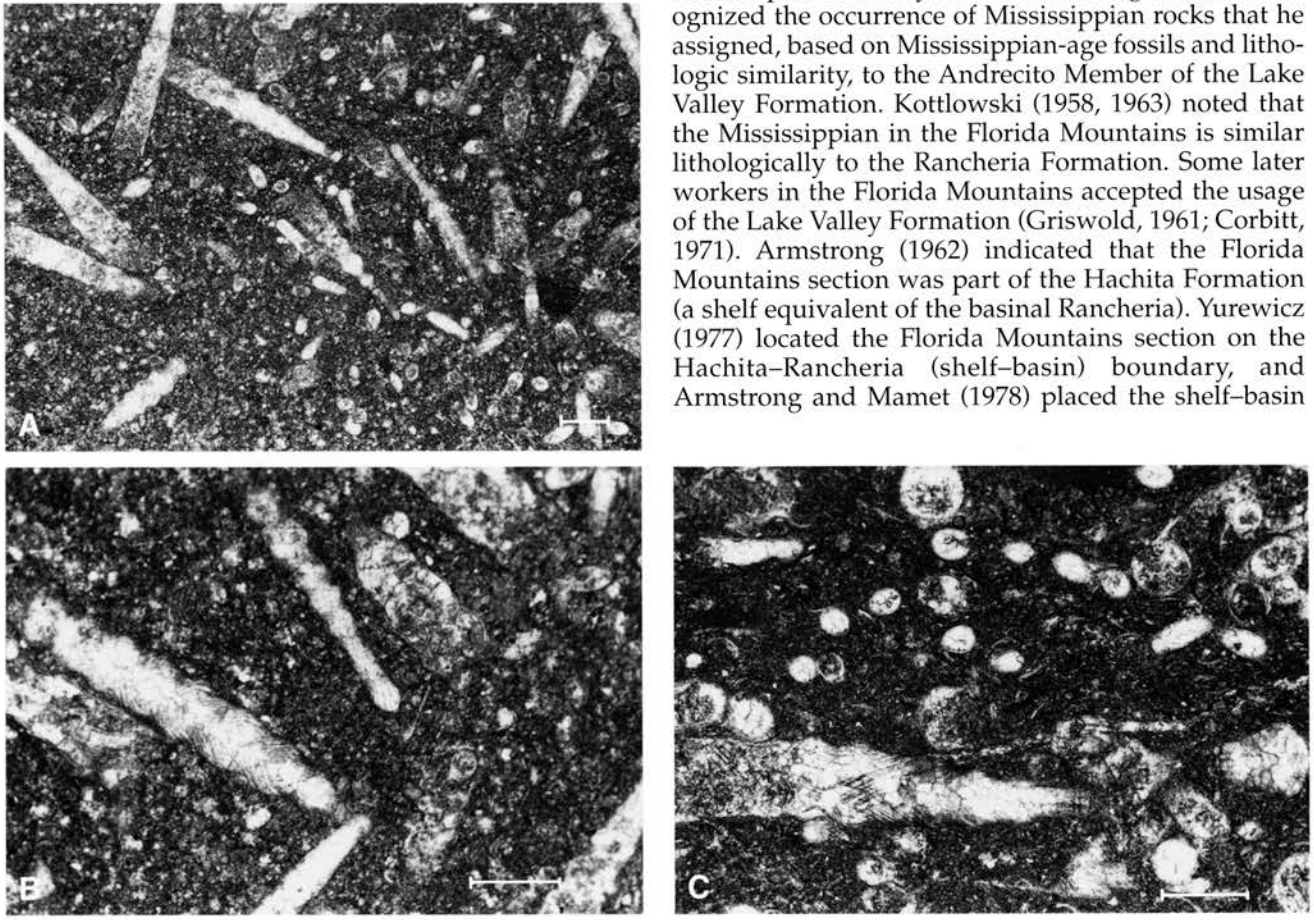


FIGURE 35—Photomicrographs of *Tentaculites* in organic-rich, micrite matrix. Sample is from 30 cm thick limestone bed 10 ft above base of Percha Shale south of Gym Peak. Scale bars = 0.2 mm.

margin just west of the Florida Mountains. I recommend assignment of the Florida Mountains section to the Rancheria Formation based on its lithology and the late Osagean–Meramecian age reported by Armstrong and Mamet (1978).

Exposures—There are only two small outcrops of Mississippian strata in the Florida Mountains, 1 mi southeast of Gym Peak and in the southeast corner of Mahoney Park. Rancheria beds south of Gym Peak disconformably overlie Percha Shale and are disconformably overlain by Hueco Limestone. The Mahoney Park outcrop is a small klippe resting on syenite.

Lithology and thickness—The Rancheria Formation exposed in the NE¼ sec. 18 T26S R7W, southeast of Gym Peak, is composed of thin-bedded, interstratified, spiculitic biomicrite (Fig. 36), silty micrite, pelneosparite, bioneosparite (wackestones and packstones), and chert. Principal allochems are spicules, echinoderms, bryozoa (near base), peloids, and a few ostracods. The pelneosparite is silty near its base and develops a pseudo-crossbedded appearance on weathered surfaces. The limestones and cherts are all medium to dark gray, but typically weather light gray to brown. Shale breaks are abundant low in section, and chert content increases upsection to nearly 50% at the top. A thickness of about 220 ft of Rancheria was measured on the south slope of the canyon, 1 mi southeast of Gym Peak. This is comparable to Bogart's (1953) measured value of 196 ft.

Approximately 100 ft of thin-bedded, interbedded limestone and chert exposed as a small klippe in the extreme southwest corner of sec. 36 T25S R8W are tentatively assigned to the Rancheria Formation. The carbonate beds are silty micrite, pelneosparite, bioneosparite, and minor spicular biomicrite (mudstone, wackestone, grainstone). Allochems are similar to those in strata south of Gym Peak (Fig. 36). One small exposure of a crinoidal biosparite (grainstone) at the northern edge of the outcrop resembles the Hachita Formation in the Klondike Hills and the "en-crinite" bed in the Rancheria at Vinton Canyon. Extensive faulting prevents determining its stratigraphic relation to the remainder of the Rancheria. Probably many feet of Mississippian rocks were eroded from the Florida Mountains area before Early Permian time.

Depositional environment—The Rancheria Formation is representative of the Mississippian deeper water carbonates in south-central New Mexico. The shelf–basin margin was probably just west or southwest of the Florida Mountains. Evidence from the Tres

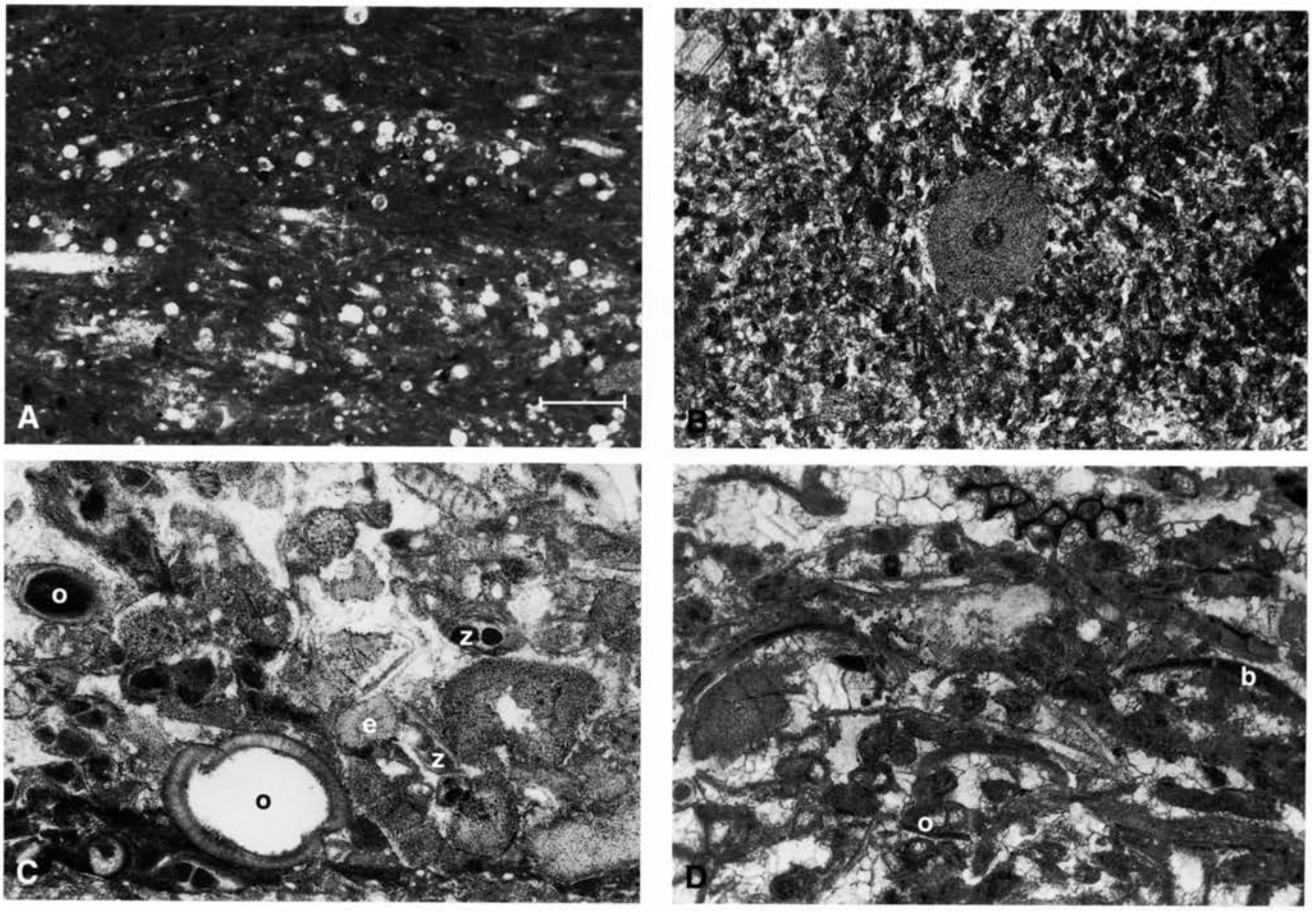


FIGURE 36—Photomicrographs of allochems in the Rancheria Formation. Scale bar for A–D = 0.2 mm. **A,** Well-laminated spicular wackestone (packed biomicrite) from south of Gym Peak. **B,** Neomorphosed peloidal wackestone (pelmicrosparite) with few echinoderm columnals. **C,** Well-laminated bioclastic grainstone (sorted biosparite) from Mahoney Park, containing ostracods (**o**), bryozoa (**z**), and echinoderms (**e**). Chert has replaced most spar cement. **D,** Bioclastic grainstone (unsorted biosparite) interlaminated with spicular wackestone (biomicrite) in Mahoney Park. Bryozoan, ostracods (**o**), echinoderm, and brachiopod (**b**) fragments cemented with coarse spar.

Hermanas Mountains and Klondike Hills to the southwest and west, respectively, indicates open-shelf environments in those areas during and following deposition of the Rancheria strata now preserved in the Florida Mountains.

Age and correlation—Armstrong and Mamet (1978) placed the Florida Mountains Rancheria strata in middle Mississippian (late Osagean–Meramecian) on the basis of conodonts. It is correlative with part of the Escabrosa Group (Hachita Formation) in southwestern New Mexico. The Florida Mountains Rancheria is probably correlative with the Las Cruces Formation and lower part of the Rancheria Formation in the Franklin Mountains. The lower part of the Rancheria in the Florida Mountains may be correlative with the Arcente and Doña Ana Members of the Lake Valley Limestone in the Sacramento Mountains.

Hueco Limestone

The Hueco Formation was named by Richardson (1904) for the type section in the Hueco Mountains in west Texas. Darton (1916, 1917b) included the Permian limestone south of Gym Peak in his Gym Limestone. Bogart (1953) assigned the name Hueco to these rocks based on lithologic similarity and a study of gastropod fauna that he concluded to be nearly identical to the Permian (Wolfcampian) Hueco fauna. Kottlowski (1958, 1963) referred to these same rocks as Hueco Limestone, but Jordan (1971), after a preliminary investigation of the southeast Florida Mountains section, stated that the Permian-age strata resembled more closely the Colina Limestone in the Sierra Alta (Fig. 2) and Big Hatchet Mountains. These strata are referred to as Hueco Limestone in this report because no additional areal or detailed studies have been conducted on these beds in Luna County.

Exposures, lithology, and thicknesses—The Hueco disconformably overlies the Rancheria Formation 1 mi southeast of Gym Peak and is angularly overlain by the Lobo Formation. The Hueco Limestone consists of thin-, medium-, and massive-bedded, dark-gray, light- to medium-gray-weathering biomicrites, bineosparites, and biosparites (wackestones, packstones, and minor grainstones). Chert development is restricted to a few scattered brown nodules. The Hueco is fossiliferous, with abundant large (up to 8 cm) bellerophonid gastropods being characteristic of this unit. Scattered silicified high-spired gastropods, solitary corals, brachiopods, and echinoid fragments are common. Examination of thin sections reveals bioturbated material with abundant fragments of gastropods, echinoderms (probably echinoids), ostracods, peloids, and forams (*Globivalvulina*?, paleotextularids, tubular *Tubertina*?, and fusulinids). The fusulinids are severely neomorphosed and occur 30 and 250 ft above the base. Dasycladacean algae are abundant in some zones. Minor amounts of trilobite, brachiopod, and bryozoan fragments occur intermittently. Reddish-brown (Abo?) siltstone interfingers with limestone near the top of the section.

Total thickness of the Hueco is difficult to determine due to fault complications. Bogart (1953) measured 548 ft of Hueco, but apparently failed to note thrusting within the Hueco. The thickness of 433 ft measured during this study is considered a minimum.

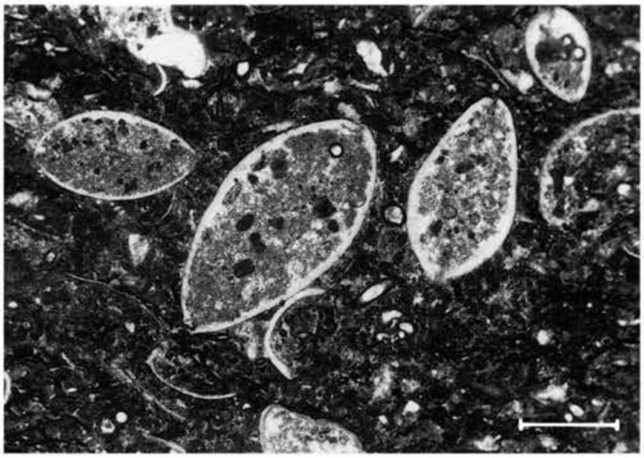


FIGURE 37—Photomicrographs of ostracods in pelmicrite matrix of Hueco Formation south of Gym Peak. Scale bar = 0.2 mm.

Depositional environment—The bioturbated foraminiferal wackestones and packstones characteristic of the Hueco Limestone southeast of Gym Peak are considered typical shallow-shelf facies. The presence of abundant gastropods, echinoderms (probably echinoids), ostracods, and peloids (Fig. 37) in some dark-gray beds suggests possible lagoonal conditions at times. Dasycladacean algae also indicate extremely shallow marine waters. The Hueco Limestone probably represents shallow-subtidal deposits. Influx of silt and fine sand probably indicates near-shore marine conditions and possibly represents regression of the shoreline in the Florida Mountains area during times of deposition.

Age and correlation—No new evidence on the age of the Hueco strata at the southeast end of the Florida Mountains was discovered during this study. Bogart (1953, p. 80) reported a "prolific fauna of small gastropods, several large gastropods, fusulinids, and other forms which are considered to be Permian (Wolfcampian) in age" from the limestones. Kottlowski (1958, 1963) referred to these limestone strata as Hueco, but Jordan (1971, p. 107) indicated that the lithology and fauna of the Permian limestones in the southeastern Florida Mountains are more similar to the "lagoonal facies of the Colina Limestone in the Sierra Alta and Big Hatchet Mountains." Kottlowski and Foster (1962) described approximately 525 ft of Hueco strata in the northeastern Tres Hermanas Mountains that may be correlative in part to the Florida Mountains section. Petrographic investigations are continuing on the sporadic, partial sections of Permian-age strata in southern Luna County. It is anticipated that these studies will provide more data to correlate the Hueco and Abo Formations of south-central New Mexico with the Horquilla(?), Earp, and Colina Formations of southwestern New Mexico and northern Chihuahua, Mexico.

Oncolite beds

A small outcrop in the N½SE¼SE¼ sec. 35 T25S R8W contains three oncolite beds interbedded with

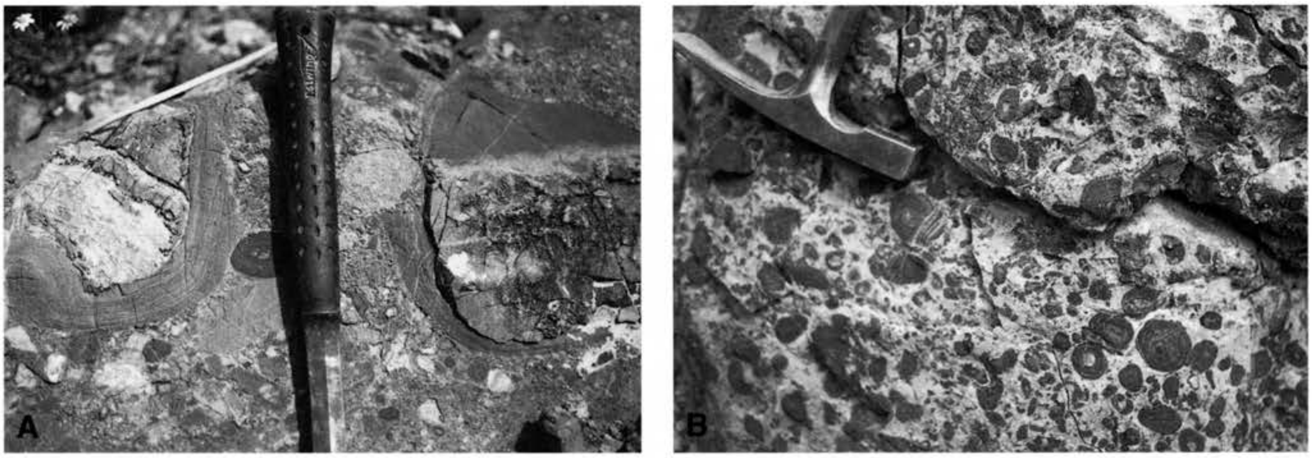


FIGURE 38—**A,** Oncolite rims on small boulders of Cambrian to Mississippian age in Mahoney Park. **B,** Oncolites "floating" in sandy and silty micrite matrix. **C,** Oncolites "floating" in silty micrite matrix and decreasing in abundance upward.

conglomerates. The base of the section is covered in a small gully and the top is in fault contact with probable El Paso Formation. Its position in the fault zone with nearby Cambrian to Mississippian rocks further hinders placing it in its proper stratigraphic position. The oncolites (Fig. 38) closely resemble large oncolites at the base of the El Paso Formation in Chaney Canyon at the north end of the Big Hatchet Mountains. The oncolite rims on the angular clasts also resemble oncolites in the upper Abo(?) just below Sarten Sandstone north of Cooke's Peak. The oncolite beds in Mahoney Park are post-Mississippian because of the enclosed clasts. Some dark-gray limestone clasts containing large gastropods resemble Permian Hueco rocks at the southeast end of the Florida Mountains. I favor a Permian age because conditions for oncolite formation were probably less favorable(?) during Lobo (Paleocene) time, which is the most logical other choice. However, the interbedded conglomerates do closely resemble Lobo-type conglomerates. Lithologic descriptions of a measured section are in Table 7.

Mesozoic(?)–Cenozoic rocks

No Triassic, Jurassic, or Lower Cretaceous rocks

TABLE 7—Lithologic description of oncolite beds in Mahoney Park.

	Thickness ft
Mostly covered; poorly lithified cobble conglomerate with abundant Paleozoic-rock clasts including Mississippian and Hueco(?); slope-former.	35
Oncolite bed; dark-gray, spherical oncolites (type R; Flugel, 1982) packed in medium to coarsely sandy matrix; oncolites range in size from 0.5 to 10 cm, average approximately 2.5 cm in diameter; ledge-former.	5
Mostly covered; poorly lithified cobble-boulder conglomerate; boulders of granite up to 60 cm; lower Paleozoic rocks, Mississippian and Hueco(?); abundant oncolite-rock float on slope, probably derived from above bed.	30
Oncolite bed; dark-gray, spherical oncolites (type R) to lensoid (type C) oncolites "floating" in finely sandy, micrite matrix; oncolites range in size from 0.2 to 8 cm, average approximately 2 cm in diameter; few clasts of Bliss, El Paso, and Montoya rocks with oncolite rims up to 6 cm thick; bed varies in thickness laterally; sand content increases upward; ledge-former.	10
Finely sandy dismicrite; poorly exposed in slope with some cobble conglomerate; nodular bedding in micrite zones that contain few oncolites; oncolites range in size from 0.3 to 2.5 cm, average approximately 1 cm; sand is mostly angular to subangular quartz and minor perthite; conglomerate clasts are mostly limestone and dolomite.	10
Oncolite bed; dark-gray, lensoid oncolites (types C and I) packed in calcareous, sandy matrix; oncolites range from 0.5 to 13 cm, average approximately 4 cm; oncolites are flattened parallel to bedding; nuclei consist of granite, quartz, chert, limestone, and dolomite fragments; intermixed sand and granules decrease upward; ledge-former.	5
Coarsely sandy pebble-cobble conglomerate at base grading up to poorly exposed sandy micrite; clasts of white, massive quartz, limestone, dolomite, chert, and granite; sand grains are quartz, chert, carbonate-rock fragments, and perthite.	8
Total exposed thickness	103

have been identified in the Florida Mountains. The lowermost beds of the Lobo Formation may be of Late Cretaceous age, but evidence is sparse and the bulk of the Lobo is believed to be of early Tertiary age. Tertiary volcanic and volcaniclastic rocks in the Florida Mountains area include thick and extensive surface deposits as well as intrusive rocks. Alluvial deposits of late Tertiary and Quaternary age blanket the bajada around the Florida Mountains and are believed to be several thousand feet thick in the adjacent basins (Table 8).

Lobo Formation

The Lobo Formation was named by Darton (1916) for the type locality at Lobo Draw in the northwest Gym Peak quadrangle. Darton (1917b) also mapped the Lobo Formation in Cooke's Range, Fluorite Ridge, and later in the Victorio Mountains (Darton, 1928). Jicha (1954) and Kottlowski (1958, 1963) recognized that the Lobo of Cooke's Range was Abo Formation (Permian). Part of the Fluorite Ridge section was reassigned by Clemons (1982c) also as Abo Formation because of proximity and similarity to the outcrops in Cooke's Range. Clemons (1982c) mapped a sequence of conglomerates, sandstones, and siltstones east and north of Fluorite Ridge as a basal member (Starvation Draw) of the Rubio Peak Formation. Subsequently these rocks have been recognized as equivalent to the Lobo Formation (Clemons, 1984; Clemons and Brown, 1984; Mack and Clemons, 1988). Lemley (1982) concluded that the Victorio Mountains section is not correlative with the Lobo Formation in the Florida Mountains, and, therefore, the Lobo is restricted in known occurrence to the Florida Mountains and Starvation Draw. It probably is present in the subsurface of adjacent areas.

Exposures—The Lobo Formation forms a continuous outcrop band from Mexican Canyon, at the northwest end of the mountains, southeastward for 4.5 mi in the high slopes over the crest to its type locality in Lobo Draw on the east side (Fig. 39). Four measured sections from this band are described in Appendix E. The uppermost siltstones and mudstones of the Lobo crop out along the southwest side of Three Little Hills, 1.5 mi southeast of Lobo Draw. Approximately 2.6 mi south of Three Little Hills the Lobo Formation is well exposed in a southeast-trending ridge, but is incomplete due to faulting that truncates the upper beds. Several small exposures of partial basal sections are scattered south of the south Florida Mountains fault where they rest on granite at elevations of 4,600–6,300 ft.

Lithology and thickness—The basal strata of the Lobo Formation reflect the underlying rock units. Where it rests on plutonic rocks, it is a cobble-to-boulder conglomerate with abundant clasts of granite, syenite, gneiss, and hornfels as well as Bliss Sandstone and lower Paleozoic limestones, dolomites, and chert. At Capitol Dome, the basal Lobo strata appear to be karat-filling deposits on Montoya beds of limestone–chert, pebble–cobble conglomerate with a dark reddish-brown mudstone matrix (Fig. 40). Near the southeast end of the Florida Mountains, the Lobo rests unconformably on the Hueco Formation. The lower 30 ft are red arkoses with abundant granite and Hueco clasts up to 60 cm across in friable, poorly sorted, fine to coarse sandstone. These reddish-brown basal units may not properly belong in the Lobo, but rather to an older depositional sequence. Lithologically, they closely resemble the "nodular limestones" at the northwest end of Fluorite Ridge and near Cooke's Peak. Kottlowski (1958, 1963) suggested a possible Permian age based on lithologic similarity to strata associated with the Abo Formation in Cooke's Range and the Robledo Mountains.

The typical Lobo in the Florida Mountains above the basal reddish units is thin- to medium-bedded, light-gray, calcareous siltstone and sandstone interbedded with yellowish-brown mudstone and sandstone, red mudstone, and pebble-to-boulder conglomerates. Composition of the conglomerate clasts and sand grains roughly represents an inverted Precambrian–Paleozoic section with Bliss Sandstone and Precambrian rock and mineral types more abundant in the upper Lobo beds, and various Paleozoic limestones, dolomites, and cherts more abundant in the lower beds. Several sand-size clasts of limestone in the Lobo beds at Capitol Dome contain the fusulinid *Eostaffella* (Fig. 40C), indicating rocks as young as Pennsylvanian–Permian in the source areas. Near

TABLE 8—Stratigraphic chart of Cenozoic rocks exposed in the Florida Mountains.

Series	Lithostratigraphic units	Thickness ft	Generalized descriptions
Holocene	alluvium	100±	Unconsolidated silt, sand, and gravel.
Pleistocene	alluvium	100±	Silt, sand, gravel partially cemented with pedogenic carbonate.
Pliocene	Mimbres formation	500+	Silt, sand, gravel well cemented with pedogenic carbonate.
Miocene	dacite	intrusive	Grayish-red, micro crystalline plug.
	fanglomerate	2,000±	Sandy, rhyolite breccia and conglomerate.
	basaltic andesite	100	Altered vesicular and amygdaloidal flows.
	rhyolite and tuff	700+	Pale-red, irregular intrusions and short flows; air-fall lithic tuffs.
	monzonite	intrusive	Altered, finely crystalline, irregular intrusions.
Oligocene	rhyolite	intrusive	Light-gray, finely crystalline dikes.
	Ash-flow tuff	300 +	Grayish-pink vitric-crystal tuff.
Eocene	Rubio Peak Formation	1,650+	Volcaniclastic conglomerates and sandstones.
Paleocene	Lobo Formation	600	Interbedded, reddishbrown mudstones, siltstones, sandstones, and conglomerates.

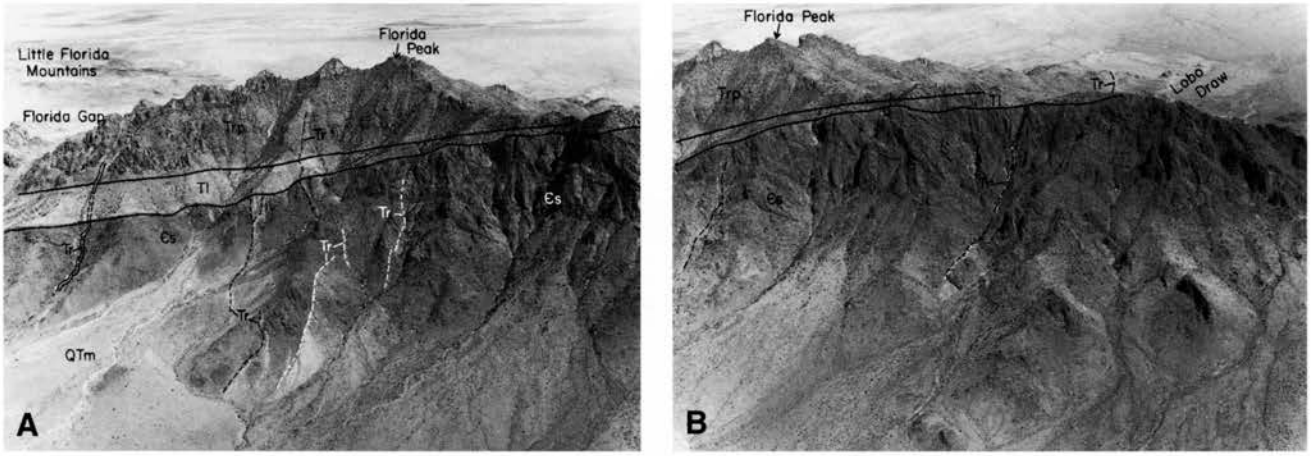


FIGURE 39—Two aerial views of western flank of Florida Mountains. The two photos were taken from different locations and at different azimuths, so they cannot be combined to form a panorama. **A,** View to northeast of Florida Peak. **B,** View to north–northeast of Florida Peak. (**Єs**, syenite; **Tl**, Lobo Formation; **Trp**, Rubio Peak Formation; **Tr**, rhyolite dikes; **Qtm**, older part of Mimbres formation. (Photo courtesy of Mobil Oil Corp.)

Capitol Dome the lower sandstones are calclithites grading upward through feldspathic sedarenites to lithic arkoses at the top (Appendices D–1, D–2). Lobo sections deposited on plutonic rocks (Appendices D–3, D–4) vary less in overall lithology, but they do tend to grade from arkoses at the base to lithic arkoses at the top. Sections typically show a general fining-upward sequence, with siltstones and interbedded fine sandstones increasing towards the top of the section, and with a cap of massive, silty micrite. Conglomerate lenses and channel-fills are common in all Lobo sections. They typically become fewer and contain smaller average-size clasts upward through the sections. No volcanic-rock fragments have been seen in the Lobo rocks south of Capitol Dome, but the upper beds west of Florida Peak and in Lobo Draw contain significant quantities of volcanic-rock fragments (Fig. 40F). Mack et al. (1983) identified up to 40% volcanic-rock fragments (andesite–basalt) in thin sections. Sporadic influxes of plagioclase grains in the Lobo sandstones are believed to have been derived from abundant hornfels included in the plutonic basement rocks.

A bed of white, calcareous, fine-grained siltstone up to 4 ft thick occurs in the Lobo Formation just north of Tubb Spring and also about 0.6 mi northeast of Tubb Spring. This is apparently the bed resembling "lithographic stone" that Darton (1916) described as containing 27% calcium carbonate, 10% magnesium carbonate, and 63% material insoluble in acid. Ripples, low-angle crossbeds, mud cracks, and burrows are present, but not abundant in most sections. No in-situ fossils were found in any of the sections. Variations in thicknesses of the Lobo Formation are due primarily to the channeled, irregular, erosional surface upon which the Lobo was deposited. The Lobo is 340 ft thick on the northwest side of Capitol Dome, 610 ft on the south side of Capitol Dome, 530 ft west of Florida Peak, approximately 200 ft on the crest of the range, and 385 ft at the type section in Lobo Draw (Appendices E–6, E–7, E–8, E–9). Lemley (1982) measured 490 ft of Lobo, including 40 ft of basal red arkoses and 450 ft of conglomerates, at the southeast end of the Florida Mountains. The top of the Lobo is not exposed in that area.

Depositional environment—The Lobo Formation in the Florida Mountains is interpreted as a nonmarine, alluvial-fan–fluvial clastic wedge. The thick conglomeratic section on the north side of the south Florida Mountains fault represents clastic accumulation near the source area. The mudstones, siltstones, sandstones, and channel conglomerates at the north end of the range, approximately 5 mi away, typify braided stream and overbank deposits in distal parts of the clastic wedge. Mack et al. (1983) divided the Lobo into three petrofacies: 1) oldest sedarenite, 2) middle arkose, and 3) youngest volcanic arenite. These represent progressive removal of Paleozoic sedimentary strata and unroofing of Precambrian and Cambrian plutonic rocks followed by onset of Eocene volcanism. Alternatively, the volcanic arenite petrofacies may indicate a new provenance being integrated at that time (early–middle Eocene) to provide volcanic detritus from older rocks. I think additional petrographic studies in southwestern New Mexico and northern Chihuahua, Mexico, will eliminate this alternate interpretation.

Age and correlation—Darton (1916) admitted there was little evidence on the age of the Lobo Formation, but assigned it a Triassic age. Lochman-Balk (1958, 1974) described the Capitol Dome section of the Lobo and said its age was unknown. Kottlowski (1958, 1960, 1963, 1965a, 1973) and Kottlowski and Foster (1962) believed that the type Lobo in the Florida Mountains was probably of Early Cretaceous age. Griswold (1961) concurred with the Early Cretaceous age, and Hayes (1975a) referred to the Lobo strata as Cretaceous in age. Dane and Bachman (1965) considered the Lobo to be Early Cretaceous(?) or Tertiary(?); so did Corbitt (1971, 1974), although he favored a Tertiary designation.

The Lobo rests on rocks as young as Early Permian and is intruded and overlain by late Eocene volcanic rocks. It is believed to be a syntectonic, clastic wedge that was deposited in response to Laramide deformation (Loring and Loring, 1980) in the Florida Mountains. This interpretation is supported by the following field observations: 1) Lobo strata in the southeast Florida Mountains rest in angular unconformity on Permian Hueco limestones that were homoclinally tilted during, or possibly before, Laramide deformation; 2) class-composition trends in the Lobo reflect unroofing of uplifted Precambrian and Paleozoic rocks; 3) basal Lobo contains abundant angular clasts of white calcite, which probably formed during Laramide deformation; 4) Lobo Formation conglomerates are displaced by the south Florida Mountains fault; and 5) thin-bedded Lobo shales and siltstones near Capitol Dome are undeformed, whereas underlying Paleozoic beds are intensely deformed, presumably by Laramide stresses. Lemley (1982) reported an early Tertiary paleomagnetic assignment for samples collected from Lobo red beds at Capitol Dome.

Clemons (1982c) informally named the Starvation Draw member of the Rubio Peak Formation in the Massacre Peak quadrangle, about 20 mi north of the Florida Mountains. Evidence obtained while mapping the Florida Mountains and current study of the Lobo Formation by Greg Mack (oral comm. 1983) indicate that the Starvation Draw member in the Massacre Peak quadrangle and the Lobo Formation in the Florida Mountains are correlative. Both units were deposited in response to, and adjacent to, Laramide uplifts. Clast lithology in both units reflects unroofing

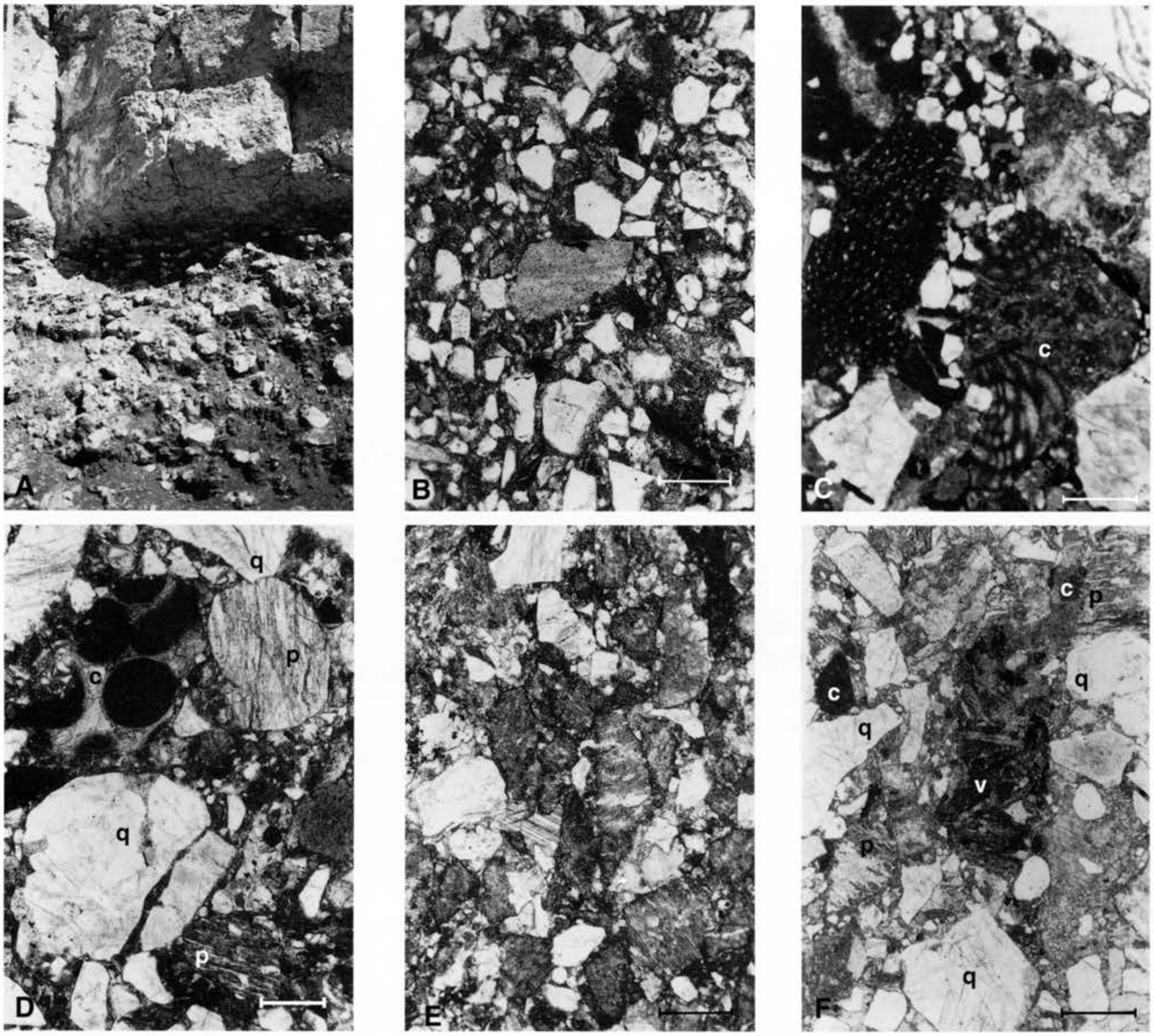


FIGURE 40—**A,** Probable karst-fill deposit of carbonate clasts in red mudstone overlain by thick-bedded sandy conglomerate in basal Lobo Formation north of Capitol Dome. **B,** Poorly sorted fine sandstone typical of Lobo Formation at Capitol Dome. Few carbonate, feldspar, and chert grains with polycyclic quartz in calcite cement. Scale bar = 0.2 mm. **C,** Fusulinids (*Eostaffella*?) in carbonate-rock fragment (**c**) indicate some Pennsylvanian rocks provided detritus to Lobo in Capitol Dome area. Bar is 0.2 mm. **D,** *Nuia* in carbonate rock fragment (**c**) indicates El Paso Formation also provided some detritus to Lobo, along with perthite (**p**) and quartz (**q**) from nearby granite or syenite. Scale bar = 0.2 mm. **E,** Typical arkose from about middle of Lobo at Capitol Dome. Scale bar = 0.2 mm. **F,** Volcanic-rock fragment (**v**) in upper Lobo on northwest slope of Capitol Dome. Other grains are quartz (**q**), perthite (**p**), and carbonate-rock (**c**) fragments. Scale bar = 0.2 mm.

of fault blocks, and grain-size distributions indicate fining-upward and basinward sequences. Volcanic detritus is absent in the basal beds, but is present in the upper parts of both the Lobo Formation and the Starvation Draw member. Therefore, usage of the name Starvation Draw member should be dropped. The Lobo Formation probably is correlative (in part or as a whole) to the Love Ranch Formation (Kottlowski et al., 1956; Seager, 1981) in south-central New Mexico, the Ringbone Formation (Zeller, 1970) in the Little Hatchet Mountains, the Little Hat Top Fanglomerate (Zeller, 1975; Reiter, 1980) in the Alamo Hueco Mountains, the Cowboy Spring Formation–Timberlake Fanglomerate (Zeller and Alper, 1965; Elston and Erb, 1977) in the Animas Mountains, the unnamed conglomerate along the northeast side of the central Cedar Mountains, and the limestone-cobble conglomerate in the west Lime Hills. The Lobo may be in part correlative to the Fort Crittenden Formation (Stoyanow, 1949; Hayes, 1970) in southeastern Arizona.

Rubio Peak Formation

The Rubio Peak Formation was named by Elston (1957) for the type section at Rubio Peak, northwest of the Mimbres River valley in southeastern Grant County. It is the basal volcanic-rock unit throughout most of Luna and Grant Counties as well as southwestern Sierra County. Darton (1916), Lochman-Balk (1958), and Corbitt (1971) mapped the Tertiary volcanic rocks in the Florida Mountains as volcanic agglomerate. Demons (1982a) tentatively correlated them with the Starvation Draw member of the Rubio Peak Formation (middle to late Eocene) in southern Cooke's Range, about 20 mi to the north. Subsequent mapping has provided evidence that the Starvation Draw member is equivalent to the Lobo Formation, and the basal volcanic unit in the Florida Mountains is mapped as Rubio Peak Formation (undifferentiated).

Exposures—Volcanic arenites assigned to the Rubio Peak Formation form the high, rugged crest and northeastern slopes of the northern Florida Mountains. They are the dominant rocks along the ridge to Capitol dome and compose Dragon Ridge and Bavajo Bill Hill. Rubio Peak rocks also underlie the pedimented surface through Florida Gap. The southernmost exposures in the Florida Mountains are in Three Little Hills, sec. 32 T25S R7W.

Lithology and thickness—About 1,650 ft of conglomerate, sandstone, and tuffaceous breccia are exposed, resting with a slight angular unconformity on the Lobo Formation. This angular unconformity is

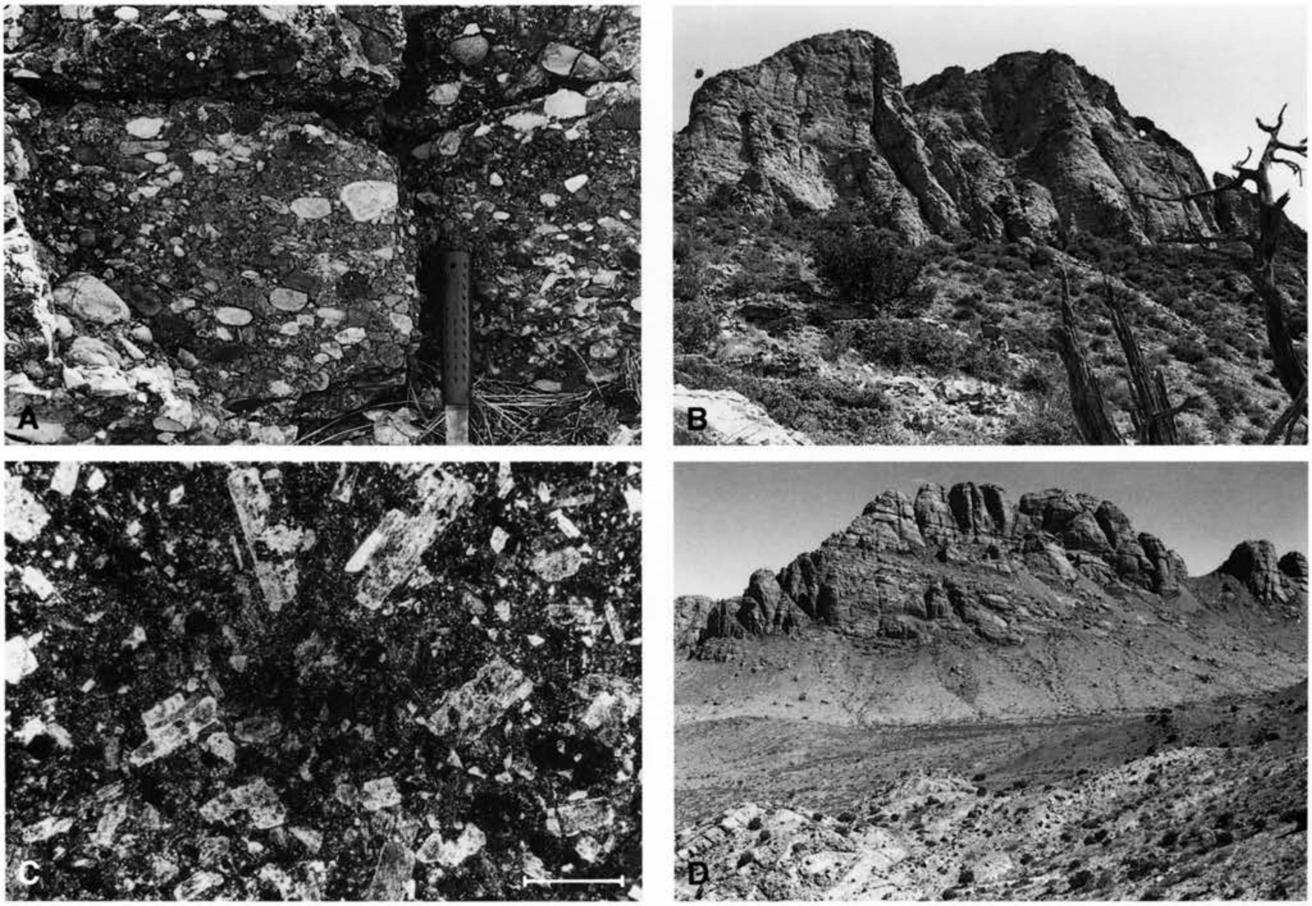


FIGURE 41—**A,** Slightly imbricated pebble–cobble conglomerate at base of Rubio Peak Formation on west slope of Florida Peak. **B,** Rubio Peak volcanic arenite sandstone forming massive cliffs north of Florida Peak. **C,** Photomicrograph of plagioclase (volcanic) arenite seen in 41B, showing intensely altered plagioclase crystals in matrix of epidote, chlorite, and fine-crystalline quartz. Photographed with crossed nicols. Scale bar = 0.2 mm. **D,** View from Capitol Dome northeast to Dragon Ridge, which is composed of Rubio Peak conglomerates and conglomeratic sandstones.

typically represented in the Florida Mountins by a poorly indurated basal Rubio Peak boulder conglomerate lying on slightly channeled Lobo red mudstone, and by northeasterly dips of the Lobo averaging approximately 25°, compared to an average of 15° for the overlying Rubio Peak strata. On the north slope of Lobo Draw the basal Rubio Peak is a well-indurated pebble conglomerate. Rubio Peak rocks consist predominantly of material derived from andesitic to dacitic tuffs and lavas, with lesser amounts of basalt clasts. The beds are chiefly fluvial, but laharic and talus(?) deposits are common in the lower part.

The basal conglomerate is composed of subangular to well-rounded clasts up to boulder size, limestones, cherty limestones, dolomite, Bliss Sandstone, granite, syenite, and volcanic rocks in a tuffaceous, sandy matrix. The conglomerate is overlain by a thick sequence of interbedded sandstones and polylithic breccia with volcanic clasts up to several feet in size. Bedding is commonly thick to massive and in many places obscure (Fig. 41B, D). Clast size decreases upward through the sequence so that the upper beds are fine- to medium-grained sandstones with a few interbedded pebble conglomerates. The sandstones are intensely propylitized, very poorly sorted, plagioclase-rich volcanic arenites with microcrystalline quartz cement (Fig. 41C). Epidote alteration is common throughout the Rubio Peak sequence and forms bright-green concretions in the sandstones. Epidote concretions up to 30 cm in diameter commonly weather out of the Rubio Peak northeast of Florida Peak. An unknown amount of Rubio Peak strata has been eroded from Florida Peak (Appendix E–10); therefore, it is not possible to measure a complete section of Rubio Peak. Total thickness where preserved in surrounding downdropped fault blocks is about 3,000 ft (Clemons, 1985b). The great thickness of fine-grained, fluvial beds and volcaniclastic debris indicates deposition in a basin adjoining a volcanic source.

Discontinuous outcrops of basaltic andesite and andesite are poorly exposed for about 7.5 mi along the western base of the Little Florida Mountains from Florida Gap to the extreme northwestern end of the mountains. The andesite is exposed in a roadcut on NM–549 in the south-central part of sec. 1 T24S R8W. Exact age of this unit is unknown, but it probably belongs in the Rubio Peak Formation. Whether the andesite in the Little Florida Mountains is intrusive or extrusive is uncertain; probably both types are present, and they may have come from some of the same vents that later supplied the voluminous rhyolites.

The dense, finely crystalline rock is characteristically medium gray to brownish gray and varies little in appearance throughout its exposures. Its microscopic appearance is that of plagioclase laths (average 0.15 mm) forming a hyalopilitic pilotaxitic texture (Fig. 42A). Less than 2% of the rock is made up of oxidized hornblende(?) microphenocrysts, tiny grains of magnetite, and an occasional augite microphenocryst. Chemical analyses and norms of four representative samples are included in Table 9.

Hornblende-andesite and basaltic-andesite dikes intrude Rubio Peak Formation and older rocks throughout the Florida Mountains. Thin sections of the mafic dikes indicate that these rocks have undergone considerable alteration. The plagioclase is sericitized and saussuritized(?); the hornblende(?) is totally converted to chlorite, carbonate, epidote(?), and quartz with only the phenocryst outline remaining. Small vesicles are filled with chlorite, carbonate, and quartz. A surprising amount of the augite (0.1–0.4 mm) in the more mafic dikes appears little altered. Although the dikes intrude Rubio Peak, they are probably closely related in time and thus are considered part of the Rubio Peak sequence.

Age and correlation—Preliminary examination of the volcanic clasts that resemble volcanic rocks in the Tres Hermanas Mountains suggests that area as a source. One of the Tres Hermanas stocks has a K–Ar age on hornblende of 49.02 ± 2.6 m.y. (Chapin, pers. comm. 1981). The Good Sight Mountains to the northeast (Clemons, 1979) or Cooke's Range to the north (Clemons, 1982c) are other possible sources. K–Ar ages on an intrusive and a flow in the Good Sight Mountains were reported as 38.1 m.y. and 37.6 m.y., respectively. Ages of Rubio Peak rocks reported from southern Cooke's Range are 37.6–44.7 m.y. The Rubio Peak is in part correlative to the Palm Park in south-central New Mexico and some of the other late Eocene volcanic rocks of southwestern New Mexico (Deal et al., 1978; Elston and Erb, 1977; Elston et al., 1979, 1983; Erb, 1979). Equivalent strata overlying the Lobo Formation in the Victoria Mountains were mapped by Kottlowski (1960) as lower Tertiary agglomerates, tuffs, and sandstones. Thorman and Drewes (1980) assigned a Paleocene or Late Cretaceous age to the unnamed sequence in the Victorio Mountains that underlies rocks from which a 41.7 m.y. fission-track age was obtained.

Miocene–Oligocene volcanic rocks

About a dozen very light-gray rhyolite dikes intrude Rubio Peak and older rocks throughout the Florida Mountains. The rhyolite is aphanitic holocrystalline and is composed of orthoclase and quartz with minor muscovite, magnetite, and pyrite. Manganese-oxide coatings are pervasive on fracture surfaces. The rhyolite dikes have predominant east and northeasterly trends. They are typically 4–8 ft thick, but pinch and swell from zero to as much as 20 ft. Apparently, they intruded en-echelon fractures and faults. Rhyolite dikes are more abundant in the mountains due east of White Hills (Fig. 3) and probably connect in the subsurface to the same source material as the small rhyolite plugs that form White Hills. A feldspar concentrate from rhyolite in White Hills yielded a K–Ar age of 29.1 ±1.3 m.y.

The Little Florida Mountains are composed mainly of rhyolites, tuffs, and fanglomerates derived from the rhyolites. Most of the volcanic materials probably were issued from vents beneath the Little Florida Mountains; one of the youngest vents is partially exposed at the southeast end of the Little Florida Mountains in the N½ sec. 5 T22S R7W. Minor ash-flow tuffs intruded by the rhyolites probably came from

TABLE 9—Chemical analyses and norms of selected volcanic and hypabyssal rocks in the Florida Mountains. **1**: calc-alkaline andesite, Rock Hound State Park; **2**: tholeiitic andesite, west side of The Little Gap; **3**: tholeiitic andesite, west side of The Little Gap, **4**: calc-alkaline andesite, NM–549 roadcut; **5**: trachybasalt (dike), Capitol Dome; **6** tholeiitic andesite (dike), east of Pacheco mine; **7**: rhyolite, Rock Hound State Park; **8**: rhyolite (perlitic obsidian), South Canyon; **9**: rhyolite (dike), Windmill Canyon; **10**: rhyolite, White Hills; **11**: rhyolite (dike), northeast corner of South Peak quadrangle; **12**: rhyolite (dike), northeast side of Mahoney Park; **13**: ash-flow tuff, 1 mi north of Rock Hound State Park; **14**: ash-flow tuff, west side of The Little Gap; **15**: rhyolite, southwest of Mamie Canyon; **16**: altered amygdaloidal basalt, southeast end of Little Florida Mountains; **17**: calc-alkaline andesite boulder in Rubio Peak Formation, Lovers Leap Canyon; **18**: monzonite (small plug), southeast of Mahoney Park. Samples 6a, 10a, and 12a are X-ray fluorescence analyses of samples 6,10, and 12, respectively.

Sample	1	2	3	4	5	6	6a	7	8	9	10	10a	11	12	12a	13	14	15	16	17	18
SiO_2	52.76	61.97	63.42	57.53	47.72	48.75	48.74	80.40	72.72	75.23	76.22	75.25	76.00	75.83	77.51	68.23	70.00	67.11	56.63	51.38	54.17
TiO_2	1.28	0.62	0.58	1.08	3.18	2.79	2.52	0.25	0.17	0.08	0.13	0.10	0.28	0.20	0.08	0.45	0.18	0.76	1.23	0.30	1.92
Al_2O_3	18.59	17.95	17.55	18.14	13.02	14.34	13.92	9.37	12.09	14.28	12.59	13.16	12.75	13.12	13.26	12.51	11.94	15.00	17.50	17.08	14.92
Fe_2O_3	7.70	4.70	4.38	5.01	12.14	14 26	13.91	1.03	1.23	0.57	2.35	2.48	2.38	2.14	2.08	1.59	1.88	2.63	8.12	9.77	9.11
MnO	0.04	0.06	0.07	0.03	0.13	0.15	0.18	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.12	0.03	0.06	0.07	0.11
MgO	3.58	1.01	0.88	1.89	6.21	3.58	4.06	0.08	0.12	0.10	0.05	0.10	0.04	0.07	0.07	0.32	0.45	0.15	0.53	3.42	3.31
CaO	8.68	5.88	6.44	7.95	7.69	5.71	6.04	0.45	1.06	0.95	0.17	0.18	0.13	0.18	0.17	4.20	5.15	0.87	1.75	5.99	5.18
Na_2O	4.15	3.93	3.90	3.93	3.82	3.28	3.16	0.89	3.04	2.52	3.65	3.68	0.48	0.22	0.16	1.19	2.49	2.49	0.82	3.96	4.87
K_2O	1.25	1.93	2.17	1.93	1.99	2.94	2.64	6.26	6.02	4.82	5.20	4.95	5.96	6.02	5.42	5.54	4.94	9.15	10.84	1.93	3.43
LOI	1.39	1.21	0.84	0.86	2.36	3.75	—	0.52	4.00	1.25	0.52	—	0.87	1.31	—	4.72	3.16	0.41	1.32	4.06	2.75
P_2O_5	0.08	0.05	0.05	0.34	0.76	1.08	1.08	0.05	—	—	0.07	0.08	0.02	0.02	0.02	0.05	0.05	0.08	0.13	0.16	0.36
Total	99.50	99.31	100.28	98.69	99.02	100.63	96.25	99.33	100.50	99.82	100.97	100.00	98.93	99.13	98.79	98.84	100.36	98.68	98.93	98.12	100.13
Qz	0.81	17.40	18.08	10.37		1.17		50.58	30.13	39.97	34.52		50.70	51.52		32.82	28.85	16.12	3.34		
Cor								0.43		3.19	0.80		5.38	6.01			0.34		1.55		
Ru								0.22	0.11	0.06						0.41		0.05			
Il	2.44	1.18	1.10	2.07	6.14	5.32		0.06	0.11	0.04	0.24		0.54	0.38		0.09		1.36	2.35	0.58	3.66
Hm								1.15	1.36	0.63	0.44		1.23	1.14		1.79	0.97	2.27			
Mt	4.03	3.08	3.01	3.76	6.87	6.23					1.72		0.80	0.18			1.03		3.97	2.62	4.97
AP	0.19	0.12	0.12	0.80	1.79	2.51		0.12			0.16		0.05	0.05		0.12	0.12	0.19	0.30	0.38	0.84
An	28.47	25.76	23.85	26.43	12.72	15.77		1.92	1.54	4.72	0.38		0.52	0.77		12.54	6.76	2.73	7.90	23.53	8.75
Ab	35.19	33.41	32.84	33.60	32.89	27.85		7.57	25.56	21.35	30.61		4.11	1.88		10.17	20.96	21.30	6.99	34.08	41.39
Or	7.41	11.47	12.77	11.54	11.98	17.45		37.24	35.38	28.54	30.48		35.69	35.94		33.09	29.07	54.72	64.64	11.61	20.38
Di	7.63	1.43	3.47	7.37	13.99	2.50			0.64							1.73	2.40	0.81		2.02	8.57
He	3.89	1.23	2.82	1.53	2.77	2.11														2.72	3.29
Fo					5.78															1.46	1.42
Fa					1.45															2.49	0.69
Wo									1.20							2.48	6.36	0.02			
En	5.40	1.86	0.57	1.34	1.01	7.79		0.20		0.25	0.12		0.10	0.17					1.33	5.65	2.28
Fs	3.15	1.83	0.54	0.32	0.23	7.53													6.30	8.74	1.00

another, unknown source. Limited basaltic andesite flows were extruded with the rhyolitic–dacitic eruptions.

Ash-flow tuff of the Little Florida Mountains

There are six small exposures of ash-flow tuff west and northwest of The Little Gap. Neither the base nor the top of the ash flow is exposed at any of these outcrops, but the tuff either rests on, or is intruded by, Rubio Peak(?) andesite and is overlain by tuffaceous sediments and flow-banded rhyolite. About 1 mi north of Rock Hound State Park more than 300 ft of south-dipping, massive ash-flow tuff is exposed in a small, prominent, west-trending ridge. Slope colluvium also obscures the contacts at this locality, but the tuff overlies the Rubio Peak Formation and was intruded by flow-banded rhyolite.

The ash-flow tuff is typically a grayish-pink to pale-red rock with abundant small, flattened, white pumice fragments. Pumice is less abundant in the massive tuff. Crystal fragments compose 7–30% of the tuff, and lithic fragments compose up to 8% of the massive tuff, but are less abundant in the small outcrops to the northwest. The basal part of the massive tuft is a lithic tuff with relatively few crystals. Plagioclase (5–12%), sanidine (1–10%), quartz (1–8%), and biotite (1–3%) with traces of hornblende and sphene crystals and rock fragments occur in a matrix of abundant axiolitic shards and glass throughout the upper three-fourths of the unit. Hydrothermal alteration has converted the plagioclase to chalky-white clays.

K–Ar ages of 37.3 ± 1.4 m.y. and 32.0 ± 1.2 m.y., respectively, were determined for biotite from the tuff cropping out west of The Little Gap and for biotite from the massive tuff north of Rock Hound State Park. The tuff in these two areas probably belongs to the same formation. The younger age for the second sample is probably the consequence of the rock having undergone more hydrothermal alteration related to younger rhyolitic intrusives.

Rhyolite and tuff of Little Florida Mountains

The western and northern parts of the Little Florida Mountains are composed mostly of flow-banded rhyolite (*Tlr*), obsidian, rhyolitic tuff, and associated tuffaceous beds (*Tlt*). Darton (1916, 1917) and Lasky (1940) described these rocks as interbedded rhyolite, obsidian flows, and tuff beds. Clemons (1982a) interpreted at least half, and maybe most, of the rhyolite exposed along the western escarpment and crest of the Little Florida Mountains as elongate, irregular, domal to dike-like intrusions. Their contacts are obscure, but appear to range from vertical to steep, east or northeast-dipping attitudes. Many of the intrusions between Rock Hound State Park and the southeast end of the range have black, perlitic obsidian border zones (Fig. 43). These rocks intruded penecontemporaneous, greenish- to orangish-gray lithic tuffs and volcaniclastic beds deposited around the vents. Exposures between the lower parts of Mamie and

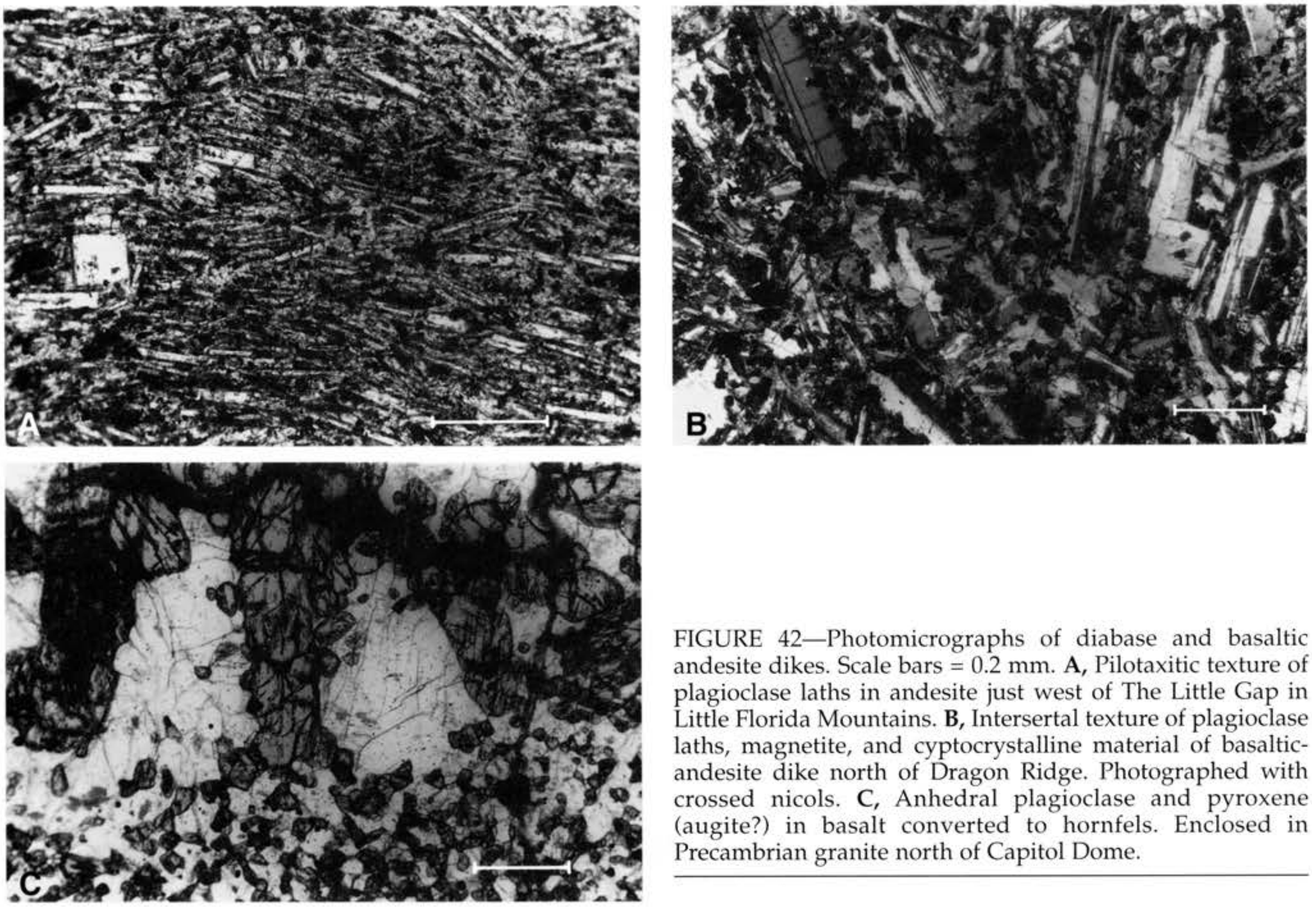


FIGURE 42—Photomicrographs of diabase and basaltic andesite dikes. Scale bars = 0.2 mm. **A,** Pilotaxitic texture of plagioclase laths in andesite just west of The Little Gap in Little Florida Mountains. **B,** Intersertal texture of plagioclase laths, magnetite, and cyptocrystalline material of basaltic-andesite dike north of Dragon Ridge. Photographed with crossed nicols. **C,** Anhedral plagioclase and pyroxene (augite?) in basalt converted to hornfels. Enclosed in Precambrian granite north of Capitol Dome.

South Canyons indicate a partly buried rhyolitic volcano and vent area with extensive hydrothermal alteration. Several west-trending rhyolite dikes form prominent, low ridges in the slopes and piedmont surface southwest of The Little Gap. Two or three small, intrusive rhyolite bodies crop out on the southwest side of the hill northwest of The Little Gap. Several flows from these intrusions flowed northeastward and formed the northeast part of the hill.

The rhyolite ranges from grayish pink and pale red to dark grayish red, is hypocrystalline to microcrystalline, and contains less than 1% of microphenocrysts. Flow-banding is prominent locally near the margins of the intrusions, but generally the rock is massive; an autobreccia texture predominates. The breccia in the southeast end of the range contains prolific cavities, apparently caused by alteration and removal of angular autoliths up to 30 cm across. Some cavities contain spherulites that formed after removal of the clasts. Spherulites up to several inches in diameter are common near contacts at the southern end of the Little Florida Mountains. Some of the spherulites have white to bluish-gray chalcedony centers. Geodes partly filled with chalcedony and occasional vugs containing clear quartz crystals are common in a zone extending from Rock Hound State Park southeastward across the range. Moderately reddish-brown jasper fills fractures in the rhyolite and tuff near the contacts throughout this same zone. Chemical analyses and norms (Table 9) reveal that these rocks are best classified as calc-alkaline rhyolite, with some grading into dacites. A whole-rock sample from the eastern edge of Rock Hound State Park (NE¼SW¼ sec. 30 T24S R7W) yielded a K–Ar age of 23.6 ± 1.0 m.y.

Basaltic andesite of Little Florida Mountains

Vesicular to amygdaloidal basaltic-andesite flows overlie rhyolite, altered tuff, and obsidian northeast of Mamie Canyon near the south end of the Little Florida Mountains (Fig. 8). The flows are overlain by massive fanglomerate breccias. There is a small outcrop of the basaltic andesite near a manganese prospect on the west side of Mamie Canyon.

The dark grayish-red to reddish-brown basaltic andesite is composed of altered plagioclase laths in an intersertal matrix of iron-oxide grains and brownish, cryptocrystalline to holohyaline material. A chemical analysis (Table 9, no. 16) indicates probable potassium metasomatism of this rock. The interior vesicles are filled mostly with calcite and some chalcedony.

The exact age of the basaltic andesite is tentatively considered to be early Miocene (post-23.6 m.y.), but may correlate with part of the Bear Springs Basalt and Uvas Basaltic Andesite.

Fanglomerate of Little Florida Mountains

The most extensive rock unit in the Little Florida Mountains is a thick fanglomerate sequence of breccias and conglomeratic sandstones. The basal breccias were deposited on an angular unconformity developed on basaltic andesite, flow-banded rhyolite, tuff, and, in the extreme northwest corner of the map area, andesite. Poorly developed pebble imbrication in the basal beds indicates a probable northeastward trans-

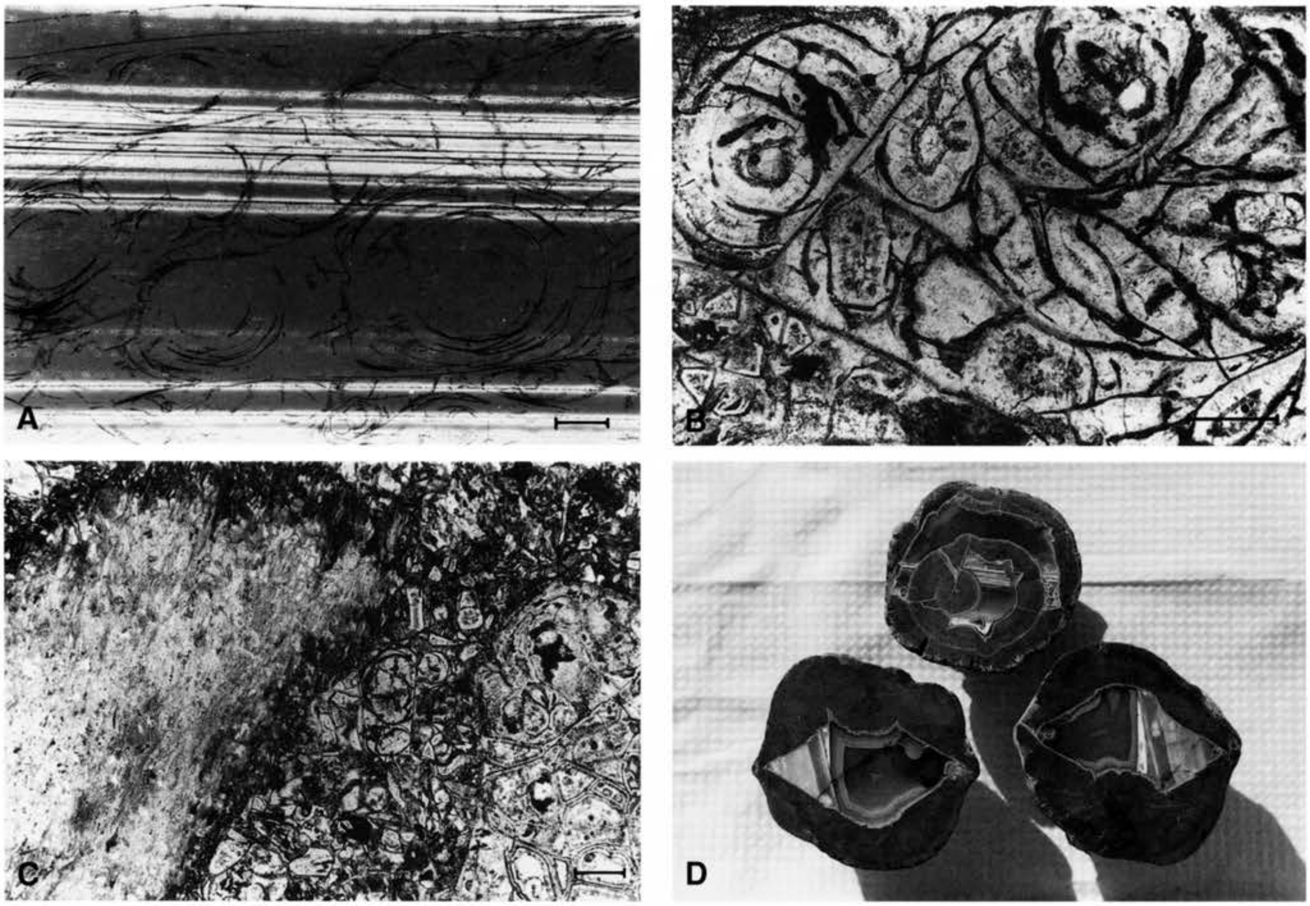


FIGURE 43—**A,** Photomicrograph of banded perlitic obsidian from Little Florida Mountains east of Agate Point. Scale bar = 0.2 mm. **B, C,** Photomicrographs of partially devitrified perlite from slope on east side of Rock Hound State Park. Scale bar = 0.2 mm. **D,** Agate nodules from tuff on east slope of Rock Hound State Park (diameters are approximately 5 cm).

port of the clasts. With few exceptions, the strata dip northeast 10–15°. These strata are the hosts for manganese, barite, and fluorite deposits. A complete section cannot be measured because of numerous faults and poor exposures, especially on the pediment surface to the northeast. Lasky (1940) stated that at least 1,000 ft of the strata are present; a thickness of approximately 2,000 ft was estimated in this study.

The basal beds contain cobbles and boulders of andesite, vesicular basaltic andesite, and rhyolite. These beds are overlain by several hundred feet of coarse-breccia beds composed of angular rhyolite clasts up to 4 ft in diameter in a red, silica-cemented, coarse sandy and muddy matrix (Fig. 44). The sand and mud typically are restricted to the interstices between the larger clasts. At a couple of horizons within this sequence the matrix is light gray, resulting in light bands noticeable on aerial photographs. At the northeast base of the mountains a sudden, considerable decrease in class size occurs, probably because of downfaulting of the northeast blocks, thus cutting out part of the fanglomerate section. As the clasts decrease from cobble to pebble size northeastward across the low hills and pediment to NM–549, the amount of interbedded sandstone increases. Moderately cemented tuffaceous sandstones are exposed in the barite prospects and pipeline roadcuts in sec. 7, and thin-bedded, pebbly sandstone crops out along the small arroyo in the southwest corner of sec. 6 north of the highway.

The fanglomerate, tentatively considered to be middle Miocene and postdating the 23.6 m.y. age of source-rock emplacement, accumulated as a result of initial uplift of the Little Florida Mountains block. This block probably represents an early stage of Basin and Range faulting in this area. The age of similar deposits related to early rift faulting in the Cedar Hills, approximately 40 mi northeast, is considered to be approximately 26 m.y. (Chapin and Seager, 1975). Seager and Hawley (1973) attributed the basal fanglomerates in the Santa Fe Group at Rincon to early Miocene block faulting. The fanglomerates of the Little Florida Mountains were lithified and faulted before manganese, barite, and fluorite mineralization occurred. Similar mineralization near Rincon is considered to be of Miocene age (Seager and Hawley, 1973).

Dacite of Little Florida Mountains

A grayish- to dusky-red, microcrystalline to hypohyaline dacite crops out at the southeast end of the Little Florida Mountains. A border zone of several feet, containing prolific spherical, ellipsoidal, and rod-shaped spherulites, displays steep-dipping to vertical-flow foliation. The dacite intrudes hydrothermally altered vent tuffs, basaltic andesite, and fanglomerate. A chemical analysis and norm is listed in Table 9 (no.

15). The high potassium content is probably a result of late-state metasomatism. If the 9.15% of potassium is used in classifying this rock, it should be called a high-potassic calc-alkaline rhyolite rather than dacite. If the assumed Miocene age of the fanglomerate is correct, the dacite is probably middle to late Miocene and may be related to the manganese, barite, and fluorite mineralization that occurs in the fanglomerate.

Monzonite of Florida Mountains

Intrusive rocks of intermediate composition crop out in several dikes and small, plug-like bodies east of Mahoney Park. The three largest and best-exposed plutons are in NE¼ sec. 36 T25S R8W and NW¼ sec. 1 and east-central sec. 2 T26S R8W. The intrusive rocks are less resistant than the Paleozoic carbonate rocks and underlie inconspicuous slopes. Locally, the intermediate intrusives occur in ridges of the Cambrian syenite. A chemical analysis (Table 9, no. 18) shows the rocks are probably monzonite. They are composed of altered andesine(?), plagioclase, and hornblende in a cryptocrystalline to microcrystalline matrix. Accessories include opaque iron oxides, apatite, and zircon. The exact age of these monzonites is unknown, but must be post-Laramide (Brown, 1982) because they intrude along Laramide faults and into small Laramide thrust sheets. Similar rocks intruded Miocene–Oligocene volcanic rocks near Deming (Clemons, 1985b).

Mimbres formation

An informal name is used for this formation until current mapping projects in the Mimbres Basin are complete (Clemons, 1982a). The formation is part of a unit that has been mapped previously as Gila Group. The piedmont-slope facies of the Mimbres formation is composed mostly of alluvial-fan and coalescent-fan deposits, and includes thin, colluvial veneers on pediment surfaces. The younger deposits are correlative with the Camp Rice Formation piedmont facies (Seager and Hawley, 1973) in south-central New Mexico and boulder-to-cobble fan deposits and erosion-surface veneers (*Qlp*) in part of southwesern New Mexico (Seager et al., 1982). The older deposits are correlative in part with the basal Camp Rice Formation, but include some Pliocene-age strata. Remnants of colluvial veneers and well-developed alluvial fans cemented with caliche are present on the well-developed bajada that surrounds the Florida Mountains. The Mimbres formation is several thousand feet thick in the adjacent Mimbres Basin (Clemons, 1985b).

Quaternary alluvium

The geology of the basin-floor areas beyond the gently sloping bajada was in large part interpreted from aerial photographs and maps with soil descriptions in the *Soil Survey of Luna County, New Mexico* (Neher and Buchanan, 1980).

Older piedmont-slope alluvium (*Qpo*) is similar in composition to the Mimbres formation piedmont-slope facies in that it invariably reflects the lithology of local source areas. It includes arroyo–terrace and fan deposits and thin (less than 10 ft) veneers on erosional surfaces, generally of late Pleistocene age. Thin soil horizons and weak soil-carbonate accumulations are present in most sections. Arroyo-channel, terrace, and fan deposits associated with modern arroyos (*Qpy*) range in age from late Wisconsinan to the present (less than 25,000 yrs B.P.). These and the late Pleistocene deposits are the products of repeated episodes of arroyo-valley and partial back-filling (Seager et al., 1975). Zones of soil-carbonate accumulation are weak or absent in the Holocene (less than 10,000 yrs B.P.) deposits. An undifferentiated piedmont unit (*Qpa*) is used in areas where *Qpo* and *Qpy* deposits did not warrant separate mapping.

FIGURE 44—Rhyolite fanglomerate of Little Florida Mountains.

Colluvial and alluvial deposits (*Qca*) have been mapped on a few slopes where they form a relatively continuous cover on older units. These deposits are generally less than 10 ft thick and, as expected, reflect the lithology of nearby higher slopes and ledges. Most of the mapping unit is an age equivalent of older and younger piedmont-slope alluvium (*Qpo* and *Qpy*). Locally, *Qca* may correlate with the younger piedmont slope facies of the Mimbres formation (*Qm*).

Basin-floor sediments (*Qbfo* and *Qbfy*) cover extensive areas east and west of the Florida Mountains. They include loamy to clayey alluvium deposited by distributaries of the Mimbres River and the Florida Mountains arroyos in an area essentially unaffected by arroyo incision. The deposits are typically devoid of gravel, but sporadic, intertonguing gravely lenses were deposited by flooded arroyos from the Little Florida Mountains and Florida Mountains, as well as from ancient Mimbres River floods. These units are approximately correlative with *Qpo* and *Qpy*, respectively.

Eolian sand (*Qs*) covers a large area along the margin of the Piedmont slopes and basin floor east and west of the mountains. Small areas of sand cover also extend into the map area from the northwest. The dunes are generally less than 10 ft high; most are more or less stabilized by desert vegetation. Nearby exposures generally warrant using a double map symbol to indicate the underlying unit, such as *Qs*/*Qbfo*.

Structural geology

Regional setting

The regional framework of southwestern New Mexico, southeastern Arizona, and northern Chihuahua, Mexico, has been a subject of much debate. Corbitt and Woodward (1973b), Corbitt et al. (1977, 1978), Drewes (1972, 1976, 1978, 1981, 1982), Nydegger (1982), Woodward (1980), and Woodward and DuChene (1981, 1982) have been strong proponents for extending the Cordilleran fold and thrust belt of the western United States (Fig. 45) southeastward across Arizona and southwestern New Mexico (Fig. 46). Opponents of this idea include Brown and Clemons (1983a, b), Davis (1979, 1981), Dickinson (1984), Jones (1963, 1966), Mack and Clemons (1988), Mayo (1966), and Seager (1983). Northwest-trending tectonic features in this region have received much attention and varying interpretations. The Texas lineament, described and discussed by Hill (1902, 1928), Ransome (1915), Baker (1927, 1935), Albritton and Smith (1957), Muehlberger (1965), Wiley and Muehlberger (1971), and others, trends approximately N 60° W through southwestern New Mexico. Turner (1962) described the N 50–60° W-trending Deming axis as a positive tectonic element since Mississippian time. Included in the Deming axis, from northwest to southeast, are the Florence and Graham uplifts in Arizona, the Burro uplift (Elston, 1958) and the Florida uplift (Florida islands of Kottlowski, 1958) in

FIGURE 45—Map of western U.S. showing the overthrust belt and its proposed continuation through southwestern New Mexico (from Drewes, 1978).

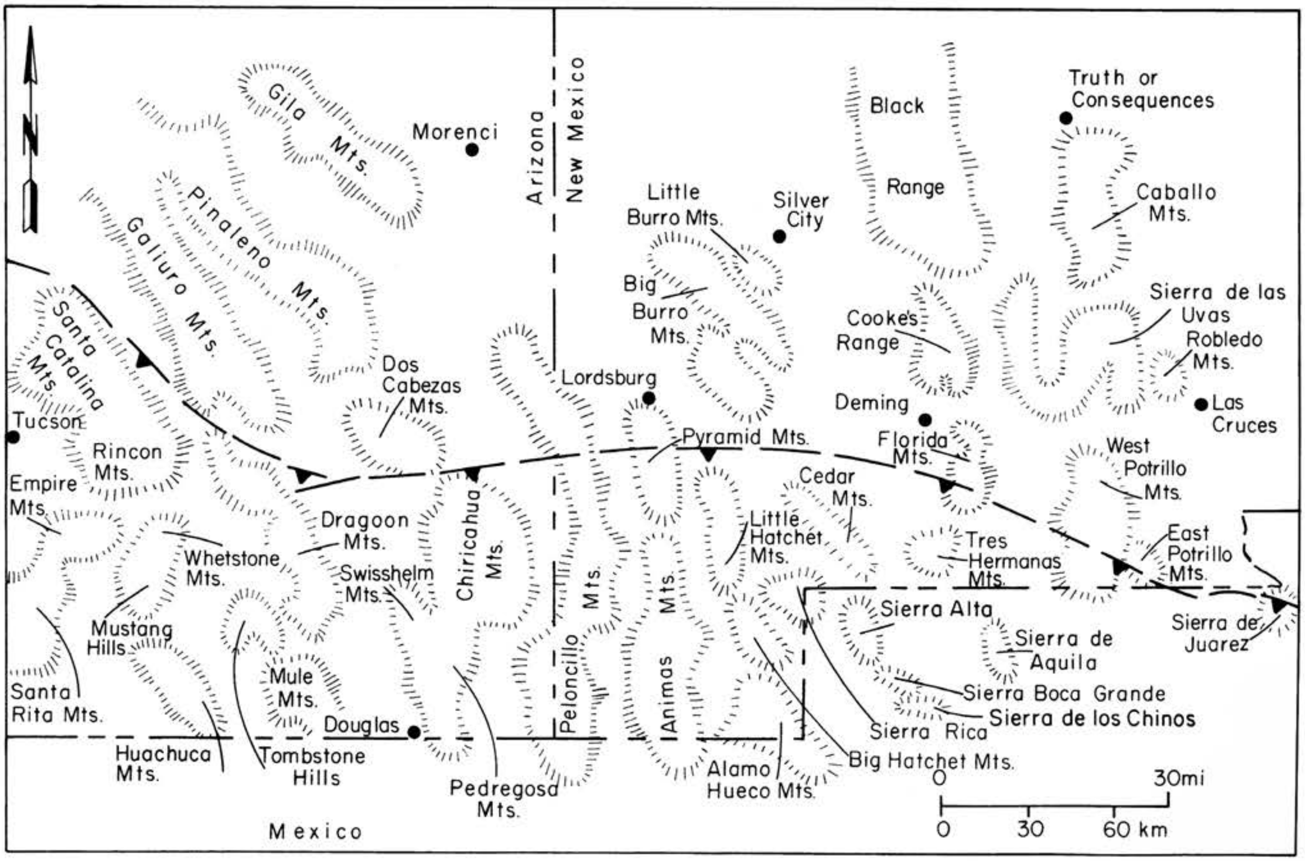


FIGURE 46—Map of hypothetical fold-thrust belt in southwestern New Mexico and southeastern Arizona.

New Mexico, and the Van Horn uplift in west Texas. Titley (1976) described six major linear discontinuities with N 55° W trends in the tectonic pattern of southeastern Arizona. He concluded that the discontinuities influenced late Paleozoic sedimentation to some degree and were more active during the Mesozoic. There is also evidence of transcurrent movement along the discontinuities. Drewes (1982) distinguished a system of northwest-trending, steep faults in southeastern Arizona that had Precambrian movements as well as Phanerozoic activity. Aldrich and Laughlin (1982) interpreted oblique-slip movements on several northwest-trending fault zones in southwestern New Mexico. The zone of northwest-trending faults, uplifts, and lineaments probably underlies much of northern Chihuahua (including part of the Pedregosa Basin) and northeastern Sonora (Fig. 47), extending to the Mojave–Sonora megashear (Silver and Anderson, 1974). Coney (1976, 1978) has described succinctly the plate-tectonic setting and Laramide-orogeny patterns of southeastern Arizona and southwestern New Mexico. Chapin and Cather (1981) presented strong evidence for the Colorado Plateau being translated northeastward during the strongest Laramide deformation, starting in early Eocene time. The Florida Mountains block (Fig. 47) was subjected to the same northeast-directed stress. Superimposed upon the northwest-trending tectonic grain of southwestern New Mexico are features produced during Basin and Range deformation. These features are predominantly north-trending as evidenced by present-day mountain ranges (Fig. 46), but a few (e.g. Cedar Mountains, Sierra Alta, and Gila Mountains) represent uplifts along reactivated northwest-trending fractures. The gravity map (Fig. 48) of Lance and Keller (1981) also

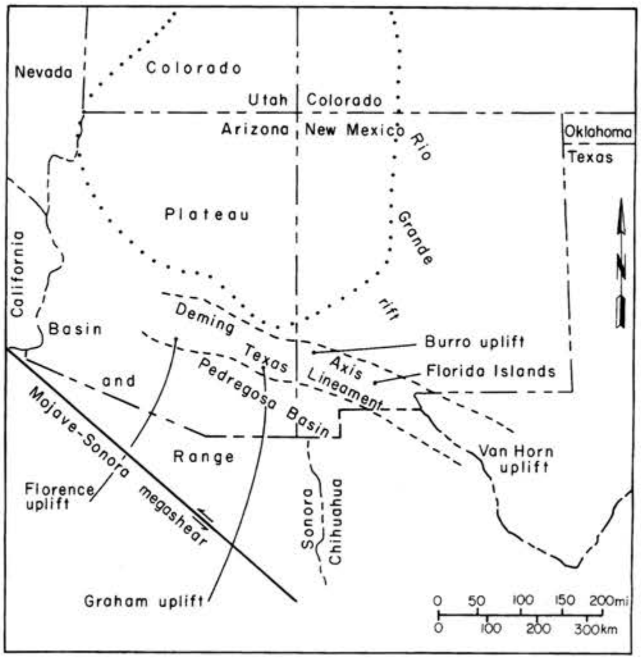


FIGURE 47—Major tectonic features of Arizona, southwestern New Mexico, and northern Mexico.

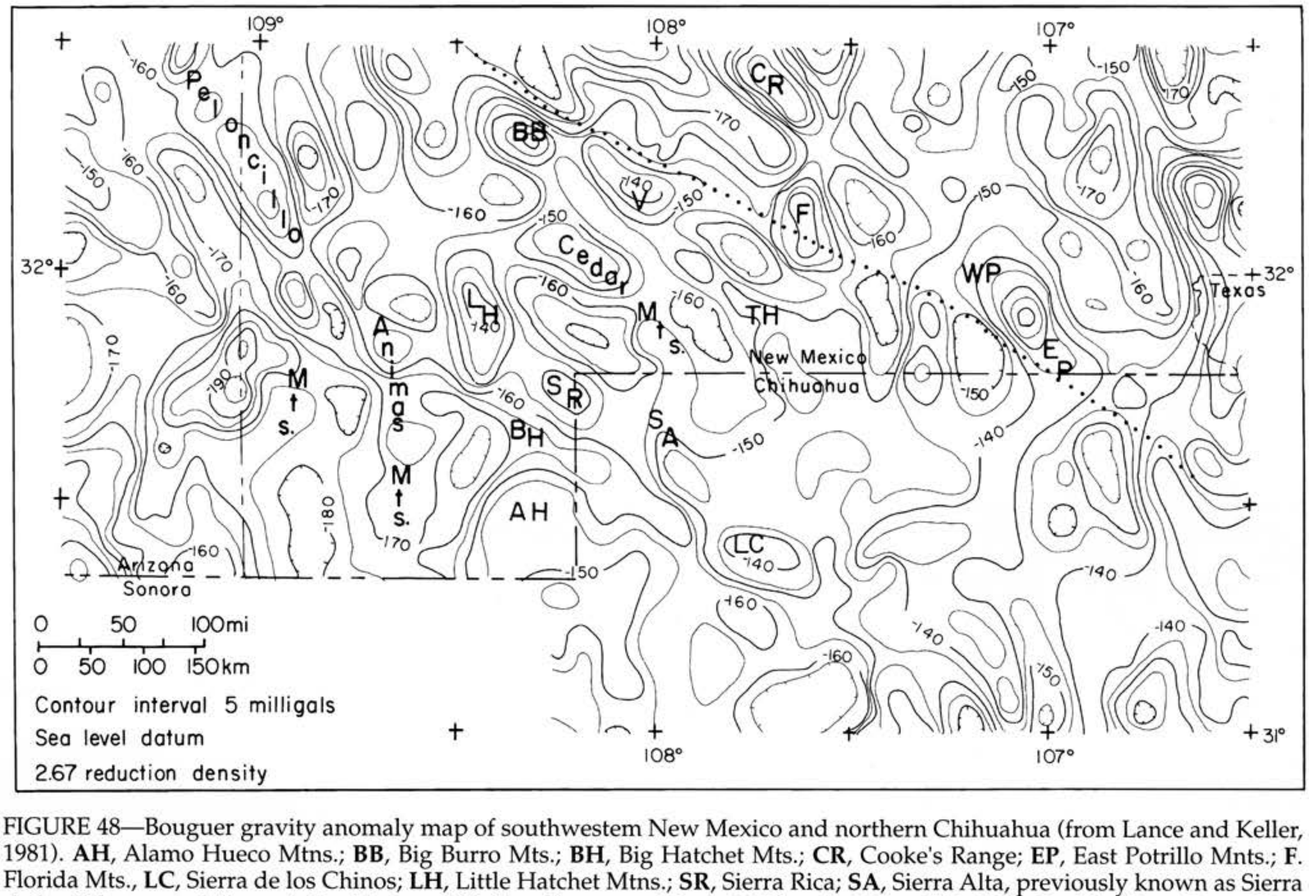


FIGURE 48—Bouguer gravity anomaly map of southwestern New Mexico and northern Chihuahua (from Lance and Keller, 1981). **AH**, Alamo Hueco Mtns.; **BB**, Big Burro Mts.; **BH**, Big Hatchet Mts.; **CR**, Cooke's Range; **EP**, East Potrillo Mnts.; **F**. Florida Mts., **LC**, Sierra de los Chinos; **LH**, Little Hatchet Mtns.; **SR**, Sierra Rica; **SA**, Sierra Alta, previously known as Sierra de las Palomas and Sierra de los Moscos; **TH**, Tres Hermanas Mtns.; **V**, Victorio Mnts.; **WP**, West Potrillo Mtns. Dotted line is probable extension of south Florida Mountains fault.

carries the imprint of both northwest- and north-trending features.

The northeastern edge of the postulated fold-thrust belt in southwestern New Mexico (Fig. 46) is shown by its proponents as underlying bolson and valley fill over 85% of its length. It is shown to be covered by a Quaternary basalt field in the west Portillo Mountains and by middle to late Tertiary volcanic rocks in the Pyramid and Peloncillo Mountains. At most, a few hundred yards of complex structures are exposed in White Cap Hill, Victorio Mountains, and Snake Hills, west and southwest of Deming. The south Florida Mountains fault (Fig. 49) is the best exposed part of the belt margin in New Mexico.

South Florida Mountains fault

The most prominent structural feature in the Florida Mountains is the south Florida Mountains fault. Darton (1917b) described this fault as a thrust dipping 40–70° south and displacing granite upon the upper beds of his Gym Limestone. Corbitt (1971, 1974) stated that this northwest-trending, steeply dipping reverse fault is steep at deep structural levels but flattens abruptly upward. This appears to be true in Mahoney Park, but close scrutiny of the fault zone in the northern part of sec. 3 T26S R8W indicates this flattening is more likely an illusion. Although the main fault is difficult to locate precisely in the massive, brecciated granite, it probably maintains a N 80° W strike with southerly dips of 65–80° through this area. The apparent flattening to 18° between the granite and the Fusselman is actually on a small subsidiary thrust plate (Fig. 50). This is easily seen, and it is a much more striking feature than the thoroughly brecciated granite in the slopes to the south and southeast. After removal of Basin and Range northeast tilting of about 20–25°, the south Florida Mountains fault strikes N 50° W and is close to vertical.

The south Florida Mountains fault places Cambrian alkali-feldspar granite against various Paleozoic formations and Precambrian quartz alkali-feldspar syenite. Several other secondary reverse(?) faults, that probably resulted in imbrication, are located southwest of the main fault within the Cambrian granite. The amount of displacement on these faults is unknown. Total width of the fault zone paralleling the south Florida Mountains fault varies from 0.5 to 2.0 mi. Within this zone are at least eight linear to sinuous faults in a somewhat anastomosing pattern. Clemons and Brown (1983) assigned the thickness of the Paleozoic section (4,000 ft) as a minimum stratigraphic separation on the south Florida Mountains fault. Thorman (1977) and Thorman and Drewes (1978, 1979, 1980, 1981) indicated probable northwest-trending strike–slip faults in southwestern New Mexico. Brown and Clemons (1983b), Clemons and Brown (1983), and Seager (1983) indicated that there may have been significant right-lateral movement on the south Florida Mountains fault. Early Paleozoic beds east and south of Gym Peak (Sheet 2) show a continuous change in strike from nearly due north 2 mi northeast of the fault to due east adjacent to the fault. A similar relationship in bedding attitudes in Mahoney Park suggests they may have been caused by drag as the north block moved eastward relative to the south block. Petrographic study of about 250 thin sections (Appendix A–2) suggests that the Cambrian syenite and quartz syenite north (down) of the fault and granite south (up) of the fault are consanguineous. Both syenites and granites contain abundant hornfels xenoliths. The overall relation is more easily explained by lateral movement on the fault as well as vertical uplift that juxtaposed the granite with syenite of the same pluton. The positions of small slices of Lobo Formation in the fault zone support horizontal (right-lateral) as well as vertical movement.

The south Florida Mountains fault cuts rocks as young as basal Lobo Formation (Paleocene–Eocene) in the southeastern Florida Mountains (Sheet 1b). The Lobo exposed along the fault consists of approximately 450 ft of conglomerate overlying 40 ft of red, arkosic sandstone and mudstone. About 4 mi northwest the Lobo is predominantly fine- to medium-grained sand-

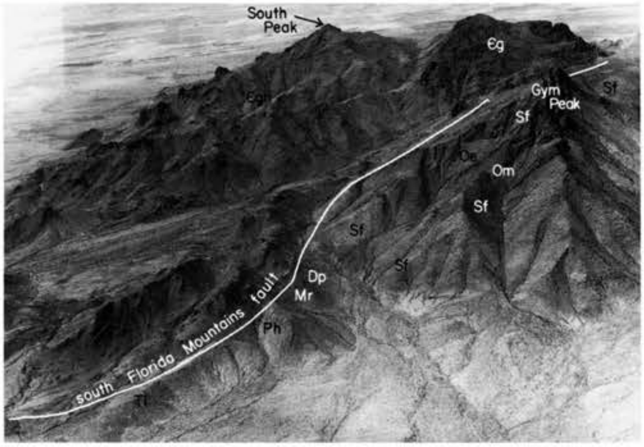
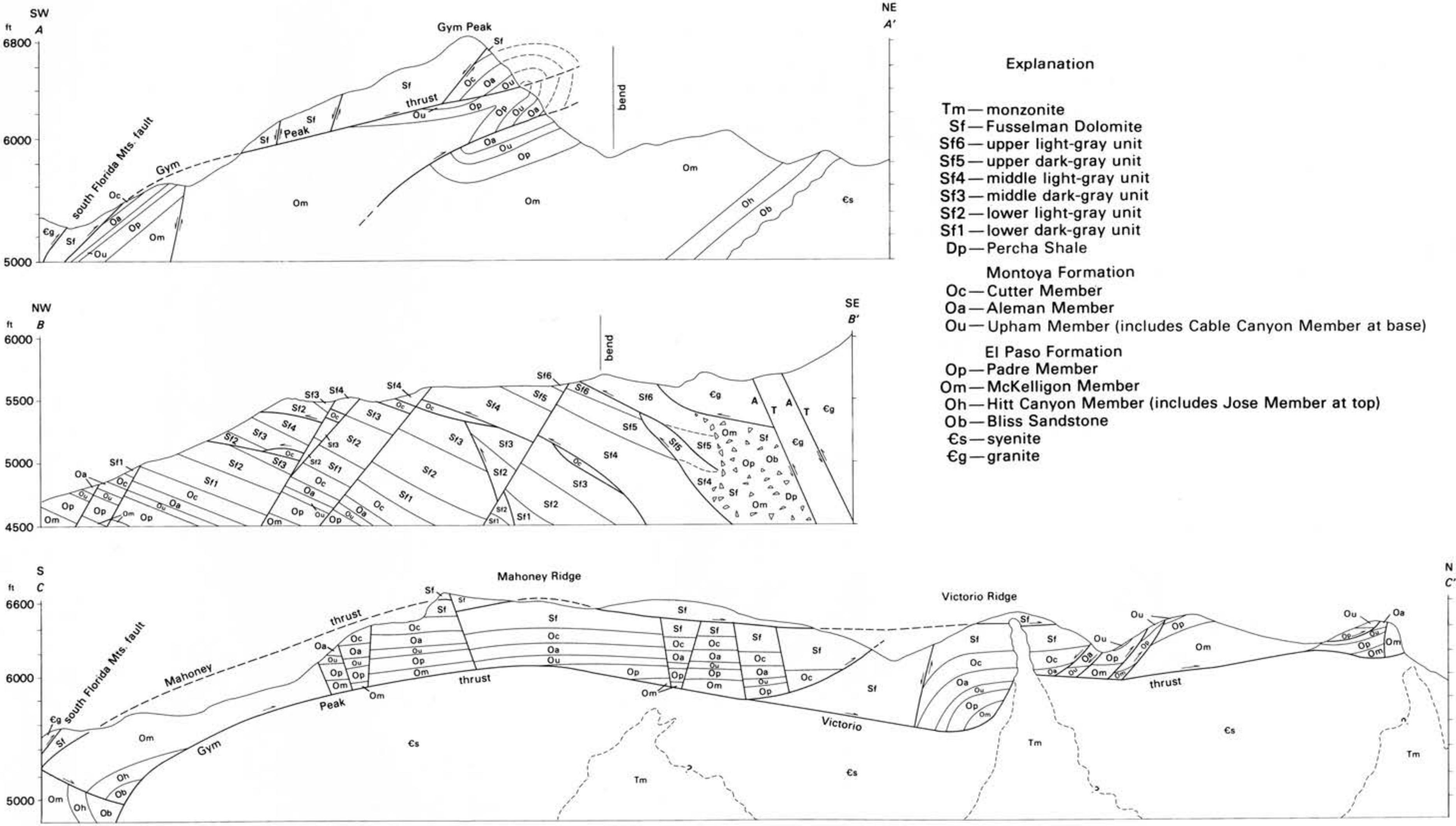


FIGURE 49—Subaerial view to southwest of Gym Peak and South Peak. Granite (**Єg**) and granite with hornfels xenoliths (**Єgh**) southwest of south Florida Mountains fault. Fault cuts diagonally across Lobo Formation (**Tl**), Hueco Limestone (**Ph**), Rancheria Formation (**Mr**), Percha Shale (**Dp**), and Fusselman Dolomite (**Sf**) that form the footwall block along with the underlying Montoya (**Om**) and El Paso (**Oe**) Formations. (Photo courtesy of Mobil Oil Corp.)

FIGURE 50—View southwest of granite (**g**) thrust over Fusselman Dolomite (**Sf**) in front of south Florida Mountains fault (**SFMP**) in Mahoney Park.



Explanation

Tm—monzonite
Sf—Fusselman Dolomite
Sf6—upper light-gray unit
Sf5—upper dark-gray unit
Sf4—middle light-gray unit
Sf3—middle dark-gray unit
Sf2—lower light-gray unit
Sf1—lower dark-gray unit
Dp—Percha Shale

Montoya Formation
Oc—Cutter Member
Oa—Aleman Member
Ou—Upham Member (includes Cable Canyon Member at base)

El Paso Formation
Op—Padre Member
Om—McKelligon Member
Oh—Hitt Canyon Member (includes Jose Member at top)
Ob—Bliss Sandstone
Ꞓs—syenite
Ꞓg—granite

FIGURE 51—Cross sections of thrust-faulted rocks adjacent to south Florida Mountains fault. **A–A'** is from Copper Kettle Canyon, (SE¼ sec. 12 T26S R8W to SE¼ sec. 1 T26S R8W; from Brown, 1982); **B–B'** is on the south side of Mahoney Park from NW¼ sec. 34 T25S R8W to NW¼ sec. 3 T26S R8W; **C–C'** is from the Priser mine to Baldy Peak (from Brown, 1982). Horizontal scale = vertical scale.

stone with much interbedded mudstone and few channel-fill conglomerates. Toward the end of Lobo time all the Paleozoic rocks had been stripped from the block south of the south Florida Mountains fault and fine-grained clastics were deposited nonconformably on the Cambrian granite (Sheet 1b; SE¼ sec. 2 T26S R8W) and between the lower Box and Copper Kettle Canyons.

Thrust faults

Numerous small thrust faults that formed penecontemporaneously with the south Florida Mountains fault displace Precambrian and lower Paleozoic rocks south of Mahoney Park and eastward from there across the crest of the range. Most of these faults involve intensely deformed, locally brecciated, complex sheets that placed younger strata over older rocks, but locally older rocks were placed over younger rocks (Figs. 51, 52). Large slabs of Cutter limestone–dolomite lie within thrust-faulted Fusselman Dolomite in the SE¼ sec. 34 T 25S R8W. Many of the thrust faults can only be mapped with confidence by using a map scale large enough to plot offsets of the six Fusselman Dolomite units, or individual members of the El Paso and Montoya Formations. Three levels (Victorio, Gym Peak, and Mahoney) of imbricate thrusting within the Paleozoic rocks were mapped by Brown (1982) and Clemons and Brown (1983). Several of the small thrust faults south of Mahoney Park (Sheet 3, Fig. 53) were probably continuous with the Victorio, Gym Peak, and Mahoney thrust faults before the formation of Mahoney Park by erosion. Additional small thrust faults underlie Capitol Dome (Sheet 3). These faults also produce intense folding and brecciation of lower Paleozoic rocks (Fig. 54).

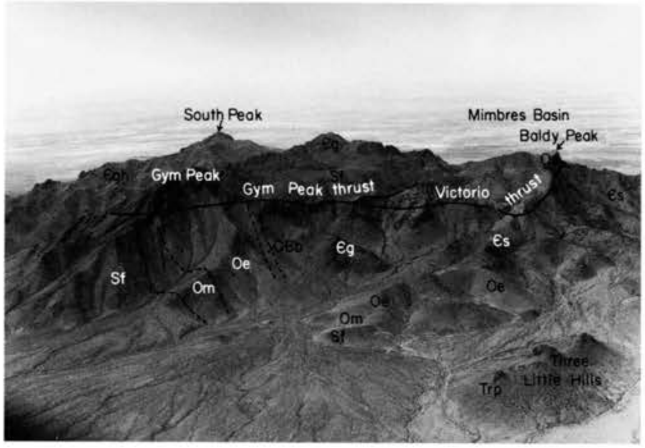


FIGURE 52—Aerial view of southeast flank of Florida Mountains. Gym Peak and Victorio thrust faults transported lower Paleozoic rocks northeastward over truncated Paleozoic strata and Cambrian syenite. Bliss Sandstone (**Ob**) nonconformably overlies the syenite (**Єs**) on northeast slopes of Gym Peak. El Paso Formation (**Oe**), Montoya Formation (**Om**), Fusselman Dolomite (**Sf**), granite (**Єg**), hornfels intruded by granite (**Єgh**), and Rubio Peak Formation (**Trp**).

Victorio thrust fault

The Victorio thrust fault (Fig. 51) is the lower surface of multiple allochthonous sheets that form Victorio Ridge and Baldy Peak. The Victorio thrust fault overlies the Mahoney Park autochthon and syenite basement. The thrust sheet is overlain by both the Gym Peak thrust fault to the south and three klippen remnants of the Mahoney thrust sheet. Three klippen remnants of the Victorio sheet also are preserved northeast of the main sheet (in SW¼ sec. 31 T25S R7W) where they rest on syenite basement.

The Victorio thrust sheet is an intensely deformed, locally brecciated, complex sheet that places younger strata over older strata (Mahoney Park autochthon) along a highly variable fault surface. The complexities include folding, at the northern end, of the McKelligon and Padre Members (El Paso Formation), which is surrounded by complicated faulting.

Tectonic elimination of strata is pervasive along the Victorio thrust surface. A notable example is well exposed at the southwestern end of the fault (in SE¼ sec. 36 T25S R8W) where the Victorio thrust fault merges with the Gym Peak thrust fault and the upper El Paso strata rest upon a tectonically truncated section of McKelligon Member only 250 ft thick. Comparison with the measured thickness of 905 ft indicates that 655 ft of section are missing. The direct

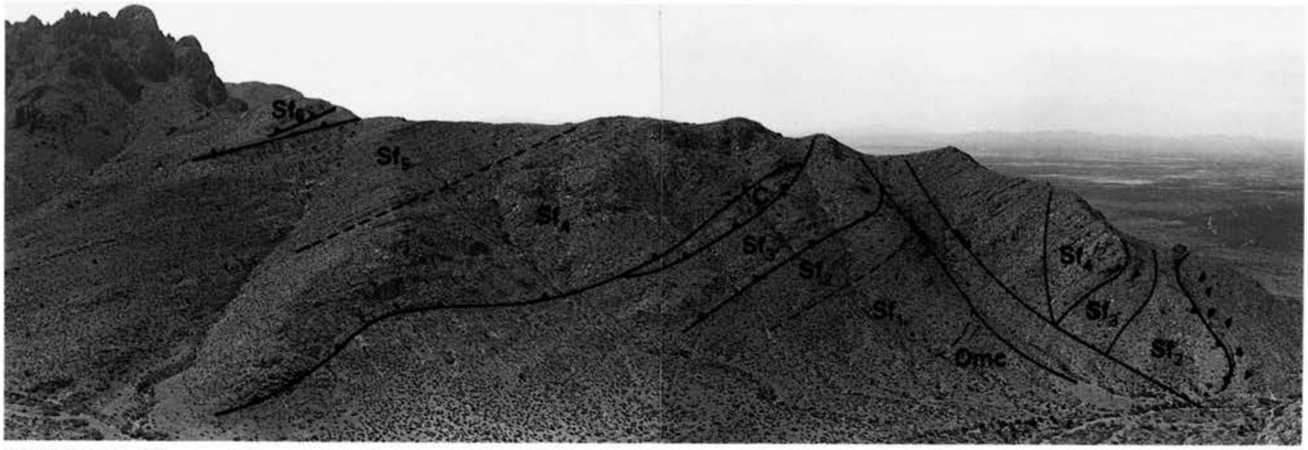


FIGURE 53—View southwest of ridge on south side of Mahoney Park showing complexly faulted Fusselman Dolomite and slab of Cutter Member (**C**) moved in by small thrust faults Cutter Member of Montoya Formation (**Omc**) in place normally overlain sequentially by six Fusselman Dolomite units (**Sf1–Sf6**).

result of this tectonic elimination is an apparent normal fault 0.25 mi to the north. Here the southward-dipping Victorio thrust fault brought the Montoya Formation upon the McKelligon strata and about 200 ft of Padre beds are cut out. Other examples of tectonic elimination are present along the trace of the thrust, where strata ranging from McKelligon Member to Fusselman Dolomite rest on syenite.

Gym Peak thrust fault

The Gym Peak thrust was named for the well-exposed, low-angle fault that underlies the upper 1,000 ft of Gym Peak (Fig. 51). In the vicinity of Gym Peak, the fault displaces strata ranging from middle El Paso Formation to Fusselman Dolomite over Bliss Sandstone to lower Fusselman beds. These younger-over-older relations are well exposed in a window on the south side of Gym Peak, where Fusselman Dolomite rests on El Paso and Montoya Formations.

The thrust-fault relations are demonstrated by a large drag fold that is well exposed in the steep cliffs north of Gym Peak. The fold is recumbent, with both upper and lower limbs cut by thrust faults (Fig. 51). The Upham and Aleman Members are repeated locally three times, with the central Montoya sequence overturned and separated by the thrust faults. Displacement on the upper thrust fault decreases northwestward and the structure becomes a recumbent anticline with an axial plane slightly inclined to the southwest. Displacement on the complementary lower thrust decreases in displacement to the southeast and the structure evolves into a recumbent syncline. The fold attitudes indicate probable generation by a northeast-yielding Gym Peak thrust fault.

The amount of horizontal displacement on the Gym Peak thrust fault may be estimated by analysis of the fold shown in cross section (Fig. 51). To restore the rocks of the fold to their original position would require at least 2,000 ft of horizontal movement. The Gym Peak thrust fault continues northwestward as the lower of two thrust levels below the north side of Mahoney Ridge. East of Mahoney Park, the Gym Peak thrust is traced southwestward back beneath the south Florida Mountains reverse fault.

Darton (1917b) and Corbitt (1971) described and mapped a large normal fault west of Gym Peak. Brown (1982) interpreted this fault as syntectonic with Laramide deformation and not Basin and Range in origin because the fault is truncated to the north and south by the Gym Peak thrust fault. The key to understanding development of extensional features within a dominantly compressive stress field comes from consideration of the following relations: 1) trend of the fault is roughly parallel to the direction of maximum compression; and 2) extreme relief changes in the Precambrian basement can localize tensional stress in an overriding allochthonous sheet, analogous to extension across the crest of domes or folds. This relationship of the major normal fault and other minor, but similar, normal faults is shown in Fig. 51. Some of the high-angle faults may be tear faults, but no evidence was found of horizontal movements on these faults.

Mahoney thrust fault

The Mahoney thrust fault is the highest thrust on Mahoney Ridge (SW¼ sec. 1 T26S R8W). East of Mahoney Park, the thrust parallels the south Florida Mountains reverse fault locally as a steep reverse fault (after removal of Basin and Range tilting the fault is nearly vertical), and it flattens upward and eastward under Mahoney Ridge. The fault trace underlies the higher levels of Mahoney Ridge and marks the lower

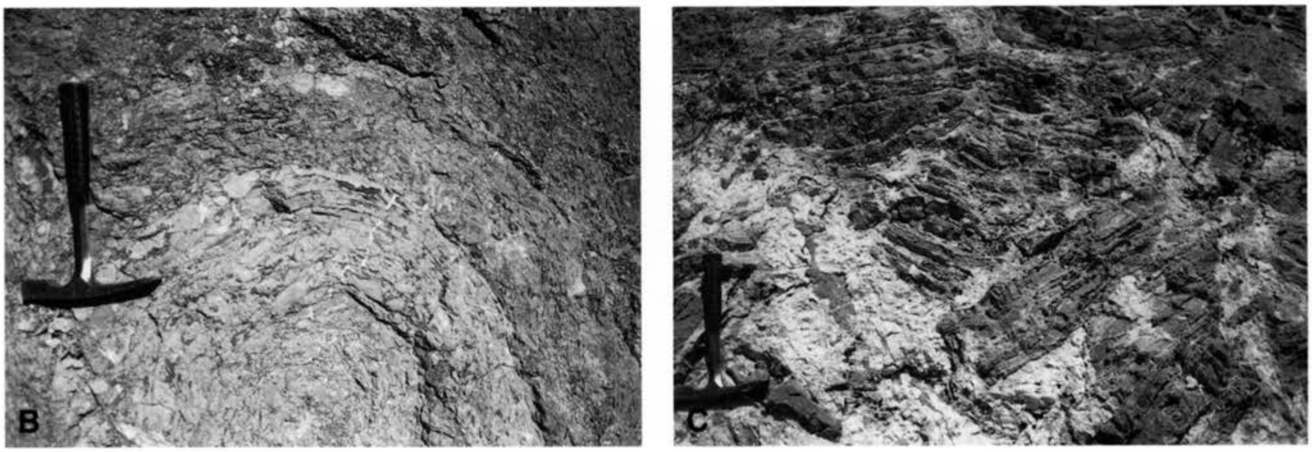


FIGURE 54—**A,** Folded and gouged Padre Member on southwest slope of Capitol Dome. **B,** Cross section of small, northwest-trending anticline in Padre Member at Capitol Dome. **C,** Brecciated Aleman Member with coarse, white-calcite matrix along small thrust at Capitol Dome.

limit of an allochthonous sheet as much as 500 ft thick. In addition to Mahoney Ridge, the thrust occurs in three isolated klippen to the north. The Mahoney thrust places younger strata over older strata (Fig. 51).

The Mahoney thrust fault is distinguished from other thrust faults by its lithology, which consists of tectonically brecciated Fusselman Dolomite except for the restricted occurrence of Percha Shale in the immediate vicinity of the south Florida Mountains reverse fault. The Mahoney thrust fault truncates underlying structures, which suggests that latest movement postdated movements on lower thrust faults. The second relation may be best explained by imbrication related to movement on the south Florida Mountains reverse fault. Sanford (1959) showed through experimental study that vertical uplift caused successive imbricating thrust slices to develop with higher levels having the latest movements. The analog here is that formation of the south Florida Mountains reverse fault initiated movement on the Gym Peak thrust (which contemporaneously influenced movement on the Victorio thrust), followed by contemporaneous and later movement on the Mahoney thrust.

Capitol Dome thrust faults

Two levels of thrusting are mapped in the Paleozoic rocks west of Capitol Dome (Sheet 3). The lower level, at its southernmost exposure, separates Bliss Sandstone and lower El Paso (Hits Canyon Member) dolomite. Faulting is not clearly evident, but some Bliss and considerable Hitt Canyon strata have been tectonically eliminated at this locale. Northward, the thrust fault gradually cuts upsection to the top of the Hitt Canyon Member and then downsection so that it is in the Bliss again at its northernmost exposure. A Tertiary andesite intruded along the thrust fault north of Capitol Dome. The upper level of thrusting lies in the upper El Paso (Padre Member) and lower Montoya (Cable Canyon–Upham Members) strata. Locally, brecciated zones in the Aleman Member (Fig. 54C) may represent a third level of thrusting. Southwest of Capitol Dome the basal 6 ft thick black limestone bed has been broken and thrust northeastward over itself for about 50 ft. On the same slope (SE¼SE¼SE¼ sec. 10 T25S R8W) the Padre Member strata have been folded into small, tight, northwest-trending folds (Sheet 3; Fig. 54). Some of the brecciated zones in the El Paso Formation west and northwest of Capitol Dome may be the result of solution collapse in caverns similar to that described for the Franklin Mountains by Lucia (1971).

Mahoney Park autochthon

The partial lower Paleozoic section beneath the Victorio thrust fault south and southwest of Baldy Peak (SW¼NE¼ sec. 36 T25S R8W) was referred to as the Mahoney Park autochthon by Brown (1982). Mahoney Park extends westward for about 1 mi from Baldy Peak. Bliss Sandstone and locally El Paso

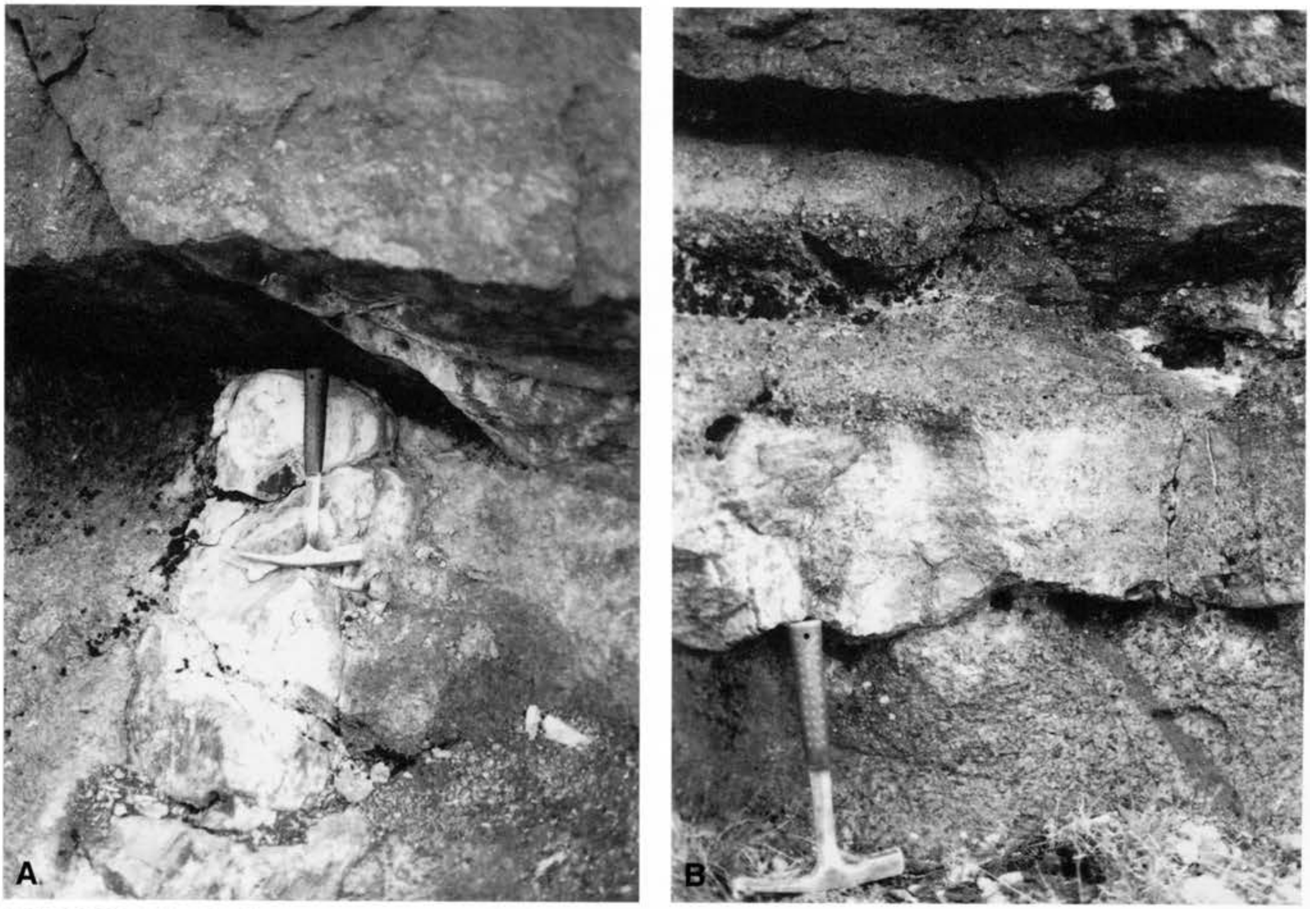


FIGURE 55—Bliss Sandstone resting nonconformably on syenite (**A**) and truncated aplite dike (**B**) east of Mahoney Park.

Formation in this area were deposited on Cambrian syenitic rocks as evidenced by nonconformable contacts (Fig. 55). Deformation is restricted to four east–northeast-trending normal faults, down to the south, which displace syenite as well as Paleozoic rocks. The development of these faults explains why these rocks remained autochthonous: thrust faults encountering massive plutonic rock transferred displacements to higher, more easily deformed levels in the Paleozoic section.

Normal faults

The Florida Mountains block has been uplifted and tilted northeastward about 23° since deposition of Rubio Peak (late Eocene) strata that form the north end of the range. Most of this movement is assigned to the west Florida Mountains fault, which is buried by alluvium south of White Hills (sec. 20 T25S R8W), but can be traced north–northeastward from a point 2.5 mi west of Capitol Dome. Windblown sand covers the fault trace in places, but a slightly eroded, west-facing, 6–10 ft high scarp truncates the Mimbres formation. The west Florida Mountains fault crosses NM–549 at the west end of the westernmost roadcut in sec. 1 T24S R8W. This range-bounding, high-angle normal fault probably was activated during the Miocene (post-29 m.y., White Hills rhyolite and post 23.6 m.y., Little Florida Mountains rhyolite) and remained active, at least intermittently, into Pleistocene time, as evidenced by offset of pediment units in the Capitol Dome quadrangle. Total vertical displacement on the west Florida Mountains fault is estimated to be about 7,000 ft. This fault may continue southward and swing southeastward between the Florida and Tres Hermanas Mountains, or it may intersect another, northwest-trending fault to the south. Corbitt (1971, 1974) placed the fault bounding the west side of the Florida Mountains along the east side of sec. 8 T26S R8W, citing as evidence the Angelus #2 "oil test" which penetrated 3,365 ft of reported Quaternary–Tertiary sediments. Records at the New Mexico Bureau of Mines & Mineral Resources show two Angelus #2 wells: 1) sec. 8 T20S R9W, total depth 150 ft gravel on granite; and 2) NE¼SE¼ sec. 8 T26S R8W, total depth 3,365 ft, Quaternary Tertiary sediments and volcanics. I believe that these two locations were reversed when they were reported.

Numerous faults in the east-central Little Florida Mountains trend north to northwest and dip 60–80°. Although both down-to-the-east and down-to-the-west movements are evident, the largest displacements have been down to the east or northeast. Lasky (1940) reported that the maximum stratigraphic throw seen in the manganese mines is approximately 200 ft; he also noted that the footwalls have steeply pitching, deep grooves suggesting dip–slip movements. Although several periods of movement can be recognized from vein structures, the latest movement predates the manganese, barite, and fluorite deposits. A small fault of similar(?) age has offset the Mimbres formation at Headquarters Draw (sec. 17 T25S R7W). The eastern block has been dropped along this fault. This fault may continue northwest through Florida Gap and may have older movements that downdropped the Little Florida Mountains block relative to the Florida Mountains.

The eastern boundary of the Florida Mountains fault block may be represented by the north-trending fault that forms a west-facing scarp about 8.5 mi east of the bedrock exposures in the Florida Mountains. This fault scarp is in sec. 14 T25S R6W, 7 mi south of the I–10 Akela exit. Permian #1 State (SE¼ sec. 4 T25S R6W) and Angelus #1 (sec. 8 T25S R6W) oil tests reported Tertiary volcanics at total depths of 3,815 ft and 3,450 ft, respectively. Eastward projection of the 20–25° dips of Rubio Peak strata in the Florida Mountains places these rocks below 4,000 ft in T25S R6W without any additional downfaulting under the wide bajada east of the mountains. Alternatively, there may be a north-trending fault under the bajada or valley fill west of the above well locations. The steep gradient on the gravity map (Fig. 48) is better explained by a steep fault than by a tilted half-graben on the east flank of the Florida Mountains. Clearly a better understanding of the valley fills and volcanics penetrated by exploration wells is needed.

The rather abrupt truncation of the southern end of the Florida Mountains indicates that there may be a N 70–80° W-trending fault covered by bajada alluvium in this area. It would run parallel to the 4 mi long rhyolite dike near the southernmost bedrock exposures. The many seismic lines that have been run across these areas in recent years should easily detect the presence of these faults.

Synthesis

Permian strata are unconformably overlain by Lobo Formation (early Tertiary) in the southeastern Florida Mountains, indicating that this area was a structural high throughout the Mesozoic era or that erosion removed the deposits by early Tertiary time. Regional stratigraphic relations support the structural high hypothesis and provide no evidence of Mesozoic rocks being stripped from the Florida Mountains area. Latest documented movements on the south Florida Mountains fault displaced Lobo conglomerates that probably had accumulated adjacent to earlier uplifted blocks. The development of imbricating thrust faults is intimately related to movements on the south Florida Mountains fault. Field evidence suggests that transport along the thrust faults was generally in a north–east direction. The interpretation that movement on the Mahoney thrust slightly postdated the lower (Gym Peak and Victorio) thrust faults best explains why most structures associated with the lower thrusts are truncated at the base of the Mahoney thrust fault (Brown, 1982).

Characteristics of Laramide structures in the Florida Mountains best fit a basement-cored uplift model with probably some associated wrench faulting (Brown and Clemons, 1983b; Seager, 1983; Mack and Clemons, 1988). The south Florida Mountains fault zone trends west–northwest parallel to the major high-angle fault zones that existed before Basin and

Range deformation in southeastern Arizona (Davis, 1979). Although small thrust faults and a few small folds of compressional origin formed during the Laramide orogeny, there is no evidence of major overthrusting.

The following lines of evidence indicate that the basement-cored uplift model is more applicable to the Laramide tectonics of the Florida Mountains than the regional overthrust model: 1) low-angle thrust displacements are predominantly of the younger-over-older type; 2) these thrust faults are mostly convex up; 3) documented vertical displacement along the south Florida Mountains fault is double that of the horizontal displacement and clearly involves Precambrian plutonic rocks; 4) total thickness of pre-Laramide Phanerozoic rocks in the area is less than 5,000 ft; 5) there is no evidence of telescoped facies; 6) the Florida Mountains have had a long history of positive structural style; and 7) the thicknesses and lithology of the syntectonic Lobo Formation (Mack et al., 1983; Mack and Clemons, 1988) represent stripping of the uplifted block and deposition in adjacent basins.

Drewes and Thorman (1980a, b) and Thorman and Drewes (1979, 1980, 1981) indicated lateral movements on several northwest-trending faults in southwestern New Mexico. As pointed out by Chapin and Cather (1981) and many other authors, recognition of strike–slip faults in the field is difficult. I believe the following characteristics of the south Florida Mountains fault (zone) provide evidence of strike–dip deformation: 1) the main faults are nearly vertical after Basin and Range tilting is removed; 2) the high-angle faults form a wide pattern of anastomosing fractures and fault breccia; 3) the strike–dip pattern of lower Paleozoic strata north of south Florida Mountains fault suggests drag associated with right-lateral motion; 4) consanguine granite and syenite are juxtaposed with granite composing the "uplifted" block; 5) Cambrian plutonic rocks are cataclastically deformed for a mile or more on either side of the high-angle, northwest-trending faults; 6) the Lobo Formation and correlative units appear to have been deposited in narrow, asymmetric, syntectonic basins; 7) positioning of the thrust-faulted areas appears to be related to undulations in the south Florida Mountains fault where compression because of lateral movement would be maximized; and 8) the Oligocene rhyolite dikes crossing the range (Fig. 56) may have intruded "gash fractures" produced by lateral movement on the north–west-trending faults.

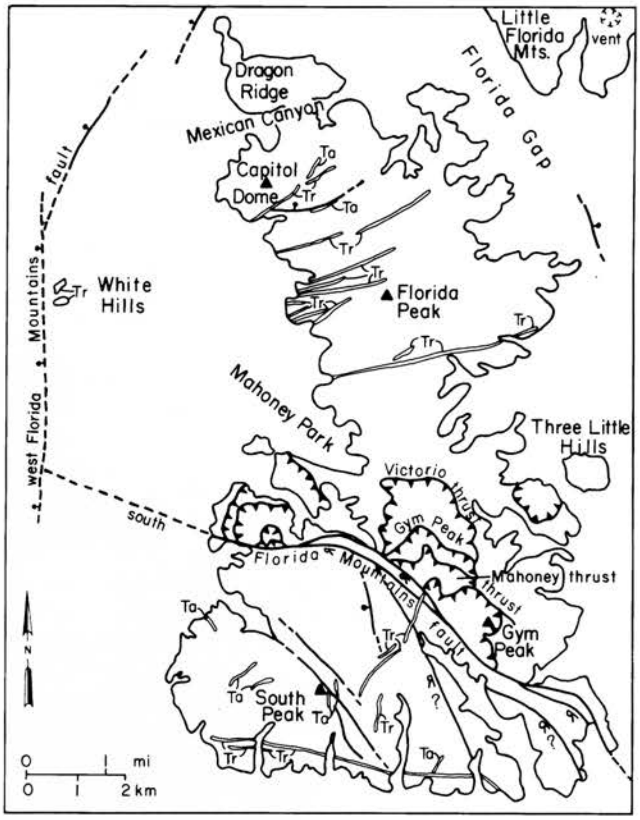


FIGURE 56—Tectonic map of Florida Mountains. **Ta** represents andesite dikes and **Tr** represents rhyolite dikes.

Mineral resources

The plutonic and volcaniclastic rocks in the Florida Mountains have undergone regnant hydrothermal alteration. Unaltered mafic minerals in the syenites and granites are rare; most show various stages of alteration to biotite, chlorite, and iron oxides. The entire Rubio Peak sequence has been intensely propylitized, and epidote concretions up to 30 cm in diameter are abundant. Joints and fractures in the Paleozoic rocks and Lobo Formation are coated locally with epidote and other secondary minerals. Syenites beneath horizontal or nearly horizontal aplite dikes are much more altered than the aplites or syenites above the dikes. This may have resulted from damming of ascending hydrothermal fluids beneath the less porous aplites. Petrographic study of the plutonic rocks shows that microscopic as well as megascopic breccia veins are abundant. These veins typically contain iron oxides, carbonate, fluorite, and locally some barite, pyrite, and chalcopyrite.

Although low-grade mineralization is widespread in the Florida Mountains, currently there are no active mines (Fig. 57). Numerous small mines and prospects with proven occurrences of zinc, copper, lead, silver, barite, fluorspar, and manganese have been worked since the late 1800s, but no work has been done on the paragenesis of the ore deposits in the Florida Mountains. Age of the mineralization is unknown, but is believed to be post-Eocene because of extensive alteration in the Rubio Peak rocks and veins formed in the fanglomerate of the Little Florida Mountains. The hydrothermal fluids could have been associated with the rhyolite dikes that cross the range (29.1 m.y.), the Little Florida Mountains rhyolite (23.6 m.y.), the Little Florida Mountains dacite (post-23.6 m.y.), or a mon-

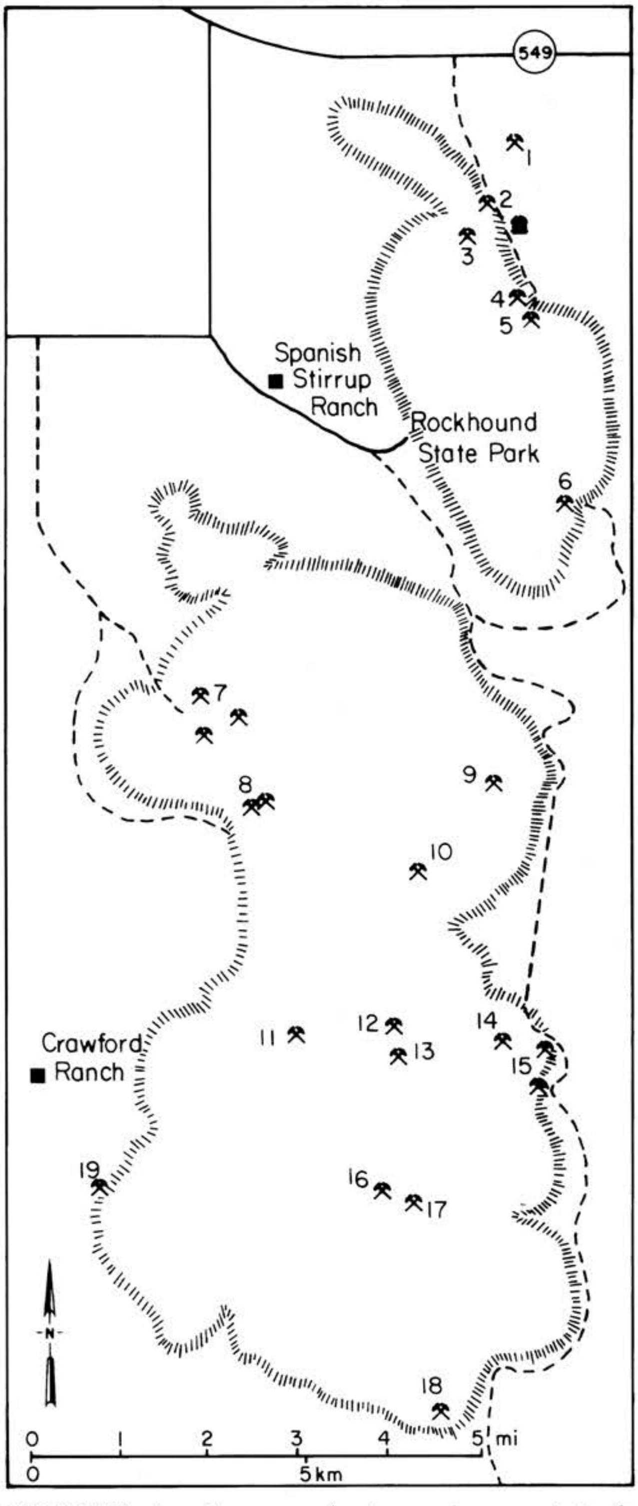


FIGURE 57—Location map of mines and prospects in the Florida Mountains. **1**, Spar Group; **2**, Ferromanganese 1 and 2; **3**, Luna; **4**, Killion; **5**, Manganese Valley; **6**, Clay quarry; **7**, San Antonio; **8**, Stenson–Copper Queen; **9**, Bradley; **10**, Atir; **11**, Park (Hilltop); **12**, Mahoney; **13**, Anniversary; **14**, San-Tex; **15**, Birchfield; **16**, Priser; **17**, Silver Cave; **18**, Pacheco; **19**, Angelus No. 2.

zonitic rock that forms small, poorly exposed outcrops in the western Gym Peak quadrangle (Clemons and Brown, 1983). Alteration of the feldspars prevents precise classification. The monzonitic rock intrudes Paleozoic rocks and is believed to be post-Laramide in age because it intrudes the small thrust sheets and along the south Florida Mountains fault. Petrographically similar monzonitic intrusions cut the Miocene–Oligocene volcanic rocks near Deming (Clemons, 1986a).

Metallic deposits

Mahoney mines

The Mahoney mines are located on Mahoney Ridge (sec. 1 T26S R8W) and are accessible by a four-wheel-drive road from Mahoney Park. The mineral claims are the property of Gene Cook of Deming and permission is required for access and use of the road.

A mine was noted by Darton (1917b) as active in 1914, but date of discovery and earlier work are unknown. Several ore shipments are believed to have been made in 1915–1917 and 1926 (Griswold, 1961). According to Gene Cook, the ore was hand-sorted and assayed at the mines, carried by pack mule to Mahoney Park, and then taken by wagon to Deming for rail shipment. The mines were apparently dormant until the late 1960s, when 15 claims were staked by Gene Cook. Recent work included mining of higher-grade mine dumps and development of exploratory adits.

The deposit is within the Mahoney thrust sheet. Mineralization is restricted to northeast-trending, near-vertical veins in brecciated Fusselman Dolomite. Locally the veins are 5 ft wide, but typically they pinch and swell. Past development of the mines included: 1) trenches on veins; 2) several vertical shafts; 3) a long adit that follows a vein southwestward from the base of the Mahoney thrust on the northeast side of Mahoney Ridge (Brown, 1982); and 4) a short adit developed during the 1970s on the crest of Mahoney Ridge.

Darton (1917b) referred to the Mahoney mines as a zinc deposit, and Griswold (1961) described them as lead–zinc–copper producers. According to Gene Cook, the predominantly zinc-rich ore occurs in localized, high-grade pockets of "dry bone" smithsonite with minor associated silver, lead, and copper values. Because of extensive mining, little ore remains for examination. The vein material is highly oxidized and contains smithsonite, cerussite(?), malachite, and azurite as potential ore minerals in a gangue of limonite, quartz, and calcite. Minor amounts of galena, sphalerite, barite, fluorite, and psilomelane were also noted. Partial analyses of two grab samples are shown in Table 10. Study of polished sections shows galena and calcite in dolomite host. The galena contains minor covellite and very tiny, elongate blebs of freibergite(?) and pyrargyrite(?). Minor euhedral pyrite occurs in the galena and calcite. A polished section of pyrite skarn (Table 10, no. 3) contains pyrite partly replaced by goethite and lepidocrocite. No silver or zinc minerals were observed.

The mineralization is not offset by Laramide deformation and, therefore, is of post-Eocene age. The veins are approximately parallel to normal faults in the Gym Peak thrust sheet below; therefore, the faults probably served as conduits for ascending ore fluids, and depo-

TABLE 10—Partial chemical analyses of selected ore and rock samples. **1**: galena in Fusselman Dolomite, Mahoney Park; **2**: galena in Fusselman Dolomite, Mahoney mines; **3**: pyrite-rich skarn, Mahoney mines; **4**: galena–barite–fluorite, Atir mine; **5**: dry-bone smithsonite, San Antonio mine; **6**: metadiorite, NM–90 roadcut Gold Hill quadrangle (Precambrian diabase dike of Hedlund, 1978); **7**, **8**: hornblende hornfels, South Peak quadrangle; **9**: Pyroxene hornfels, South Peak quadrangle; **10**: hornblende hornfels, Gym Peak quadrangle. *Analyses in ppm; **nd**: none detected; **NA**: not analyzed; **tr**: trace.

Sample number	percent Cu	percent Pb	percent Zn	oz/ton Ag	oz/ton Au	ppm Ni	ppm Co	ppm Cr
1	0.009	7.77	0.006	nd	nd	NA	NA	NA
2	0.038	34.29	6.68	20.56	nd	NA	NA	NA
3	0.023	0.07	0.043	5.74	nd	NA	NA	NA
4	0.02	4 99	3.69	0.86	tr	NA	NA	NA
5	0.45	0.75	46.1	0.40	nd	NA	NA	NA
6	101*	NA	NA	NA	NA	142	72	203
7	155*	NA	NA	NA	NA	252	51	656
8	86*	NA	NA	NA	NA	198	74	230
9	72*	NA	NA	NA	NA	499	106	833
10	128*	NA	NA	NA	NA	140	64	227

sition occurred in the chemically and texturally receptive Fusselman Dolomite.

Silver Cave mine

The Silver Cave mine is located at the head of the canyon on the south slopes of Gym Peak (SW¼ sec. 7 T26S R7W).

Lindgren et al. (1910) mentioned mineral development at the Silver Cave mine but did not visit the area. Darton (1917b) referred to the mine as a silver–lead deposit. The mine was active during the period 1881–1885 and produced 1,800 tons of oxidized silver ore valued at $60,000 (Jones, 1904). Apparently, there has been no production since that time. The mine is covered by two patented claims, the Silver Cave Lode (M.S. 644) and the Pocohonta Lode (M.S. 632; Griswold, 1961).

Mineralization occurs in Fusselman Dolomite on part of the homocline that forms most of Gym Peak. The south Florida Mountains fault is approximately 250 ft to the south; it brecciated the Fusselman host rock locally.

A north-trending, inclined adit was used for extraction of ore and access to slopes. Mineralization was in a north-trending, vertical vein. Only small amounts of galena and cerrusite remain in the adit and on nearby dumps. Griswold (1961) noted a small shaft 150 ft northeast of the incline where some stoping was done on a N 80°W fracture zone that contained replacement pods of oxidized lead–zinc ore (cerrusite and smithsonite? in a gangue of limonite, calcite, and quartz). This shaft is now inaccessible, but the small mine dumps indicate little underground development. Prospect pits are ubiquitous in the hillsides surrounding the mine, but no significant mineral occurrences were noted. Mineralization is similar to that on Mahoney Ridge.

Anniversary prospect

The Anniversary prospect is located approximately 1,300 ft southwest of the Mahoney mines (SW¼ sec. 1 T26S R8W). It is the property of Gene Cook, the man who filed six claims in 1970 (Anniversary 16). Access is by a four-wheel-drive road that connects with the Mahoney mines road.

A small deposit of fluorite (200 tons, 60% effective) was leased and mined by Bailey Fluorspar Company of Marfa, Texas, which operated a fluorspar shipping terminal in Deming (McAnulty, 1978). The fluorite occurs as open-space filling and replacement of El Paso limestone in and near a fault-breccia zone. The deposit was localized near a change in strike of a major high-angle fault that forms the northern boundary of an intricately step-faulted zone that continues southeast for approximately 0.5 mi.

Priser mine

The Priser mine is located on the southwest slopes of Gym Peak near the head of Copper Kettle Canyon (NW¼SE¼ sec. 12 T26S R8W). Access is by a four-wheel-drive road through Copper Kettle Canyon.

This mine was described by Clemons and Brown (1983), but examination was restricted to surface exposures because the underground workings were considered unsafe. Manganese and fluorite mineralization, with manganese predominating, was observed on the dumps. Mineralization occurred in plutonic rocks that are brecciated and sheared by movement on the south Florida Mountains fault. The size of the mine dumps indicates minor underground development.

Atir mine

The Atir mine is located near the head of Lobo Draw (SE¼ sec. 24 T25S R8W). Griswold (1961) referred to this mine as the Waddel prospect. It was renamed and explored by Consolidated Minerals Corp. in 1959.

The Atir mine exploited mineralization in the Lobo Formation along a west-trending, south-dipping, normal fault zone that dropped Lobo down against Cambrian syenite. Development consists of an adit and several winzes on the vein, which dips 60° south. The adit is about 170 ft long, with good fluorite–barite–galena mineralization for the first 50 ft and spotty mineralization for another 50 ft; the last 70 ft is mostly syenite gouge. Ore was transported by bucket-cable line down to a crusher located 800 ft below and 2,100 ft east of the mine. A partial analysis of a sample from the adit wall is shown in Table 10. Study of a polished section of galena ore shows the paragenetic sequence to be quartz–galena–calcite–cerussite–± covellite. No silver minerals were observed. Another ore sample, not sectioned, contains a small amount of sphalerite.

During 1979 and 1980, Barite of America Co. drove a large adit from a point 2,100 ft southeast of the Atir mine through syenite cut by rhyolite and basaltic-andesite dikes in an attempt to intersect the Atir vein at a lower level. The adit trends N 30°W for 775 ft. At 600 ft a branch adit extends 220 ft to the N 55°E. A 900 ft horizontal drill core was taken in a N 60°W direction from the end of the 775 ft adit (Fig. 58). The adits and core transected many small fissure veins, but exploration ceased in 1980 and the prospect is inactive currently. Approximately 60% of the core is intensely prospect is in Precambrian hornblende and pyroxene hornfels. These hornfels have been referred to previously as gabbro, diorite, meladiorite, andesite, and diabase. The hornfels were produced by intrusion of a volcanic sequence by syenite magma. The vein trends N 70°E and dips steeply south. Three adits have been driven along the vein; the upper one is labeled Stenson mine and the lower one Copper Queen mine on the topographic quadrangle. Griswold (1961) reported the middle adit showed a vein containing chalcopyrite with pyrite, magnetite, and quartz. Partial oxidation of vein minerals produced malachite and limonite.

Bradley mine

The Bradley mine is located about 2 mi south of Florida Gap in SW¼ SE¼ sec. 18 T25S R7W. Griswold (1961) believed this mine was one of the oldest in the Florida Mountains because it was active around the turn of the century. The deposit is along an east-trending, vertical vein in Rubio Peak tuffaceous sandstones and conglomerate. Dump material extracted from the vein contains galena, sphalerite(?), chalcopyrite, pyrite, limonite, calcite, and quartz (Griswold, 1961). The Stub mine, 1 mi northwest in Windmill Canyon, is believed to have produced minor amounts of ore similar to that from the Bradley mine. The Stub mine consists of two shafts of unknown depth along an east-trending vein in Rubio Peak tuffaceous sandstones and conglomerate.

Little Florida Mountains mining district

The Little Florida Mountains mining district is located at the northeastern end of the range, approximately 2 mi south of NM–549 (Fig. 57). First claims in the district were filed in 1918 and various mines were worked sporadically until 1959, with principal production preceding 1939. Approximately 95% (16,000 tons of hand-sorted ore) of the district's manganese production came from the Manganese Valley mine. Second in importance was the Luna mine (labeled West mine on current topographic maps). A third group of claims (American Group) apparently had little production (Lasky, 1940; Evans, 1949; Griswold 1961). The U.S. Bureau of Mines conducted an exploratory project of trenching, sampling, and core drilling in 1940–1941. Work included 1,690 ft of trenches, 4,588 ft of diamond-drill cores, analyzing 924 mine samples, 92 drill-hole samples, and 23 tailings samples, sinking 59 ft of shaft on the Manganese Valley mine, and pumping out and rehabilitating the Luna mine (Evans, 1949).

The deposits are along north-trending veins emplaced along fault fissures. All the veins and mine workings are in the rhyolite fanglomerate of the Little Florida Mountains. Each vein typically has an almost perfect slickensided and grooved footwall composed of silicified (jasperoid) fault breccia (Lasky, 1940; Evans, 1949). Lasky (1940) reported that the ore consists of manganite, psilomelane, pyrolusite, and wad that 1) fill hanging-wall fractures, 2) replace post-jasperoid, but pre-mineral, fault gouge and breccia, and 3) replace some fanglomerate clasts. Hanging-wall fractures are commonly filled with crystalline manganite. Much of the ore consists of hard psilomelane crusts and partial replacement of rock fragments in a matrix of soft, clayey material composed chiefly of wad and pyrolusite. Some of this "pudding ore" contains botryoidal hematite, which is so abundant locally that it reduces the value of the ore.

Joan Beyer (written comm. 1983) analyzed several samples of manganese ore from the Manganese Valley and Luna mines (Fig. 60A, B) in polished sections and by x-ray defractometry. She reported that the ores contain cryptomelane, pyrolusite, psilomelane, ramsdellite, hollandite, coronadite(?) with hematite, manganocalcite, calcite, quartz, and barite. The Spar Group of claims, north of the principal manganese deposits, contains barite and fluorite mineralization that was mined intermittently from 1925 to 1951. The barite– fluorite veins are along similar north-trending faults in the rhyolite fanglomerate and are believed to be related to the same general period of mineralization (middle–late Miocene?). Griswold (1961) indicated the probable paragenesis of fluorspar ore was an initial stage of fluorspar, barite, calcite, and quartz, followed by recurrent movement along the veins and then deposition of manganese oxides.

Other mines and prospects

The following manganese mines are reported to have shipped small tonnages during World War II, and again in the middle 1950s (Griswold, 1961). Pacheco mine, a manganese deposit located in NW¼NW¼ sec. 24 T26S R8W, was previously named the White King mine. Griswold (1961, p. 128) mislocated this mine in sec. 13. San-Tex mine, a manganese deposit located in E½SE¼ sec. 31 T25S R7W, was previously named the White King mine. Griswold (1961, p. 128) mislocated this mine in T26S. Birchfield mines (Fig. 60C) are manganese prospects located in NE¼ sec. 6 T26S R7W. Birchfield zinc prospect is located in SW¼ sec. 32 T25S R7W. Griswold (1961) reported that a carload of zinc ore was reported to have been shipped from the deposit in 1949, but only manganese minerals were found in the dumps and mine workings during this study.

A small prospect in the small, northwest-trending canyon in the NW¼ sec. 9 T26S R8W is in hornfels and granite. No ore minerals were seen, but probably traces of copper mineralization similar to the Stenson and Copper Queen mines to the north attracted prospectors. A partial analysis of a pyroxene hornfels from this prospect is shown in Table 10 (no. 9). In general, propylitization is not as pervasive in the southern Florida Mountains as it is in the syenites to the north. Locally, the granite contains disseminated gossan zones. Angelus No. 2 "oil test" with total depth of 3,365 ft reported by Kottlowski, Foster, and Wengerd (1969, p. 191) and Wengerd (1970) in NE¼SE¼ sec. 8 T26S R8W is approximately 0.25 mi southwest of the prospect described above. Examination of records at the New Mexico Bureau of Mines & Mineral Resources disclosed that there are two Angelus No. 2 "wells." The other one was only 180 ft deep and reported gravel to total depth. I believe this 180 ft hole was drilled about 1920(?) in search of mineralization in the granite under pediment gravels.

Clay, sand, and gravel

A clay pit at the southeast end of the Little Florida Mountains is located in altered tuff associated with rhyolite. The period of activity, amount and type of material removed, and its use have not been determined. Neither Lasky (1940) nor Griswold (1961) mentioned the clay quarry, but the U.S.G.S. topographic map published in 1964 shows a gravel quarry at this location.

Numerous sand and gravel quarries, gravel pits, and borrow pits are scattered over the area northwest and west of the Florida Mountains (because of proximity to Deming). These alluvial deposits of the ancestral Mimbres River and major Florida Mountains arroyos are used for building and road construction. The New Mexico Highway Department periodically operates a crusher in a gravel quarry in SW¼ sec. 21 T26S R8W. Similar alluvial gravels are abundant under caliche caps all around the southwestern end of the Florida Mountains. Abandoned gravel pits near NM–11 have provided materials from unconsolidated arroyo distributary deposits. Reserves appear to be adequate for many years.

Oil and gas

Most of the Paleozoic rocks exposed in the Florida Mountains probably underlie basin alluvium and Tertiary volcanic rocks to the east and west of the mountains. Thompson (1981, 1982) indicated that El Paso, Montoya, Percha, Rancheria, and Hueco strata possess fair potential as source rocks and parts of the El Paso, Montoya, Fusselman, and Hueco Formations are evaluated as fair to good reservoir rocks. Thompson et al. (1978) also ranked the El Paso and Fusselman dolostones as two of the best exploration objectives in the Pedregosa Basin and adjoining areas. Greenwood (1970), Greenwood and Kottlowski (1975), Greenwood et al. (1977), Kottlowski (1965b, 1971), Kottlowski, Foster, and Wengerd (1969), Thompson, et al. (1978), and Wengerd (1969, 1970) have discussed

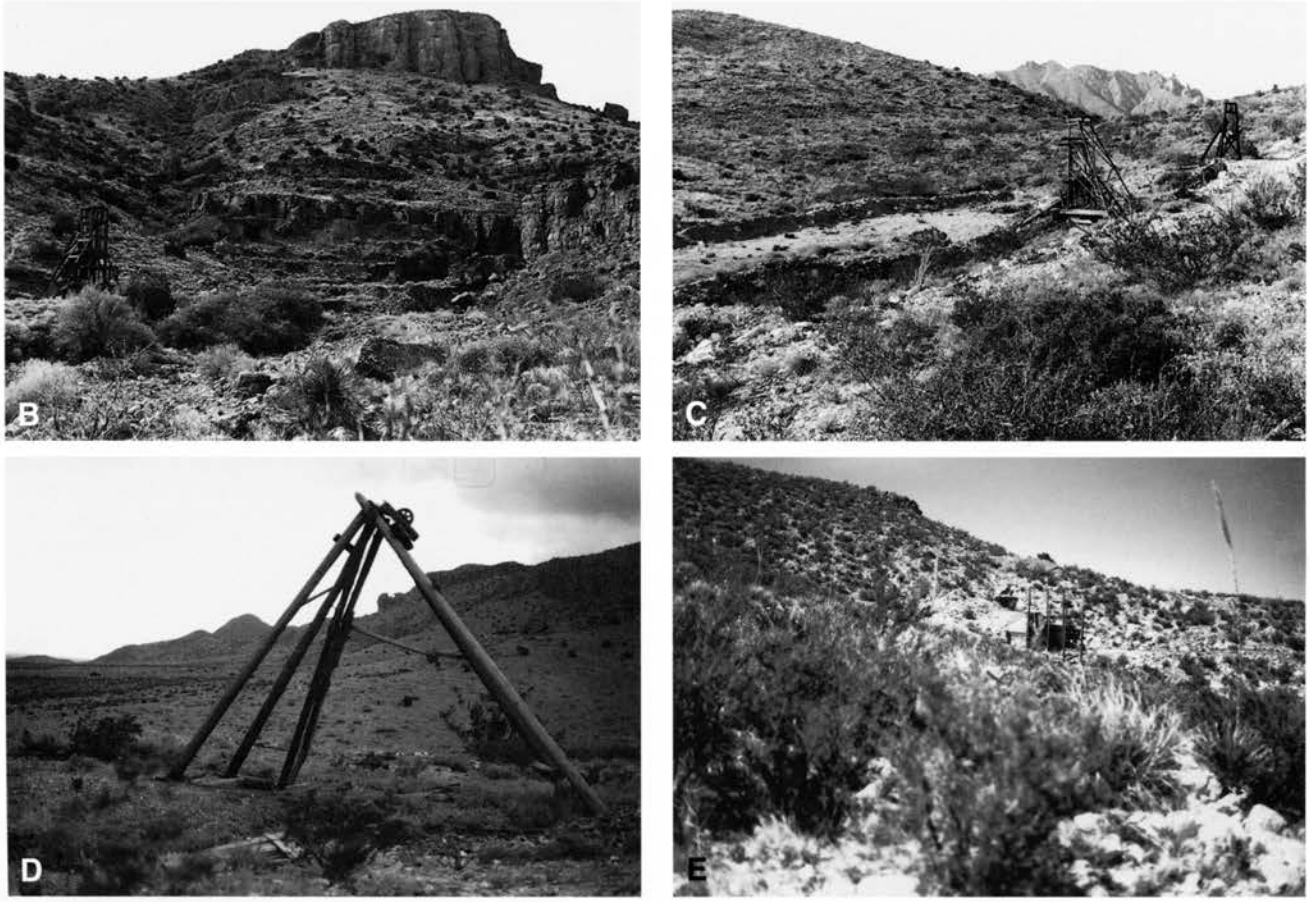


FIGURE 60—**A,** Luna manganese mine. **B,** Manganese Valley mine. **C,** Birchfield manganese mine with Florida Peak in background. **D,** Remains of headframe on northern end of Luna vein; Little Needle's Eye is in background near the Luna mine. **E,** Mahoney mine on crest of southern Florida Mountains.

the oil and gas exploration wells and petroleum potential of south-central and southwestern New Mexico. Broadhead (1982, 1983, 1984) reported results of recent exploration in southwestern New Mexico. Key oil and gas exploration wells drilled in Luna County through 1983 are shown in Fig. 61.

Frontier exploration in southwestern New Mexico has been encouraged because of the stratigraphic similarities of the Paleozoic section with that of the Permian Basin and of the Lower Cretaceous section with that of the western Gulf Basin. Pennsylvanian and Cretaceous rocks are missing in the Florida Mountains, the Mississippian consists of only 250 ft of Rancheria Limestone, and the Permian is represented by only about 400 ft of Hueco Limestone. All of these systems increase in thickness rapidly to the southwest off the flank of the Burro–Florida uplift. The Mississippian section in the Klondike Hills, 30 mi west of the Florida Mountains, contains more than 1,200 ft of carbonates (Armstrong, 1970). The upper Paleozoic section in Sierra Alta (Fig. 61), 30 mi southwest of the Florida Mountains, contains about 8,000 ft of carbonates and shales (Diaz and Navarro, 1964; Wilson et al., 1969). The Lower Cretaceous section contains more than 10,000 ft of clastic and carbonate rocks just southwest of Sierra Alta (Thompson et al., 1978).

Upper Paleozoic and Lower Cretaceous rocks of varying thicknesses must underlie much of southwestern Luna County. Outcrops in the northeastern Tres Hermanas Mountains (Kottlowski and Foster, 1962) contain Mississippian (360 ft), Pennsylvanian (560 ft), and Permian (525 ft) rocks. The Permian section may be several hundred feet thicker because what was mapped as Fusselman Dolomite (Balk, 1962) may be Epitaph Dolomite. Supporting evidence for this interpretation is present about 2.5 mi to the west in the West Lime Hills. I have re-examined the section published by Kottlowski and Foster (1962), and I have studied petrographic thin sections from this section on two 2,300 ft cores 1 and 2 mi north of West Lime Hills and from two small outliers 2.8 and 3.5 mi northwest of West Lime Hills. The northernmost exposure is Hueco or Colina Limestone, and the small hill 0.7 mi to the southeast of that exposure is composed of prob-

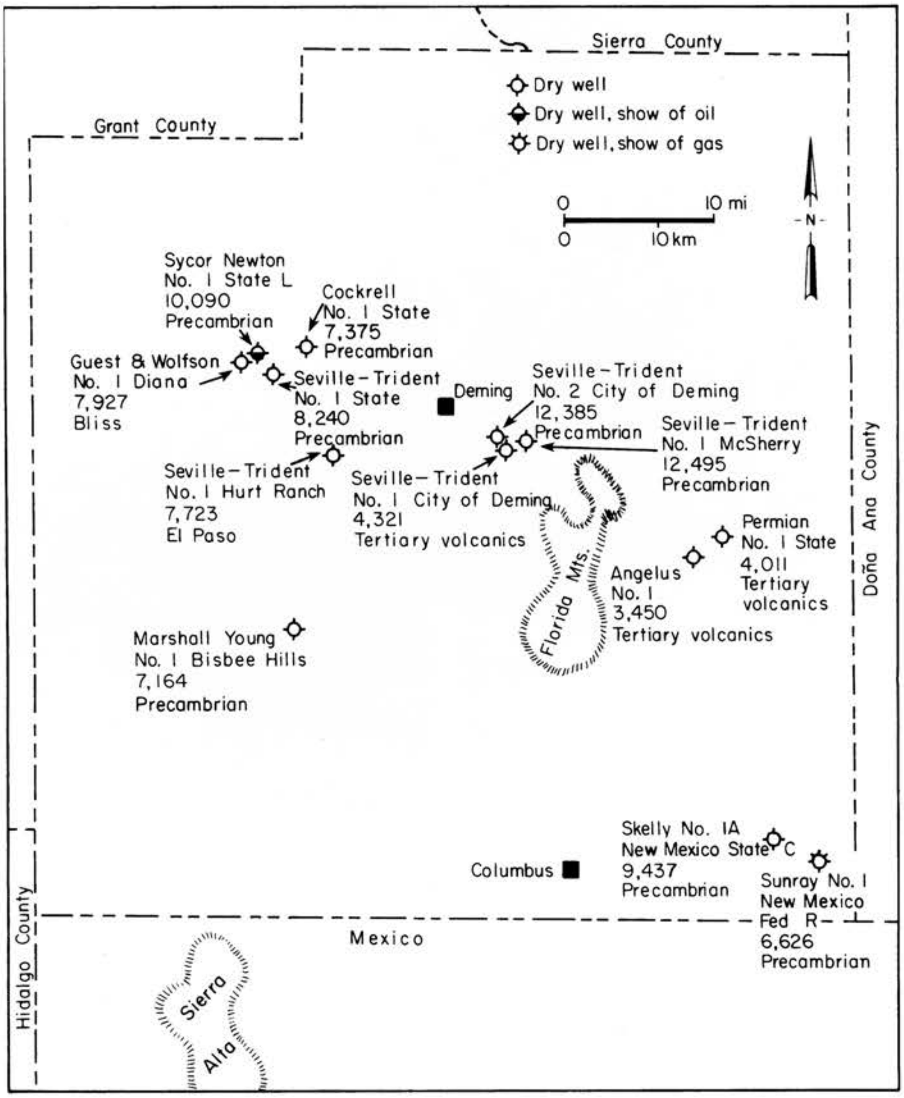


FIGURE 61—Map of Luna County showing locations of key oil and gas exploration wells. Listed at each well are the name, total depth, and rock penetrated in the well bottom.

able Colina Limestone overlain by Epitaph Dolomite. One of the cores between this hill and the West Lime Hills contains about 1,500 ft of fossiliferous, black limestone and shale probably belonging to the Colina. The basal 370 ft of the West Lime Hills section is now interpreted (Greg Mack, oral comm. 1984) to be correlative with the Hell-to-Finish Formation (Lower Cretaceous). The top of the Hell-to-Finish section is in fault contact with about 400 ft of massive marbleized limestones, which are probably of Permian age. These are overlain by, or are in fault contact with, about 400 ft of conglomerates that are probably correlative with the Lobo Formation (Paleocene?). Several hundred feet of limestone and dolomite that cap the long ridge of the West Lime Hills have been thrust onto the Lobo conglomerates. A. C. Selby and T. R. Carr of ARCO Exploration Company collected and identified early Leonardian conodonts from the dolomites (Thompson, 1982). Some of the limestones contain solitary corals and large gastropods similar to those typical of the Colina–Hueco Formations. Therefore the carbonates composing the small thrust plate are considered correlative with the Colina–Epitaph Formations.

Renewed interest and frontier oil and gas exploration in southwestern New Mexico were stimulated by the postulated continuation of the western fold-thrust belt through the state. Field work in this region during the past several years has produced no supporting evidence for large-scale thrusting. Present tectonic interpretations favor a basement-cored uplift model with small-scale thrusting on the flanks and possibly some wrench-fault components (Brown and Clemons, 1983b; Clemons and Brown, 1983; Clemons, 1985a; Davis, 1979, 1981; Dickinson, 1984; Seager, 1983). In consideration of this interpretation, exploration should be conducted to search for targets in possible subsurface northwest-trending basins (possibly en-echelon) produced between the uplifts by Laramide stresses and now buried by Basin and Range deformation and deposition. I also recommend that potential targets are located southwest of the Burro–Florida uplift (Figs. 47, 61).

Ground water

Probably the chief and most valuable resources of the Mimbres Basin area surrounding the Florida Mountains are its ground water and fertile soil. Darton's (1916) study of Luna County evaluated and documented the ground water and soil of the area. McLean (1977) made another study of the hydrology of the Mimbres Basin, and Neher and Buchanan (1980) made a soil survey of Luna County.

References

Albritton, C. C., and Smith, J F., 1957, The Texas lineament; *in* Relaciones entre la tectonica y la sedimentacion, tomo 2: Twentieth International Geological Congress, Mexico City, 1956, sec. 5, pp. 501–518.

Aldrich, M. J., and Laughlin, A. W., 1982, Orientation of least principal horizontal stress: Arizona, New Mexico, and the Trans-Pecos area of west Texas: Los Alamos National Laboratory, New Mexico, LA–9158–Map, scale 1:1,000,000.

American Commission on Stratigraphic Nomenclature, 1961, Code of stratigraphic nomenclature: American Association of Petroleum Geologists, Bulletin, v. 45, pp. 645–665.

Armbrustmacher, T. J., 1984, Alkaline rock complexes in the Wet Mountains area, Custer and Fremont Counties, Colorado: U.S. Geological Survey, Professional Paper 1269, 33 pp.

Armstrong, A. K., 1962, Stratigraphy and paleontology of the Mississippian System in southwestern New Mexico and adjacent southeastern Arizona: New Mexico Bureau of Mines and Mineral Resources, Memoir 8, 99 pp.

Armstrong, A. K., 1970, Mississippian stratigraphy and geology of the northwestern part of the Klondike Hills, southwestern New Mexico: New Mexico Geological Society, Guidebook to 21st Field Conference, pp. 59–63.

Armstrong, A. K., and Mamet, B. L., 1978, The Mississippian System of southwestern New Mexico and southeastern Arizona: New Mexico Geological Society, Guidebook to 29th Field Conference, pp. 183–192.

Bachman, G. O., 1968, Geology of the Mockingbird Gap quadrangle, Lincoln and Socorro Counties, New Mexico: U.S. Geological Survey, Professional Paper 594–J, 43 pp.

Bachman, G. O., and Myers, D. A., 1969, Geology of the Bear Peak area, Dona Ana County, New Mexico: U.S. Geological Survey, Bulletin 1271–C, 46 pp.

Baker, C. L., 1927, Exploratory geology of a part of southwestern Trans-Pecos Texas: University of Texas (Austin), Bulletin 2745, 70 pp.

Baker, C. L., 1935, Major structural features of Trans-Pecos Texas; *in* The geology of Texas: University of Texas (Austin), Bulletin 3401, v. 2, pp. 137–214.

Balk, R., 1962, Geologic map of Tres Hermanas Mountains: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 16, scale 1:48,000.

Ballman, D. L., 1960, Geology of the Knight Peak area, Grant County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 70, 39 pp.

Becker, C. M., 1914, Historical and geological survey of the Florida Mountains: Mining Science, v. 70 (August), pp. 35–36.

Bogart, L. E., 1953, The Hueco (Gym) Limestone, Luna County, New Mexico: Unpublished MS thesis, University of New Mexico (Albuquerque), 91 pp.

Bowsher, A. L., 1968, The Devonian System in New Mexico; *in* Toomey, D. E (ed.), Silurian–Devonian rocks of Oklahoma and environs, 1967 symposium: Tulsa Geological Society Digest, v. 35, pp. 259–276.

Broadhead, R. F., 1982, Oil and gas discovery wells drilled in New Mexico in 1981: New Mexico Geology, v. 4, no. 2, pp. 17–19, 32.

Broadhead, R. F, 1983, Oil and gas discovery wells drilled in New Mexico in 1982 New Mexico Geology, v. 5, no. 2, pp. 30–34.

Broadhead, R. F., 1984, Oil and gas discovery wells drilled in New Mexico in 1983: New Mexico Geology, v. 6, no. 2, pp. 21–27.

Bromfield, C. S., and Wrucke, C. T., 1961, Reconnaissance geologic map of the Cedar Mountains, Grant and Luna Counties, New Mexico: U.S. Geological Survey, Miscellaneous Field Studies Map MF–159.

Brookins, D. G., 1974a, Preliminary radiometric age determinations from the Florida Mountains, New Mexico: El Paso Geological Society, Guidebook 8, pp. 47–56.

Brookins, D. G., 1974b, Radiometric age determinations from the Florida Mountains, New Mexico: Geology, v. 2, pp. 555–557.

Brookins, D. G., 1980a, Geochronologic evidence for Paleozoic plutonic activity in the Florida Mountains, New Mexico (abs.): American Association of Petroleum Geologists, Bulletin, v. 64, pp. 681–682.

Brookins, D. G., 1980b, Paleozoic plutonism from southern New Mexico: Evidence from the Florida Mountains: Geophysical Research Letters v. 7, pp. 741–744.

Brookins, D. G., and Corbitt, L. L., 1974, Preliminary Rb–Sr study of igneous rocks of the Florida Mountains, New Mexico (abs.): E.O.S. (American Geophysical Union, Transactions), v. 55, pp. 470–471.

Brookins, D. G., Rautman, C. E., and Corbitt, L. L., 1978, Uranium and thorium abundances and whole rock chemistry of the Florida Mountains, New Mexico—preliminary study: University of New Mexico (Albuquerque), New Mexico Energy Institute, Report no. 77–1104C, 22 pp.

Brown, G. A., 1982, Geology of the Mahoney mine–Gym Peak area, Florida Mountains, Luna County, New Mexico: Unpublished MS thesis, New Mexico State University (Las Cruces), 82 pp.

Brown, G. A., and Clemons, R. E., 1983a, Florida Mountains, southwest New Mexico—part of Cordilleran overthrust belt or foreland block uplift? (abs.): American Association of Petroleum Geologists, Bulletin, v. 67, p. 432.

Brown, G. A., and Clemons, R. E., 1983b, Florida Mountains section of southwest New Mexico overthrust belt—a reevaluation: New Mexico Geology, v. 5, no. 2, pp. 26–29.

Chapin, C. E., and Cather, S. M., 1981, Eocene tectonics and sedimentation in the Colorado Plateau–Rocky Mountains area, *in* Dickinson, W. R., and Payne, W. D. (eds.), Relations of tectonics to ore deposition in the southern Cordillera: Arizona Geological Society Digest (Tucson), v. XIV, pp. 173–198.

Chapin, C. E., and Seager, W. R., 1975, Evolution of the Rio Grande rift in the Socorro and Las Cruces areas: New Mexico Geological Society, Guidebook to 26th Field Conference, pp. 297–321.

Clemons, R. E., 1979, Geology of Good Sight Mountains and Uvas Valley southwest New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 169, 31 pp.

Clemons, R. E., 1982a, Geology of Florida Gap quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 52, scale 1:24,000.

Clemons, R. E., 1982b, Preliminary report on petrography and age of Florida Mountains plutonic rocks: New Mexico Geology, v. 4, no. 3, pp. 33–38.

Clemons, R. E., 1982c, Geology of Massacre Peak quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 51, scale 1:24,000.

Clemons, R. E., 1982d, Florida Mountains plutonic rocks (Luna County, New Mexico) are Precambrian age; *in* Hagni, R. D. (ed.), Process mineralogy II: The Metallurgical Society of American Institute of Mining Engineers, pp. 411–420.

Clemons, R. E., 1984, Geology of the Capitol Dome quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 56, scale 1:24,000.

Clemons, R. E., 1985, Geology of the South Peak quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 59, scale 1:24,000.

Clemons, R. E., 1986a, Petrographic analysis of cuttings and interpretive stratigraphy of Seville–Trident exploration wells near Deming, New Mexico: New Mexico Geology, v. 8, pp. 5–11.

Clemons, R. E., 1986b, The Florida Mountains: revisited; *in* Geology of South-central New Mexico: El Paso Geological Society Field Trip, pp. 125–140.

Clemons, R. E., and Brown, G. A., 1983, Geology of Gym Peak quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 58, scale 1:24,000.

Cloud P. E., and Barnes, V. E., 1948, The Ellenburger Group of central Texas: University of Texas (Austin), Bureau of Economic Geology, Publication 4621, 473 pp.

Coney, P. J., 1976, Plate tectonics and the Laramide orogeny: New Mexico Geological Society, Special Publication 6, pp. 5–10.

Coney, P. J., 1978, The plate tectonic setting of southeastern Arizona: New Mexico Geological Society, Guidebook to 29th Field Conference, pp. 285–290.

Cooper, G. A., and Dutro, J. T., 1982, Devonian brachiopods of New Mexico: Bulletins of American Paleontology, v. 82–83, no. 315, 215 pp.

Corbitt, L. L., 1971, Structure and stratigraphy of the Florida Mountains, New Mexico: Unpublished PhD dissertation, University of New Mexico (Albuquerque), 115 pp.

Corbitt, L. L., 1974, Structure and stratigraphy of the Florida Mountains: El Paso Geological Society, Guidebook 8, pp. 16–29.

Corbitt, L. L., and Woodward, L. A., 1970, Thrust faults of the Florida Mountains, New Mexico, and their regional tectonic significance: New Mexico Geological Society, Guidebook to 21st Field Conference, pp. 69–74.

Corbitt, L. L., and Woodward, L. A., 1973a, Upper Precambrian diamictite of the Florida Mountains, southwestern New Mexico: Geological Society of America, Bulletin, v. 84, pp. 171–173.

Corbitt, L. L., and Woodward, L. A., 1973b, Tectonic framework of the Cordilleran foldbelt in southwestern New Mexico: American Association of Petroleum Geologists, Bulletin, v. 57, pp. 2207–2216.

Corbitt, L. L., Nials, F. L., and Varnell, R. J., 1977, Structure of Brockman Hills, southwestern New Mexico: American Association of Petroleum Geologists, Bulletin, v. 61, pp. 601–607.

Corbitt, L. L., Nials, F. L., and Varnell, R. J., 1978, Laramide thrust faulting, Klondike Hills, southwestern New Mexico: New Mexico Geological Society, Guidebook to 29th Field Conference, pp. 297–300.

Cunningham, J. E., 1974, Geologic map and sections of Silver City quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 30, scale 1:24,000.

Dane, C. H., and Bachman, G. O., 1965, Geologic map of New Mexico: U.S. Geological Survey, scale 1:500,000.

Darton, N. H., 1916, Geology and underground water in Luna County, New Mexico: U.S. Geological Survey, Bulletin 618, 188 pp.

Darton, N. H., 1917a, A comparison of Paleozoic sections in southern New Mexico: U.S. Geological Survey, Professional Paper 108C, pp. 31–55.

Darton, N. H., 1917b, Description of the Deming quadrangle: U.S. Geological Survey, Atlas, Deming Folio, no. 207, 15 pp.

Darton, N. H., 1928, "Red beds" and associated formations in New Mexico: U.S. Geological Survey, Bulletin 794, 356 pp.

Davis, G. H., 1979, Laramide folding and faulting in southeastern Arizona: American Journal of Science, v. 279, pp. 543–569.

Davis, G. H., 1981, Regional strain analysis of the superposed deformations in southeastern Arizona and the eastern Great Basin; *in* Dickinson, W. R., and Payne, W. D. (eds.), Relations of tectonics to ore deposits in the Southern Cordillera: Arizona Geological Society Digest (Tucson), v. XIV, pp. 155–171.

Deal, E. G., Elston, W. E., Erb, E. E., Peterson, S. L., Reiter, D. E., Damon, P. E., and Shafiqullah, M., 1978, Cenozoic volcanic geology of the Basin and Range province in Hidalgo County, southwestern New Mexico: New Mexico Geological Society, Guidebook to 29th Field Conference, pp. 219–229.

Diaz, T. G., and Navarro, A. G., 1964, Lithology and stratigraphic correlation of the upper Paleozoic in the region of Palomas, Chihuahua: West Texas Geological Society, Publication 64–50, pp. 65 84.

Dickinson, W. R., 1984, Reinterpretation of Lime Peak thrust as a low-angle normal fault: implications for the tectonics of southeastern Arizona: Geology, v. 12, pp. 610–613.

Drewes, H., 1972, Structural geology of the Santa Rita Mountains southeast of Tucson, Arizona: U.S. Geological Survey, Professional Paper 748, 35 pp.

Drewes, H., 1976, Laramide tectonics from Paradise to Hell's Gate southeastern Arizona: Arizona Geological Society Digest (Tucson), v. 10, pp. 151–167.

Drewes, H., 1978, The Cordilleran orogenic belt between Nevada and Chihuahua: Geological Society of America, Bulletin, v. 89, pp. 641–657.

Drewes, H., 1981, Tectonics of southeastern Arizona: U.S. Geological Survey, Professional Paper 1144, 96 pp.

Drewes, H., 1982, Northwest-trending basement flaws—A control to fluid movement and possible measure of rate of plate convergence; *in* Powers, R. B. (ed.), Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists (Denver), v. 1, pp. 421 423.

Drewes, H., and Thorman, C. H., 1980a, Geologic map of the Steins quadrangle and the adjacent part of the Vanar quadrangle, Hidalgo County, New Mexico: U.S. Geological Survey, Miscellaneous Geologic Investigations Map 1–1220, scale 1:24,000.

Drewes, H., and Thorman, C. H., 1980b, Geologic map of the Cotton City quadrangle and the adjacent part of the Vanar quadrangle, Hidalgo County, New Mexico: U.S. Geological Survey, Miscellaneous Geologic Investigations Map 1–1221, scale 1:24,000.

Dunham, R. J., 1962, Classification of carbonate rocks according to depositional texture: American Association of Petroleum Geologists, Memoir 1, pp. 108–121.

Elston, W. E., 1957, Geology and mineral resources of Dwyer quadrangle, Grant, Luna, ant Sierra Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 38, 86 pp.

Elston, W. E., 1958, Burro uplift, northeastern limit of sedimentary basin of southwestern New Mexico and southeastern Arizona: American Association of Petroleum Geologists, Bulletin, v. 42, pp. 2513–2517.

Elston, W. E., and Erb, E. E., 1977, Cenozoic volcanic–tectonic setting; *in* Thompson, S. III (compiler), Geology, petroleum source rocks, and thermal metamorphism in KCM No. 1 Forest Federal well, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 152, pp. 53–62.

Elston, W. E., and Deal, E. G., 1979, Tertiary geology of Hidalgo County, New Mexico: New Mexico Geology, v. 1, no. 1, p. 16.

Elston, W. E., Deal, E. G., and Logsdon, M. J., 1983, Geology and geothermal waters of the Lightning Dock region, Animas Valley and Pyramid Mountains, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 177, 44 pp.

Entwistle, L. P., 1944, Manganiferous iron-ore deposits near Silver City, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 19, 70 pp.

Erb, E. E., 1979, Petrologic and structural evolution of ash-flow tuff cauldrons and non-cauldron-related volcanic rocks in the Animas and southern Peloncillo Mountains, Hidalgo County New Mexico: Unpublished PhD dissertation, University of New Mexico (Albuquerque), 286 pp.

Evans, A. M., 1949, Investigations of manganese deposits, Little Florida Mountains mining district, Luna County New Mexico: U.S. Bureau of Mines, Report of Investigations 4536 11 pp.

Evans, K. V., 1984, Ordovician plutonism in east-central Idaho: variation on a Canadian theme (abs.): Geological Society of America, Abstracts with Programs, v. 16, p. 504.

Evans, K. V., and Clemons, R. E., 1987, U–Pb geochronology of the Florida Mountains, New Mexico: New evidence for latest Cambrian–earliest Ordovician alkalic plutonism (abs.): Geological Society of America, Abstracts with Programs, v. 19, pp. 657–658.

Evans, K. V., and Clemons, R. E., 1988, Cambrian–Ordovician (500 Ma) alkalic plutonism in southwestern New Mexico: U–Th–Pb isotopic data from the Florida Mountains: American Journal of Science, v. 288, pp. 735–755.

Flower, R. H., 1953a, Age of the Bliss Sandstone, New Mexico: American Association of Petroleum Geologists, Bulletin, v. 37, pp. 2054–2055.

Flower, R. H., 1953b, Paleozoic sedimentary rocks of southwestern New Mexico: New Mexico Geological Society, Guidebook to 4th Field Conference, pp. 106–112.

Flower, R. H., 1957, Studies of the Actinoceratida: New Mexico Bureau of Mines and Mineral Resources, Memoir 2, 101 pp.

Flower, R. H., 1958, Cambrian–Mississippian beds of southern New Mexico: Roswell Geological Society, Guidebook 11, pp. 61–78.

Flower, R. H., 1964, The nautiloid order Ellesmeroceratida (Cephalopoda): New Mexico Bureau of Mines and Mineral Resources, Memoir 12, 234 pp.

Flower, R. H., 1965, Early Paleozoic of New Mexico: New Mexico Geological Society, Guidebook to the 16th Field Conference, pp. 112–131.

Flower, R. H., 1969, Early Paleozoic of New Mexico and El Paso region: El Paso Geological Society, Ordovician Symposium, pp. 31–101.

Flugel, E., 1982, Microfacies analysis of limestones: Springer-Verlag, New York, 633 pp.

Folk, R. L., 1954, The distinction between grain size and mineral composition in sedimentary-rock nomenclature: Journal of Geology, v. 62, pp. 344–359.

Folk, R. L., 1962, Spectral subdivision of limestone types:

American Association of Petroleum Geologists, Memoir 1, pp. 62–84.

Folk, R. L., 1974, Petrology of sedimentary rocks: Hemphill Publishing Co., Austin, Texas, 182 pp.

Geological Society of America, 1963, Rock-color chart: Geological Society of America.

Gillerman, E., 1958, Geology of the central Peloncillo Mountains, Hidalgo County, New Mexico, and Cochise County, Arizona: New Mexico Bureau of Mines and Mineral Resources, Bulletin 57, 152 pp.

Gordon, C. H., and Graton, L. C., 1906, Lower Paleozoic formations in New Mexico: American Journal of Science, 4th ser., v. 21, pp. 390–395.

Greenwood, E., 1970, Oil and gas possibilities in the Pedregosa Basin: New Mexico Geological Society, Guidebook to 21st Field Conference, p. 105.

Greenwood, E., and Kottlowski, F. E., 1975, Geology of the Pedregosa Basin in southwesternmost New Mexico and adjoining areas; *in* Hills, J. M. (ed.), Exploration from the mountains to the basin: El Paso Geological Society, pp. 29–36.

Greenwood, E., Kottlowski, F. E., and Armstrong, A. K., 1970, Upper Paleozoic and Cretaceous stratigraphy of the Hidalgo County area, New Mexico: New Mexico Geological Society, Guidebook to the 21st Field Conference, pp. 33–44.

Greenwood, E., Kottlowski, F. E., and Thompson, S. III, 1977, Petroleum potential and stratigraphy of Pedregosa Basin: comparison with Permian and Orogrande Basins: American Association of Petroleum Geologists, Bulletin, v. 61, pp. 1448–1469.

Griswold, G. B., 1961, Mineral deposits of Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 72, 157 pp.

Harbour, R. L., 1972, Geology of the northern Franklin Mountains, Texas and New Mexico: U.S. Geological Survey, Bulletin 1298, 129 pp.

Hawley, J. W., 1981, Pleistocene and Pliocene history of the International Boundary area, southern New Mexico: El Paso Geological Society, Field Trip Guidebook, pp. 26–32.

Hayes, P. T., 1970, Cretaceous paleogeography of southeastern Arizona and adjacent areas: U.S. Geological Survey, Professional Paper 658–B, 42 pp.

Hayes, P. T., 1975a, Cambrian and Ordovician rocks of southern Arizona and New Mexico and westernmost Texas: U.S. Geological Survey, Professional Paper 873, 98 pp.

Hayes, P. T., 1975b, Selected stratigraphic sections of Cambrian and Ordovician rocks in Arizona, New Mexico, and western Texas: U.S. Geological Survey, Open-file Report 75–178, 51 pp.

Hedlund, D. C., 1978, Geologic map of the Gold Hill quadrangle, New Mexico: U.S. Geological Survey, Miscellaneous Field Studies Map, MF–1035, scale 1:24,000.

Hill R. T., 1902, The geographic and geologic features, and their relationship to the mineral products of Mexico: American Institute of Mining Engineers, Transactions, v. 32, pp. 163–178.

Hill, R. T., 1928, Transcontinental structural digression (abs.): Geological Society of America, Bulletin, v. 39, pp. 265.

Howe, H. J., 1959, Montoya Group stratigraphy (Ordovician) of Trans-Pecos Texas: American Association of Petroleum Geologists, Bulletin, v. 43, pp. 2285–2332.

Jahns, R. H., 1955, Geology of the Sierra Cuchillo, New Mexico: New Mexico Geological Society, Guidebook to 6th Field Conference, pp. 158–174.

Jicha, H. L., 1954, Geology and mineral resources of the Lake Valley quadrangle, Grant, Luna, and Sierra Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 37, 93 pp.

Johnson, J. H., 1966, The Late Cambrian algal genus, *Nuia* from Brewster County, Texas: Journal of Paleontology, v. 40, pp. 433–434.

Jones; F A., 1904, New Mexico mines and minerals: Santa Fe, 349 pp.

Jones, R. W., 1963, Structural evolution of part of southeastern Arizona: American Association of Petroleum Geologists, Memoir 2, pp. 140–151.

Jones, R. W., 1966, Differential vertical uplift—a major factor in the structural evolution of southeastern Arizona: Arizona Geological Society Digest (Tucson), v. 8, pp. 97–124.

Jones, W. R., Hernon, R. M., and Moore, S. L., 1967, General geology of Santa Rita quadrangle, Grant County, New Mexico: U.S. Geological Survey, Professional Paper 555, 144 pp.

Jordan, C. E, 1971, Lower Permian stratigraphy of southern New Mexico and west Texas: Unpublished Ph.D. dissertation, Rice University (Houston, Texas), 136 pp.

Kelley, V. C., and Bogart, L. E., 1952, Gym limestone, New Mexico: American Association of Petroleum Geologists, Bulletin, v. 36, pp. 1644–1646.

Kelley, V. C., and Furlow, J. W., 1965, Lower Paleozoic wedge edges in south-central New Mexico—New control: Geological Society of America, Bulletin, v. 76, pp. 689–694.

Kelley, V. C., and Silver, C., 1952, Geology of the Caballo Mountains: University of New Mexico (Albuquerque), Publications in Geology, no. 4, 286 pp.

Keyes, C. R., 1940, Gym limestone of New Mexico is what? Pan-American Geologist, v. 73, pp. 368–370.

King, P. B., King, R. E., and Knight, J. B., 1945, Geology of Hueco Mountains, El Paso and Hudspeth Counties, Texas: U.S. Geological Survey, Oil and Gas Investigations, Preliminary Map 36.

Kottlowski, F. E., 1957, High-purity dolomite deposits of south-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 47, 43 pp.

Kottlowski, F. E., 1958a, Pennsylvanian and Permian rocks near the late Paleozoic Florida Islands: Roswell Geological Society, Guidebook 11, pp. 79–87.

Kottlowski, E E., 1958b, Geologic history of the Rio Grande near El Paso: West Texas Geological Society, Guidebook for Franklin and Hueco Mountains, pp. 46–54.

Kottlowski, E E., 1960, Summary of Pennsylvanian sections in southwestern New Mexico and southeastern Arizona: New Mexico Bureau of Mines and Mineral Resources, Bulletin 66, 187 pp.

Kottlowski, F. E., 1962, Reconnaissance of commercial high-calcium limestones of New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 60, 77 pp.

Kottlowski, F. E., 1963, Paleozoic and Mesozoic strata of southwestern and south-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 79, 100 pp.

Kottlowski, F. E., 1965a, Facets of the late Paleozoic strata in southwestern New Mexico: New Mexico Geological Society, Guidebook to 16th Field Conference, pp. 141–147.

Kottlowski, F. E., 1965b, Sedimentary basins of south-central and southwestern New Mexico: American Association of Petroleum Geologists, Bulletin, v. 49, pp. 2120–2139.

Kottlowski, F. E., 1971a, Petroleum potential of southwest New Mexico and south Arizona; *in* Cram, I. A. (ed.), Future petroleum provinces of the United States—Their geology and potential: American Association of Petroleum Geologists, Memoir 15, v. 1, pp. 431–448.

Kottlowski, F. E., 1971b, Paleozoic geologic history of southwest New Mexico and northern Chihuahua tectonic belt; *in* Seewald, K., and Sundeen, D. (eds.), The geologic framework of the Chihuahua tectonic belt: West Texas Geological Society, Publication 71–59, pp. 25–37.

Kottlowski, F. E., 1973, Pre-Pliocene rocks in La Mesa region, southern Dona Ana County, New Mexico: El Paso Geological Society, Guidebook 7, pp. 37–46.

Kottlowski, F. E., and Foster, R. W., 1962, Pre-Tertiary strata of Tres Hermanas Mountains, Luna County, New Mexico: American Association of Petroleum Geologists, Bulletin, v. 46, pp. 2090–2098.

Kottlowski, F. E., and Pray, L. C., 1967, Silurian outcrops of south-central and southwestern New Mexico: Tulsa Geological Society Digest, v. 35, pp. 209–230.

Kottlowski, F. E., Foster, R. W., and Wengerd, S. A., 1969, Key oil test and stratigraphic sections in southwest New Mexico: New Mexico Geological Society, Guidebook to the 20th Field Conference , pp. 186–196.

Kottlowski F. E., LeMone, D. V., and Foster, R. W., 1969, Early Ordovician highlands of Precambrian rocks and their associated facies: El Paso Geological Society, Guidebook 3, pp. 134–142.

Kottlowski, F. E., Flower, R. H., Thompson, M. L., and Foster, R. W., 1956, Stratigraphic studies of the San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 1, 132 pp.

Kuellmer, F. J., 1954, Geologic section of the Black Range at Kingston, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 33, 100 pp.

Lance, J. O., and Keller, G. R., 1981, A regional gravity study of southwestern New Mexico and adjacent areas: El Paso Geological Society, Field Trip Guidebook, pp. 86–90.

Lasky, S. G., 1940, Manganese deposits in the Little Florida Mountains, Luna County, New Mexico: U.S. Geological Survey, Bulletin 922–C, 73 pp.

Laudon, L. R. and Bowsher, A. L., 1949, Mississippian formations of southwestern New Mexico: Geological Society of America, Bulletin, v. 60, pp. 1–87.

Lemley, 1. A., 1982, The Lobo Formation and lithologically similar units in Luna and southwestern Dona Ana Counties, New Mexico: Unpublished MS thesis, New Mexico State University (Las Cruces), 95 pp.

LeMone, D. V., 1969a, Cambrian–Ordovician in El Paso border region: New Mexico Bureau of Mines and Mineral Resources, Circular 104, pp. 17–25.

LeMone, D. V., 1969b, Cambrian–Ordovician in El Paso border region: El Paso Geological Society, Guidebook 3, pp. 145–162.

LeMone, D. V., 1969c, Lower Paleozoic rocks in the El Paso area: New Mexico Geological Society, Guidebook to the 20th Field Conference, pp. 68–79.

LeMone, D. V., 1974, The Lower Ordovician Florida Mountains Formation stratotype, Luna County, New Mexico: El Paso Geological Society, Guidebook 8, pp. 36 46.

LeMone, D. V., 1976a, Cyclic digitate algae of the Canadian (Lower Ordovician) Jose Formation, southern Franklin Mountains, El Paso County, Texas: El Paso Geological Society, Quinn Memorial Volume, pp. 11–24.

LeMone, D. V., 1976b, The Lower Ordovician Florida Mountains Formation of the Franklin Mountains, El Paso County, Texas: El Paso Geological Society, Quinn Memorial Volume, pp. 25–33.

Lindgren, W., Graton, L. C., and Gordon, C. H., 1910, The ore deposits of New Mexico: U.S. Geological Survey, Professional Paper 68, pp. 289–290.

Lochman-Balk, C., 1958, The Capitol Dome section, Florida Mountains: Roswell Geological Society, Guidebook 8, pp. 47–52.

Lochman-Balk, C., 1970, Upper Cambrian faunal patterns on the craton: Geological Society of America, Bulletin, v. 81, pp. 3197–3224.

Lochman-Balk, C., 1971, The Cambrian of the craton of the United States; *in* Lower Paleozoic rocks of the world, v. 1: John Wiley & Sons, Inc., London, pp. 79–167.

Lochman-Balk, C., 1974, The Capitol Dome section, Florida Mountains: El Paso Geological Society, Guidebook 8, pp. 7–15.

Loring, A. K., and Armstrong, D. G., 1980, Cambrian–Ordovician syenites of New Mexico: Geology, v. 8, pp. 344–348.

Loring, A. K., and Loring, R. B., 1980, Age of thrust faulting, Little Hatchet Mountains, southwestern New Mexico: Isochron/West, no. 27, pp. 29–31.

Loring, A. K., Clemons, R. E., and Armstrong, D. G., 1987, Petrologic, paleomagnetic, and structural evidence of a Paleozoic rift system in Oklahoma, New Mexico, Colorado, and Utah: Discussions and reply: Geological Society of America, Bulletin, v. 99, pp. 315–318.

Lucia, F. J., 1969, Sedimentation and paleogeography of the El Paso Group: West Texas Geological Society, Guidebook 68–55a, pp. 61–75.

Lucia, F J., 1971, Lower Paleozoic history of the western Diablo Platform, west Texas and south-central New Mexico: Society of Economic Paleontologists and Mineralogists, Permian Basin Section, Field Conference Guidebook of Robledo Mountains and Franklin Mountains, pp. 174–214.

Lynn, G. C., 1975, Stratigraphic correlation of the El Paso and Montoya Groups in the Victorio Mountains, the Snake Hills, and the Big Florida Mountains in southwestern New Mexico: Unpublished MS thesis, University of Arizona (Tucson), 115 pp.

Mack, G. H., and Clemons, R. E., 1988, Structural and stratigraphic evidence for the Laramide (early Tertiary) Burro uplift in southwestern New Mexico: New Mexico Geological Society, Guidebook to the 39th Field Conference, pp. 59–66.

Mack, G. H., Clemons, R. E., and Seager, W. R., 1983, Paleogene sandstone petrofacies in south-central New Mexico—Evidence for change from Laramide deformation to volcanism (abs.): Geological Society of America, Abstracts with Programs, v. 15, no. 6, p. 633.

Maslov, V. P., 1956, Fossil calcareous algae of the U.S.S.R.: Akademia Nauk SSSR, Institut Geologicheskikh Nauk, Trudy, v. 160, 301 pp. (In Russian)

Matheny, R. K., and Brookins, D. G., 1983, Geochronologic studies of igneous rocks from Florida Mountains, New Mexico (abs.): New Mexico Geology, v. 5, no. 3, p. 67.

Mayo, E. B., 1966, Preliminary report on a structural study in the Museum Embayment, Tucson Mountains, Arizona: Arizona Geological Society Digest, v. 8, pp. 1–32.

McAnulty, W. N., 1978, Fluorspar in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 34, 61 pp.

McEvers, L., LeMone, D. V., and Von Finger, K., 1983, Fusselman Dolomite of north Franklin Mountains, Doña Ana County, New Mexico (abs.): New Mexico Geology, v. 5, no. 3, p. 64.

McLean, J. S., 1977, Hydrologic maps and data in the Mimbres basin, New Mexico: U.S. Geological Survey, Open-file Report 77–314, 531 pp.

McLemore, V. T., 1980, Carbonatites in the Lemitar Mountains, Socorro County, New Mexico: New Mexico Geology, v. 2, pp. 49–52.

McLemore, V. T., 1981, Regional implications of carbonatites in the Lemitar Mountains, Socorro County, New Mexico (abs.): Geological Society of America, Abstracts with Programs, v. 13, no. 7, p. 508.

McLemore, V. T., 1987, Petrologic, paleomagnetic, and structural evidence of a Paleozoic rift system in Oklahoma, New Mexico, Colorado, and Utah: Discussions and Reply: Geologic Society of America, Bulletin, v. 99, pp. 315–318.

Muehlberger, W. R., 1965, Late Paleozoic movement along the Texas lineament: New York Academy of Science, Transactions, ser. 11, v. 27, no. 4, pp. 385–392.

Muehlberger, W. R., 1980, Texas lineament revisited: New Mexico Geological Society, Guidebook to the 31st Field Conference, pp. 113–121.

Muehlberger, W. R., 1986, Different slip senses of major faults during different orogenies: The rule?: 6th International Conference on basement tectonics, Proceedings, pp. 76–81.

Muehlberger, W. R., Hedge, C. E., Denison, R. E., and Marvin, R. E, 1966, Geochronology of the midcontinent region, United Sates; *in* Southern area: Journal of Geophysical Research, v. 71, pt. 3, pp. 5409–5426.

Neher, R. E., and Buchanan, W. A., 1980, Soil survey of Luna County, New Mexico: U.S. Soil Conservation Service and New Mexico Agricultural Experiment Station, 80 pp.

North American Commission on Stratigraphic Nomenclature, 1983, North American Stratigraphic code: American Association of Petroleum Geologists, Bulletin, v. 67, pp. 841–875.

Nydegger, G. L., 1982, The Las Vegas–El Paso gap: a review of the southern part of the Cordilleran overthrust belt; *in* Powers, R. B. (ed.), Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists (Denver), v. 1, pp. 391–407.

Olson, J. C., Marvin, R. F., Parker, R. L., and Mehnert, H. H., 1977, Age and tectonic setting of lower Paleozoic alkalic and mafic rocks, carbonatites, and thorium veins in south-central Colorado: U.S. Geological Survey, Journal of Research, v. 5, pp. 673–687.

Ottensman, C., 1982, A facies and paleoenvironmental analysis of part of the Bliss Formation (Cambrian–Ordovician) in southern New Mexico and western Texas: Unpublished MS thesis, University of Texas (Dallas), 208 pp.

Paige, S., 1916, Description of the Silver City quadrangle, New Mexico: U.S. Geological Survey, Atlas, Silver City Folio, no. 199, 19 pp.

Palmer, A. R., 1983, The decade of North American geology 1983 geologic time scale: Geology, v. 11, pp. 503–504.

Pratt, W. P., 1967, Geology of the Hurley West quadrangle Grant County, New Mexico: U.S. Geological Survey, Bulletin 1241–E, 91 pp.

Pratt, W. P., and Jones, W. R., 1961, Montoya Dolomite and Fusselman Dolomite in Silver City region, New Mexico: American Association of Petroleum Geologists, Bulletin, v. 45, pp. 484–500.

Pray, L. C., 1953, Upper Ordovician and Silurian stratigraphy of the Sacramento Mountains: American Association of Petroleum Geologists, Bulletin, v. 37, pp. 1894–1918.

Pray, L. C., 1958, Stratigraphic section, Montoya Group and Fusselman Formation, Franklin Mountains, Texas: West Texas Geological Society, Guidebook to Franklin and Hueco Mountains, Texas, pp. 30–42.

Pray, L. C., 1961, Geology of the Sacramento Mountains escarpment, Otero County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 35, 144 pp.

Pray, L. C., and Bowsher, A. L., 1952, Fusselman Limestone of the Sacramento Mountains, New Mexico (abs.): Geological Society of America, Bulletin, v. 63, p. 1342.

Ransome, F. L., 1915, The Tertiary orogeny in the North American cordillera and its problems; *in* Problems of American geology: Yale University Press (New Haven), pp. 287–376.

Reiter, D. E., 1980, Geology of the Alamo Hueco and Dog Mountains, Hidalgo County, New Mexico: Unpublished MS thesis, University of New Mexico (Albuquerque), 100 pp.

Richardson, G. B., 1904, Report of a reconnaissance in Trans-Pecos, Texas, north of the Texas and Pacific Railway: Texas University Mineral Survey, Bulletin 9, 119 pp.

Richardson, G. B., 1908 Paleozoic formations in Trans-Pecos, Texas: American Journal of Science, 4th ser., v. 25, pp. 474–484.

Richardson, G. B., 1909, Description of the El Paso district: U.S. Geological Survey, Atlas, El Paso Folio, no. 166, 11 pp.

Rosato, R. V., 1971, Devonian stratigraphy of south-central New Mexico and adjacent Texas: Society of Economic Paleontologists and Mineralogists, Permian Basin Section, Field Conference Guidebook of Robledo and Franklin Mountains, pp. 49–63.

Sanford, A. R., 1959, Analytical and experimental study of simple geologic structures: Geological Society of America, Bulletin, v. 70, pp. 19–52.

Seager, W. R., 1973, Geologic map and sections of Bishop Cap–Organ Mountains area, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 29, scale 1:24,000.

Seager, W. R., 1975, Geologic map and sections of south half of San Diego Mountain quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 35, scale 1:24,000.

Seager, W. R., 1981, Geology of Organ Mountains and southern San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 36, 97 pp.

Seager, W. R., 1983, Laramide wrench faults, basement-cored uplifts, and complementary basins in southern New Mexico: New Mexico Geology, v. 5, no. 4, pp. 69–76.

Seager, W. R., and Hawley, J. W., 1973, Geology of Rincon quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 101, 42 pp.

Seager, W. R., Clemons, R. E., and Hawley, J. W., 1975, Geology of Sierra Alta quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 102, 56 pp.

Seager W. R., Clemons, R. E., Hawley, J. W., and Kelley, R. E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 53, sheet 1, scale 1:125,000.

Silver, L. T., and Anderson, T. H., 1974, Possible left-lateral early to middle Mesozoic disruption of the southwestern North American craton margin (abs.): Geological

Society of America, Abstracts with Programs, v. 6, p. 955.

Sorauf, J. E., 1984, Devonian stratigraphy of the San Andres Mountains, Doña Ana, Sierra, and Socorro Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 189, 32 pp.

Stacy, J. S., and Hedlund, D. C., 1983, Lead-isotopic compositions of diverse igneous rocks and ore deposits from southwestern New Mexico and their implications for early Proterozoic crustal evolution in the western United States: Geological Society of America, Bulletin, v. 94, pp. 43–57.

Soule, J. M., 1972, Structural geology of northern part of Animas Mountains, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 125, 15 pp.

Stevenson, E V., 1945, Devonian of New Mexico: Journal of Geology, v. 53, pp. 217–245.

Stoyanow, A. A., 1949, Lower Cretaceous stratigraphy in southeastern Arizona: Geological Society of America, Memoir 38, 169 pp.

Streckeisen, A., 1976, To each plutonic rock its proper name: Earth Science Reviews, v. 12, pp. 1–33.

Streckeisen, A., 1979, Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites, and melititic rocks: Geology, v. 7, pp. 331–335.

Thompson, S. III, 1981, Analysis of petroleum source and reservoir rocks in southwestern New Mexico: New Mexico Energy and Minerals Department, Report EMD 2–66–3306, 120 pp.

Thompson, S. III, 1982, Oil and gas exploration wells in southwestern New Mexico: Rocky Mountain Association of Geologists, Cordilleran Overthrust Belt, Texas to Arizona Field Conference, pp. 137–153.

Thompson, S. III, and Potter, P. E., 1981, Paleocurrents of Bliss Sandstone (Cambrian–Ordovician), southwestern New Mexico and western Texas: New Mexico Bureau of Mines and Mineral Resources, Annual Report for 1979–1980, pp. 36–51.

Thompson, S,. III, Tovar, R. J. C., and Conley, J. N., 1978, Oil and gas exploration wells in the Pedregosa Basin: New Mexico Geological Society, Guidebook to 29th Field Conference, pp. 331–342.

Thorman, C. H., 1977, Geologic map of parts of the Coyote Peak and Brockman quadrangles, Hidalgo and Grant Counties, New Mexico: U.S. Geological Survey, Miscellaneous Field Studies Map, MF–924, scale 1:24,000.

Thornton, C. H., and Drewes, H., 1978, Geologic map of the Gary and Lordsburg quadrangles, Hidalgo County, New Mexico: U.S. Geological Survey, Miscellaneous Investigations Map, I–1151, scale 1:24,000.

Thorman, C. H., and Drewes, H., 1979, Geologic map of the Saltys quadrangle, Grant County, New Mexico: U.S. Geological Survey, Miscellaneous Field Studies Map, MF–1137, scale 1:24,000.

Thorman, C. H., and Drewes, H., 1980, Geologic map of the Victorio Mountains, Luna County, southwestern New Mexico: U.S. Geological Survey, Miscellaneous Field Studies Map, MF–1175, scale 1:24,000.

Thorman, C. H., and Drewes, H., 1981, Geologic map of the Gage SW quadrangle, Grant and Luna Counties, New Mexico: U.S. Geological Survey, Miscellaneous Investigations Map, 1–1231, scale 1:24,000.

Titley, S. R., 1976, Evidence for a Mesozoic linear tectonic pattern in southwestern Arizona: Arizona Geological Society Digest (Tucson), v. 10, pp. 71–101.

Toomey, D. F., and Klement, K. W., 1966, A problematical micoorganism from the El Paso Group (Lower Ordovician) of west Texas: Journal of Paleontology, v. 40, pp. 1304–1311.

Turner, G. L., 1962, The Deming axis, southeastern Arizona, New Mexico, and Trans-Pecos Texas: New Mexico Geological Society, Guidebook to the 13th Field Conference, pp. 59–71.

Wengerd, S. A., 1969, Geologic history and the exploration for oil in the border region: New Mexico Geological Society, Guidebook to 20th Field Conference, pp. 197–204.

Wengerd, S. A., 1970, Petroleum prospects in southwestern New Mexico: New Mexico Geological Society, Guidebook to 21st Field Conference, pp. 91–104.

Wiley, M. A., and Muehlberger, W. R., 1971, The Texas lineament; *in* Seewald, K., and Sundeen, D. (eds.), The geologic framework of the Chihuahua tectonic belt: West Texas Geological Society (Midland), Publication 71–59, pp. 15–23.

Wilson, J. L., Madrid-Solis, A., and Malpica-Cruz, R., 1969, Microfacies of Pennsylvanian and Wolfcampian strata in southwestern U.S.A. and Chihuahua, Mexico: New Mexico Geological Society, Guidebook to 20th Field Conference, pp. 80–90.

Woodward, L. A., 1970, Precambrian rocks of southwestern New Mexico: New Mexico Geological Society, Guidebook to 20th Field Conference, pp. 27–31.

Woodward, L. A., 1980, A hard look at overthrust belt prospects in southwest New Mexico: Oil and Gas Journal, v. 78, no. 16, pp. 114–116.

Woodward, L. A., and DuChene, H. R., 1981, Overthrust belt of southwestern New Mexico: Comparison with Wyoming–Utah overthrust belt: American Association of Petroleum Geologists, Bulletin, v. 65, pp. 722–729.

Woodward, L. A., and DuChene, H. R., 1982, Tectonics and hydrocarbon potential of thrust and fold belt of southwestern New Mexico; *in* Powers, R. B. (ed.), Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists (Denver), v. 1, pp. 409–419.

Yurewicz, D. A., 1977, Sedimentology of Mississippian basin-facies carbonates, New Mexico and west Texas—The Rancheria Formation: Society of Economic Paleontologists and Mineralogists, Special Publication 25, pp. 203–219.

Zeller, R. A., Jr., 1965, Stratigraphy of the Big Hatchet Mountains area, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 16, 128 pp.

Zeller, R. A., Jr., 1970, Geology of the Little Hatchet Mountains, Hidalgo and Grant Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 96, 23 pp.

Zeller, R. A., Jr., 1975, Structural geology of Big Hatchet Peak quadrangle, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 146, 23 pp.

Zeller, R. A., Jr., and Alper, A. M., 1965, Geology of the Walnut Wells quadrangle, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 84, 105 pp.

Appendix A-1

Modes of hornfels

Pl, plagioclase; **Bi**, biotite; **Am**, amphibole; **Py**, pyroxene; **Ol** olivine; **Alt**, alteration products; **Acc**, accessory minerals; **tr**, trace.

Sample number	Pl	Bi	Am	Py	Ol	Alt	Acc	Name
199	47					53		Hornblende hornfels
200	57	2	6			35	tr	Hornblende hornfels
201	67		26			2	5	Hornblende hornfels
202	54	17	24			2	3	Hornblende hornfels
203	64	tr	25	1		2	8	Hornblende hornfels
204	62	17	8	9		2	2	Hornblende hornfels
205	40		46			4	10	Hornblende hornfels
206	49	1	46	tr		tr	4	Hornblende hornfels
207	42	2	37	6		5	8	Hornblende hornfels
208	44		50			2	4	Hornblende hornfels
209	45		47			2	6	Hornblende hornfels
210	61		32			1	5	Hornblende hornfels
211	44	6	40	4		1	5	Hornblende hornfels
212	60		31			3	6	Hornblende hornfels
213	59		36	2			3	Hornblende hornfels
214	51	3	36	4		2	4	Hornblende hornfels
215	46	9	38			1	6	Hornblende hornfels
216	56	1	33			3	7	Hornblende hornfels
217	41	1	54			1	3	Hornblende hornfels
218	44		49			1	6	Hornblende hornfels
219	43	11	34	9		1	2	Hornblende hornfels
220	43	13	28	7		2	7	Hornblende hornfels
221	45	1	46	2		1	5	Hornblende hornfels
222	46	2	45			1	6	Hornblende hornfels
223	52	2	23	19			4	Pyroxene hornfels
224	54	12	14	15			5	Pyroxene hornfels
225	30	1	21	17		20	11	Pyroxene hornfels
226	43	1	tr	48		1	7	Pyroxene hornfels
227	33	19	22	7	14	1	3	Pyroxene hornfels
228	21	9	42	11	13	1	3	Pyroxene hornfels
229	41	2	2	48			7	Pyroxene hornfels
230	45	3	1	41			10	Pyroxene hornfels

Appendix A–2

Modes of plutonic rocks

Qz, quartz; **Kf**, potassium feldspar; **Pl**, plagioclase; **Bi**, biotite; **Am**, amphibole; **Alt**, alteration products; **Acc**, accessory minerals; **tr**, trace.

Sample number	Qz	Kf	Pl	Bi	Am	Alt	Acc	Name
1	26	71			2	6	1	Aplite
2	19	72			6		3	Aplite
3	26	70			4		tr	Aplite
4	24	70				6	tr	Aplite
5	30	67				3	tr	Aplite
6	28	64				3	tr	Aplite
7	32	44	24		tr		tr	Aplite
8	31	37	28		tr	2	2	Aplite
9	33	59				7	1	Aplite
10	33	37	27		2		1	Aplite
11	35	58		tr	3	1	3	Aplite
12	31	69			tr	tr	tr	Aplite
13	23	71			3	1	2	Aplite
14	21	79			tr	tr	tr	Aplite
15	28	66			4	2	tr	Aplite
16	27	70			2	1	tr	Aplite
17	23	74			2		1	Aplite
18	33	63			1	2	1	Aplite
19	21	60			17	2		Aplite
20	24	67			5	1	3	Aplite
21	30	65			1	2	2	Aplite
22	33	61			3	3		Granite
23	22	71				6	1	Granite
24	24	66				10	tr	Granite
25	23	65				12	tr	Granite
26	28	63				9	tr	Granite
27	31	61				8	tr	Granite
28	26	67			5		2	Granite
29	30	62			7	1	tr	Granite
30	21	68				11	tr	Granite
31	30	63			7		tr	Granite
32	24	61				14	1	Granite
33	34	62				4	tr	Granite
34	41	50				9	tr	Granite
35	41	47				12	tr	Granite
36	30	61				9	tr	Granite
37	30	62				2	6	Granite
38	21	69			10	tr	tr	Granite
39	23	65				12	tr	Granite
40	24	58				18	tr	Granite
41	28	65			7	tr	tr	Granite
42	33	48	16			2	1	Granite
43	22	70			7	1	tr	Granite
44	20	73			7		tr	Granite
45	28	65			7	tr	tr	Granite
46	26	67			6	1	tr	Granite
47	27	67			1	4	1	Granite
48	37	59			2	2	tr	Granite
49	30	67			tr	3	tr	Granite
50	35	61			1	2	1	Granite
51	28	67			3	1	1	Granite
52	29	70			1		tr	Granite
53	20	78			2		tr	Granite
54	21	70			8	tr	1	Granite
55	29	64			6	1	tr	Granite
56	22	72			5	1	tr	Granite
57	28	61			10		1	Granite
58	32	62				3	3	Granite
59	23	72			5		tr	Granite
60	31	66			3		tr	Granite
61	38	59			1	2	tr	Granite
62	33	59				7	1	Granite
63	21	66			11	1	1	Granite
64	36	61				2	1	Granite
65	23	73				4	tr	Granite
66	27	62			10	1	tr	Granite
67	20	76			2	2	tr	Granite
68	27	70			1	2	tr	Granite
69	26	67				7	tr	Granite
70	20	56				24	tr	Granite
71	23	23				10	tr	Granite
72	26	59				15	tr	Granite
73	25	66				8	1	Granite
74	21	74				5	tr	Granite
75	26	59				15	tr	Granite
76	28	60				11	1	Granite
77	28	63				9	tr	Granite
78	43	50				6	1	Granite
79	25	58				17	tr	Granite
80	43	49				8	tr	Granite
81	29	56				15	tr	Granite
82	20	70				10	tr	Granite
83	24	68				8	tr	Granite
84	41	52				6	1	Granite
85	29	68	tr			3	tr	Granite
86	22	75	tr			3	tr	Granite
87	28	67	tr			5	tr	Granite
88	28	65	tr			7	tr	Granite
89	22	65	3			10	tr	Granite
90	18	76				4	2	Quartz syenite
91	15	72			8	4	1	Quartz syenite
92	5	87			7		1	Quartz syenite
93	8	79				13	tr	Quartz syenite
94	15	76				9	tr	Quartz syenite
95	19	66				15	tr	Quartz syenite
96	16	76			8		tr	Quartz syenite
97	6	86			5	3		Quartz syenite
98	17	83					tr	Quartz syenite
99	16	73				11	tr	Quartz syenite
100	5	84				11	tr	Quartz syenite
101	8	84			4	3	1	Quartz syenite
102	5	85				9	1	Quartz syenite
103	5	85				10	tr	Quartz syenite
I04	8	83				9	tr	Quartz syenite
105	15	78				7	tr	Quartz syenite
106	11	84				5		Quartz syenite
107	8	8	4			8	tr	Quartz syenite
108	7	79				14	b	Quartz syenite
109	15	75				10	tr	Quartz syenite
110	11	82				7	tr	Quartz syenite
111	10	83				7	tr	Quartz syenite
112	13	78				9	tr	Quartz syenite
113	6	71				23	tr	Quartz syenite
114	10	80				10	tr	Quartz syenite
115	6	85				9	tr	Quartz syenite
116	15	71				14	tr	Quartz syenite
117	14	75				10	1	Quartz syenite
118	9	79				11	1	Quartz syenite
119	8	82			1	9	tr	Quartz syenite
120	5	84			6	3	2	Quartz syenite
121	19	69			10	1	1	Quartz syenite
122	12	68				18	2	Quartz syenite
123	13	68				18	1	Quartz syenite
124	5	82			tr	12	1	Quartz syenite
125	9	79			tr	11	1	Quartz syenite
126	8	83				8	1	Quartz syenite
127	6	84				9	1	Quartz syenite
128	5	84				10	1	Quartz syenite
129	16	67				17	tr	Quartz syenite
130	18	68				14	tr	Quartz syenite
131	18	80	tr			2	tr	Quartz syenite
132	14	79				6	1	Quartz syenite
133	16	67				17	tr	Quartz syenite
134	15	77				8	tr	Quartz syenite
135	18	81				1	tr	Quartz syenite
136	9	80		1	8	1	1	Quartz syenite

Sample number	Qz	Kf	Pl	Bi	Am	Alt	Acc	Name
137	3	92			4		1	Syenite
138	4	73			7	15	1	Syenite
139	4	76				20	tr	Syenite
140	4	85				10	1	Syenite
141	3	74				23	tr	Syenite
142	1	80				17	2	Syenite
143	2	74				23	1	Syenite
144	tr	80				18	2	Syenite
145	1	91				8	b	Syenite
146	3	91				6	tr	Syenite
147	4	86				10	tr	Syenite
148	2	86				11	1	Syenite
149	1	88				11	tr	Syenite
150	4	83				13	tr	Syenite
151	4	86				10	tr	Syenite
152	1	90				9	tr	Syenite
153	4	83				13	tr	Syenite
154	4	83				12	1	Syenite
155	4	75				20	1	Syenite
156	4	76				19	1	Syenite
157	2	87				11	tr	Syenite
158	2	88				10		Syenite
159	1	88			5	6	tr	Syenite
160	3	81		1	8	6	1	Syenite
161	2	85			8	4	1	Syenite
162	2	81				16	1	Syenite
163	2	88				10	tr	Syenite
164	2	82				16	tr	Syenite
165	3	92				5	tr	Syenite
166	2	83				15	tr	Syenite
167	2	86				11	1	Syenite
168	3	87				8	2	Syenite
169	4	83				13	tr	Syenite
170	2	86				12	tr	Syenite
171	2	85				13	tr	Syenite
I72	2	84				13	1	Syenite
173	2	83		2	7	4	2	Syenite
174	2	80		3	12		3	Syenite
175	1	93		1	4		1	Syenite
176	1	90		1	6	1	1	Syenite
178	2	85				13	tr	Syenite
179	3	85				12	tr	Syenite
180	3	87				10	tr	Syenite
181	4	77				18	1	Syenite
182	4	79				19	1	Syenite
183	1	91			6	2	tr	Syenite
184	2	92			5	1	tr	Syenite
185	tr	89			9	1	1	Syenite
186	2	88			9	1	tr	Syenite
187	4	92			3	1	tr	Syenite
188	4	92			3	1	tr	Syenite
189	b	83		4	9	2	2	Syenite
190		84		3	2	10	1	Syenite
191	2	89		1	6	2	tr	Syenite
192	2	90			2	5	1	Syenite
193	3	89			6	tr	2	Syenite
194	2	89			7	1	1	Syenite
195	43	5	26			25	1	Quartz monzonite
196	11	36	37		8	3	5	Quartz monzonite
197	5	43	31		16	3	2	Quartz monzonite
198	1	17	51		27	tr	4	Monzodiorite

Appendix B–1

Summary of allochems in El Paso Formation at Capitol Dome

The following table is a summary of allochem content, type of matrix, and terrigenous material in El Paso Formation at Capitol Dome section. **A**, abundant; **C**, common; **s**, scarce; **t**, trace; **x**, indicates micrite or spar in matrix.

Member	Ft above base	Brachiopods	Cephalopods	Echinoderms	Gastropods	*Nuia*	Ostracods	Sponges	Trilobites	Intraclasts	Ooliths	Peloids	Micrite	Spar	Quartz
Padre	130	C		A		t			A	C			x	x	
	125	A		A					C	A				x	
	120	s		A					C	A				x	
	110			t				t	t				x		t
	106			t				t					x		
	105	s		s	s				s	A				x	
	100	s		C	A		s	A	s				x	x	
	90	s		s	s			A	s				x		
	85	t		t	t			A	t				x		
	75			t	t			A	t				x		
	73			s		A	t		t	t				x	
	65			s	s			A	s			A	x		
	53							A	t			A	x		
	About 60 ft of section eliminated by fault														
	45	s		A	A			s	A				x		
	39			s				s				s	x		
	35			C	A				A	A				x	
	25			t				C	s				x		t
	20	s		A	A			s	A				x		t
	19	t		s	t	s		C	s				x		t
	18	t		s	t			C	s				x		t
	10	s		C	A			C	C	s			x		
	5			t	t		s		t			A	x		s
	0			t	t		s		t			A	x		s
McKelligon Canyon	141	s		A	s	A			C	s			x	x	
	140			t		A			t				x		C
	135	s		C	s	C		A	C	s			x		t
	130	s	C	C	s	C		A	C	s			x		
	125	C		C	A	C		A	C				x		s
	120	s		C	t	C		A	C				x		t
	119	s		A	s	A		A	s				x		
	113	s		A	s	A		A	s				x		
	107	C		A	A	A		A	C	A			x	x	
	104	C	A	A	A	A		C	C	A				x	
	100	t		s		s		C					x		
	96			s		A		C	s				x		t
	91	s			s			A	C				x		
	85	s		A				A	A	A				x	
	81			C		s		A						x	
	75					C		s	s				x		
	70			C	s	s		A	C	C			x	x	
	66	s		s					s	A			x	x	
	63	s		C		A			s				x		
	60			A	C	t			t	A			x	x	
	55	s		C	s	s		s		A				x	
	50	t		C		C				A			x	x	
	48			s				C	s			C	x		
	43			t				C	t			C	x		t
	40			t	t			A	s	C			x		
	35			C	t	C		s	C					x	t
	32	t		C	C	A		C	s	A			x	x	
	30	C		C	s	A		s	s				x		
McKelligon Canyon	25	C	C	C	A	A		s		t			x		
	20	C		C	t	A		s	s				x		
	14			A	C	C		C		C		s	x		
	10	t		t		A		t	t			t	x		
	5	t		A	C			A	A	C			x		
	0			t				A	s			C	x		
	About 50–100 ft of above section repeated by fault														
	450			C	s	C		A	s	s			x		
	415			s	s	C		s	s	t			x		
	395	C		C	A			A	C	t			x		
	375			A	C	C		A	t				x		
	345			C	C	t		C	t	A			x		
	295			C		C		A	C	C			x		
	270	C		C	A	A		A	C	A			x	x	
	260			C	A					A				x	
	250	C		C	C	C		C	C	A			x	x	
	245	t		A	A	A		C	A				x		
	235	A		C	A			A	A	t			x		
	225			C				C	C			C	x		
	210			A	s	s		A	A	C			x	x	
	205			s		A			A	C			x	x	
	198	s		A	A	t		A	A	A			x		
	192		C	A	C			C	A	C			x	x	
	185	s		t	s			s	s	t			x		
	180	A		A	C			C	A	C			x	x	
	175	A		s	A	s		s	s				x		
	170	A		s	A	t		s	s				x		
	165			s	s	A		s	s				x		
	160	C		A	A	C		C					x		
	155	C	s	C	C	C		A	A	t			x		
	150	C	s	s	s	t		A	A	t			x		
	148	s		C		A		C	A				x		
	143	s		C	C	C			C	A			x		
	135	s		C	A	A			A	t			x		
	130	s	s	A	A			C	A				x		t
	125	s	C	A	A			C	A				x		t
	120	s	C	C	A			s	C				x		
	115	s		C	A	s		s	C				x		
	110	s	C	C	A			t	A					x	t
	105	s		C	A	A		A	A	C			x		
	100	s	s	C	A	A		A	A	C			x		
	90		C	s	A	C		A	A	t			x		
	85			C	A	C		A	A	t			x		
	75			C	A			A	C	A				x	
	70			C	A	A		A	C	t			x		
	60	A		C	s	s		C	C				x		
	55			C		C		C	s				x		
	45			s	A	t		A	t			s	x		
	40			A	t	t		t					x		
	35			C	A	A		A	A	A			x	x	
	30			C	A	C		A	A	A			x	x	
	26					t			A	A				x	

Member	Ft above base	Brachiopods	Cephalopods	Echinoderms	Gastropods	*Nuia*	Ostracods	Sponges	Trilobites	Intraclasts	Ooliths	Peloids	Micrite	Spar	Quartz
	25			A	A	t		A	A	A			x	x	
	20			s	C			A	A	C			x		
	15			s	C			A	A	C			x		
	10	t		A	C			A	A				x		
	3	C		s	A	s		A	A				x	x	
16	0			C	C	s		A	A				x	x	
Jose	16			C					C	A	A			x	C
	12			C					A	C	A		x		C
	10			C	C			A	A	s			x		
74	0			C		s		t	A	s		s		x	
Hitt Canyon	74			s	t			A	s				x		
	70			C	s	A		A	C	s			x		
	68	t		C	C	A		C	C	C				x	t
	65			C	t	C		t	s	A				x	C
	59			s		A			s	A			x	x	t
	50			C		C		t	t	A				x	
	40			s	t	t		t	t	A				x	
	29			A	s	s		A	A	s		s	x		
	25			A		A			A	A			x		
	15			C	t	s		t	A	s			x		
	10	t		s	t	s			A	A			x		
175															

The lower 175 ft of the Hitt Canyon Member is dolomite with abundant *Girvanella*(?) oncoliths; the few allochem ghosts may include *Nuia*. Probable thrust fault exists in 20-ft covered zone between dolomite (below) and limestone (above).

Appendix B–2

Summary of allochems in El Paso Formation at Victorio Canyon

The following table is a summary of allochem content, type of matrix, and terrigenous material in El Paso Formation at Victorio Canyon section. **A**, abundant; **C**, common; **s**, scarce; **t**, trace; **x**, indicates micrite or spar in matrix; numbers in second column indicate total thicknesses of Flower's and LeMone's faunal units (formations).

Members	Formations of Flower (1969), LeMone (1969a)	Ft above base	Brachiopods	Cephalopods	Echinoderms	Gastropods	*Nuia*	Ostracods	Sponges	Trilobites	Intraclasts	Ooliths	Peloids	Micrite	Spar	Quartz
Padre	Florida Mountains	48	s		A	A				A	s				x	
		44			A	C				A	C				x	
		38	C		A	A				A	s		C		x	
		35	C		A	C				s	C		C		x	
		30	s		A	C	C		s	C	s				x	
		25	C		C	s			A	C				x		
		23	s		A	C		s		A	C	s			x	
		19							s	s				x		
		15	C		A		t			A	A		A		x	
		13			A			C	A	C	A		A		x	t
		10	s							A	A				x	t
		2	s		C			t	C	C	C		A		x	t
	220															
	Scenic Drive	215							A					x		
		208			C			s	C				A	x		
		203			C			C	C	s			A	x		
		198	t		A				A		C			x		
		190	s		C	C		s	C	C	C			x		
		185	C		C	C		s	C	C				x		
		180	C		A	s	t	t	A	C				x		
		170	C		A	s		t	A	C	C			x		
		155	s		A	C			C	C	s		C	x		
		145	s		C	A		t	C	C			s	x		
		140	s		C	A			A	C	C		C		x	
		130	s		C				A	C	s		A	x		t
		120			C				A	C				x		
		108				t			s	t				x		
		100	t		C	A			A	A	s			x		
		95			A	s				A	A				x	
		91		s	s	A			A	A	C			x		
		87	s		s	A			A	A	C		A	x		t
		85			s	A			C	A	s				x	t
		80				s			s					x		
		75	s	C	A	A			A	A	t			x		t
		70		C	A	A			s	A					x	t
		65		s	s	C			C	s				x		
		60		s	A	C			A	C				x		
		55	s		C	C				C	C		C		x	C
		50	C		C	C				A	s		t		x	s
		45			s					t	C		A		x	s
		40								s			A		x	t
		32			C		A			s					x	
		23			A	C	C		A	s				x		t
		15			A	C	C		s	s				x		s
		10	s		A	s	A		A	s				x		
		5			A	A	A				A				x	
		4			C	C	A		A	s				x		
	355															
		353			C	C	A		C	s				x		
		350			C	C	A		A	s				x		
		340			C	A	C		C	s	C			x		

Members	Formations of Flower (1969), LeMone (1969a)	Ft above base	Brachiopods	Cephalopods	Echinoderms	Gastropods	*Nuia*	Ostracods	Sponges	Trilobites	Intraclasts	Ooliths	Peloids	Micrite	Spar	Quartz
McKelligon Canyon	McKelligon Canyon	335			A	C	s		A	s				x		
		330			A	A	s		C	C				x		
		317			C	C			s	C	C				x	
		300			s		s		A	s	C			x		
		285		s	A	s	A			s	A				x	
		280			A	s	s			s	A				x	
		275			s	s			C	s				x		
		265	s		A		s		A	C				x		
		250			A	C	s		C	C				x		
		245			C		A		A	C				x		
		240			C	C	s		C	s				x		
		216	s		C	C	s		A	s				x		
		215			C		C			s	A				x	
		214	s		C	A	s		A	C				x		
		199			s		A			s					x	
		190			C	C	C		A	C				x		
		185			C	C	A		A	C				x		
		175		s	C	s	C		A	C					x	
		153	s		A	C	C		A	C				x		
		120	C		C	A	s		A	C				x		
		102	s		C	A			A	C				x		
		90	C		C	s	A			s	A				x	
		85	C		C	A	s		C	s				x		
		76	C		C	s	A			s	A				x	
		62	s		A	C	C		C	s				x		
		52	s		C	A	s		C	C				x		
		40	C		C	A				A				x		
		35	s		C	C	C			C				x		
		30	C		C	C			C	C	A				x	
		20	s		A	C			A	C				x		
		10			A	A			A	A				x		
	135															
	Snake Hills	133			A	A			A	A				x		
		125			C	A			C	C				x		
		115		s	A	A	t		A	A				x		
		110			A	A			A	A				x		
		95		s	A	A	c		A	A				x		
		88			C	A			C	C				x		
		78		s	C	C			C	C				x		
		70	s	s	C	A			C	C			s	x		
		60			A	A	A		C	C			C	x		
		50			C	A			A	C				x		
		40	s		C	A				C			C	x		
		35			C	A	A		C	C				x		
		30			C	A	s		A	C	C			x		
		25	s		C	A			A	C			s	x		
		20			C	A	s		A	C	C			x		
		10			C	A			A	C	C				x	
		0			C	C	A		C	A	s			x		
	70															
		70			C	A			C	A	s			x		

Members	Formations of Flower (1969), LeMone (1969a)	Ft above base	Brachiopods	Cephalopods	Echinoderms	Gastropods	*Nuia*	Ostracods	Sponges	Trilobites	Intraclasts	Ooliths	Peloids	Micrite	Spar	Quartz
	Mud Springs Mtn.	60			C	A			C	A				x		
		50			C	C				A	C				x	
		42			C	C			A	A				x		
		39											A		x	
		30	s		A	C			C	C				x		
		20	s			s			A	C				x		
		10			C					C	A				x	
		5	s		A				C	s				x		
		0			A	s			C	A				x		
	10															
Jose	Jose	10			A				A	C	A				x	t
		8			C	t			A	A					x	
		5						C	C				C	x		
		3			A				A	A	A				x	
		2			A	C		C	A					x		
		1			A	C			A					x		
		0			A		t		A	C	A				x	
	100															
Hitt Canyon	Victorio Hills	100	C		C	s	s		C	C				x		
		97	s		C	C	C	t	C	s				x		
		92			C	C	C	t	C	s				x		t
		88	C		A	C	A			C					x	s
		83			C		C				A				x	s
		79			C	C	C		C	C					x	C
		75			C	C	C		C	C					x	
		70			C	s				s	A				x	
		65									A				x	
		60				s					A				x	
		55			s		s		s	s				x		
		54			C	C	C				A				x	
		50			t		t		s	t				x		
		45			s		t				A				x	
		35	t		t				t	t				x		
		18	t		t					t				x		
		13			C	s	A			s	C				x	
		1	t		C	C	t		A	A				x		
	45															
	Cooks	42	t	s	A	A	t			C	C				x	
		38			S		C		A	s				x		
		34			A					C	A				x	
		30	s		C	s			s	A	C			x		
		25			C		A		s	A	C				x	
		22			A		C			C	A				x	
		20			A	s	A		A	A	t				x	
		17			A	s	A		A	A	t			x		
		13	s		A	A	s			A	A				x	
		10	t		A		C			C					x	
		5	t		A	A	t		t	A	s	C		x		
		4			s	s			A	s				x		
	162															

The lower 162 ft of Hitt Canyon Member is dolomite with abundant *Girvanella*(?) oncoliths and very few allochem hosts.

Appendix C–1

Summary of allochems in Montoya Formation at Capitol Dome

The following table is a summary of allochem content, type of matrix, and terrigenous material in Montoya Formation at Capitol Dome section. **A**, abundant; **C**, common; **s**, scarce; **t**, trace; **x**, indicates micrite or spar in matrix.

Member	Ft above base	Brachiopods	Bryozoa	Echinoderms	Gastropods	Ostracods	Spicules	Trilobites	Intraclasts	Peloids	Micrite	Spar	Dolomite	Quartz
Cutter	80												A	
	60	A	C	A	A	C		s			x		A	
	55	A	A	A	s	s		s			x		x	
	50	A	A	C							x		C	
	45	A	A	C				s			x		C	
	40	A	A	C		t		s			x		C	
	38	A	A	C				s			x		C	
	31	A	A	A				s				x		
	27	s	C	A		t		s		A	x		s	
	19	t	s	C	t			t		C	x		t	
	15	s	C	A		t		s		A	x		t	
	10		t	t									A	
	5	s	C	A							x		t	
	0												A	

Aleman Member: 90 ft of dolomite and chert; one micrite (microspar) zone at 65 ft contains ostracods, echinoderms, spicules, and traces of trilobites and brachiopods.

Upham Member: 50 ft of dolomite.

Cable Canyon Sandstone Member: 12 ft of sandy dolomite overlie 3 ft of crinoidal dolomite.

Appendix C–2

Summary of allochems in Montoya Formation at Mahoney Park

The following table is a summary of allochem content, type of matrix, and terrigenous material in Montoya Formation at Mahoney Park section. **A**, abundant; **C**, common; **s**, scarce; **t**, trace; **x**, indicates micrite or spar in matrix.

Member	Ft above base	Brachiopods	Bryozoa	Corals	Echinoderms	Gastropods	Ostracods	Spicules	Trilobites	Intraclasts	Peloids	Micrite	Spar	Dolomite	Quartz
Cutter	173													A	
	170													A	
	165													A	
	160			t										A	
	150	C		C										A	
	140	t			t			t						A	
	130	t			t									A	
	120	t	t		C	t	A	A	t				x	C	
	110						t	t					x	C	
	109				C		A	A					x	C	
	100	C			A		A	A					x	C	
	90												x	C	
	80	A	A		C		s		s				x	t	
	75	A	A		A		t		s				x	C	
	65	A	A		A		t	s	t				x	C	
	64	C			s		A		s				x	C	
	55												x	C	
	45						t						x	t	
	40						C	C					x	s	
	35						A	A					x	t	
	30	C	C		A	s			s	C				xs	
	25	A	A		s					s			x	xC	
	20				s		t						x	s	
	12				A		s		t					s	
	11	s	A		A	s			C				x	xt	
	10	A			C	A	s		A			s	x	t	
	7	A	C		C	s	t		s				x	C	
	5	A	C		C	s			t				x	C	
Aleman	110	A	s		A		s	C	s				x	t	
	100							A	t				x	C	
	85	A	s		A		s	C	s				x	s	
	80	s			A		A	A					x	t	
	70	s			A		A	A					x	t	
	60	t			C		C		t				x	t	
	50	s			A		A		s				x	t	
	45	t			s		s		t				x	t	
	40				s		s		t				x	t	
	35				s		s		t				x	t	
	30					A	t						x	s	
	25	t				A							x	s	
	20					A	t						x	s	
	15													A	
	0													A	

Upham Member: 36 ft of dolomite, quartz-sand content increases downward from trace at 10 ft to 5% at base; lower 8 ft include neomorphosed echinoderms, brachiopods, gastropods, and trilobites.

Cable Canyon Sandstone Member: 21 ft of sandy dolomite underlain by 7 ft of dolomitic limestone; quartz-sand content increases downward from 5% at top to 60% 8 ft above base, then decreases to 5% at base; dolomitic limestone contains neomorphosed echinoderms, brachiopods, trilobites, and a trace of ostracods.

Appendix C–3

Summary of allochems in Montoya Formation at Victorio Canyon

The following table is a summary of allochem content, type of matrix, and terrigenous material in Montoya Formation at Victorio Canyon section. **A**, abundant; **C**, common; **s**, scarce; **t**, trace; **x**, indicates micrite or spar in matrix.

Member	Ft above base	Brachiopods	Bryozoa	Corals	Echinoderms	Gastropods	Ostracods	Spicules	Trilobites	Intraclasts	Peloids	Micrite	Spar	Dolomite	Quartz
Cutter	215													A	
	190			t										A	
	90	s												A	
	70	A	A	s	A	s	s		C			x		s	
	56	A	A	s	A	s	s		C			x		t	
	55	s			s		s		s		s	x		s	
	45						s				A	x		C	
	40	A	C		C	C	C		C			x		C	
	25	C	C		A		t		C				x	t	
	20	A	C		C	C	s	A	C		C	x		t	
	10	A	A		A	C		C	A			x		t	
	0	t	s		A								x	t	
Aleman	110	C			s			t	A		A	x			
	95	C			s			s	A		A	x			
	90	s			s			C	A		A	x			
	75	C			s				A		A	x			
	65				s				A		A	x			
	50								A		A	x		t	
	30				t				A		A	x		s	
	0													A	

Upham Member: 40 ft of dolomite; approximately 1% quartz sand at base.

Cable Canyon Sandstone Member: 25 ft of sandy dolomite.

Appendix D–1

Summary of grain size and composition of Lobo Formation at northwest Capitol Dome

The following table is a summary of grain size and percentage grain composition in Lobo Formation at northwest Capitol Dome section: NW¼NW¼SW¼ sec. 11 T25S R8W (300 grains were counted). **Mxl**, monocrystalline; **Pxl**, polycrystalline; **K**, potassium; **P**,plagioclase; **Cht**, chert; **Crf**, carbonate; **Srf**, sandstone; **Vrf**, volcanic; **Prf**, plutonic.

Ft above base	Grain size					Quartz		Feldspar		Rock fragments				
	mud	fin	med	crs	cgl	Mxl	Pxl	K	P	Cht	Crf	Srf	Vrf	Prf
340	x													
335				x	x	25	5	29	4	6	15	11	0	5
330				x		26	4	32	2	5	23	6	0	2
310		x				48	1	13	1	5	31	0	0	1
290			x			35	3	32	1	4	21	2	0	2
285		x				40	2	19	1	8	29	1	0	0
275			x		x	28	3	28	1	6	20	10	0	4
235		x				44	4	16	1	6	26	2	0	1
205		x				52	1	8	1	6	32	0	0	0
170			x		x	24	2	18	0	6	41	8	0	1
165		x				53	1	11	0	5	29	1	0	0
125				x		41	1	11	a	5	40	1	0	0
120	x													
115			x			41	4	29	3	4	16	3	0	0
105	x													
95		x				40	2	16	1	3	37	0	0	1
85		x				41	2	6	0	8	42	1	0	0
75		x				56	1	1	0	6	36	0	0	0
65			x			21	3	1	0	8	57	10	0	0
60		x				58	1	3	1	8	29	0	0	0
50			x			36	1	2	1	16	44	0	0	0
20	x			x										
10	x			x										

Appendix D–2

Summary of grain size and composition of Lobo Formation at Tubb Spring

The following table is a summary of grain size and percentage grain composition in Lobo Formation at Tubb Spring section: SW¼SW¼ sec. 11 T25S R8W (300 grains were counted). **Mxl**, monocrystalline; **Pxl**, polycrystalline; **K**, potassium; **P**, plagioclase; **Cht**, chert; **Crf**, carbonate; **Srf**, sandstone; **Vrf**, volcanic; **Prf**, plutonic.

Ft above base	Grain size					Quartz		Feldspar		Rock fragments				
	mud	fin	med	crs	cgl	Mxl	Pxl	K	P	Cht	Crf	Srf	Vrf	Prf
600	x													
580			x			58	1	21	6	6	7	1	0	0
545				x		44	0	21	2	8	22	3	0	0
525			x			50	1	20	5	9	13	2	0	0
500	x													
480	x													
455		x				52	2	17	4	17	7	1	0	0
410			x			48	4	14	3	9	21	1	0	0
375		x				53	4	11	3	9	19	1	0	0
350		x				45	13	7	2	17	13	3	0	0
345				x		35	3	13	2	19	24	4	0	0
335		x				78	1	1	2	12	6	0	0	0
325	x													
310														
300					x									
280			x			53	4	8	2	16	15	2	0	0
270					x									
260		x				69	3	7	1	14	6	0	0	0
250	x													
240		x				56	4	12	2	13	12	1	0	0
215		x				62	3	7	1	15	12	0	0	0
210		x				61	5	5	1	6	21	1	0	0
200		x				48	3	4	2	17	24	2	0	0
190	x													
170	x													
140		x				62	7	4	1	12	12	2	0	0
135		x				52	4	1	1	9	19	14	0	0
125		x				55	4	3	0	22	13	3	0	0
120	x													
115		x				53	5	4	0	17	19	2	0	0
105		x				60	2	1	0	14	21	2	0	0
85		x				45	4	1	0	22	21	2	0	0
70	x													
65			x			42	3	0	0	12	39	3	0	1
60			x			33	2	0	0	14	36	15	0	0
50	x				x									

Appendix D–3

Summary of grain size and composition o Lobo Formation at West Florida Mountains

The following table is a summary of grain size and percentage grain composition in Lobo Formation at West Florida Mountains section: SW¼ sec. 13 T25S R8W (30 grains were counted). **Mxl**, monocrystalline; **Pxl**, polycrystalline; **K**, potassium; **P**, plagioclase; **Cht**, chert; **Crf**, carbonate; **Srf**, sandstone; **Vrf**, volcanic; **Prf**, plutonic.

Ft above	Grain size					Quartz		Feldspar		Rock fragments				
base	mud	fin	med	crs	cgl	Mxl	Pxl	K	P	Cht	Crf	Srf	Vrf	Prf
485			x			38	2	16	4	3	30	0	7	0
450	x													
430					x	30	2	32	2	2	20	2	2	8
410	x													
390			x			40	3	24	4	5	16	3	1	4
370			x			31	2	36	2	4	21	0	0	4
350	x													
310				x		47	7	23	1	3	8	5	0	6
295				x	x	8	1	10	0	5	39	32	1	4
285		x				59	1	28	0	5	5	1	0	1
270				x		50	0	0	22	6	18	4	0	0
260		x				56	0	0	37	4	2	1	0	0
230	x													
200		x			x	56	1	34	0	3	4	1	0	0
170			x			62	2	27	0	4	4	t	0	0
135	x													
120		x				63	1	28	0	4	2	1	0	0
110		x				95	1	3	1	t	t	0	0	0
80			x			96	1	0	0	1	1	1	0	0
70			x			92	1	0	0	2	2	3	0	0
60				x		49	1	17	2	7	4	20	0	0
30		x												
20					x									
0					x									

Appendix D–4

Summary of grain size and composition of Lobo Formation at Lobo Draw

The following table is a summary of grain size and percentage grain composition in Lobo Formation at Lobo Draw: SW¼SW¼ sec. 19 T25S R7W (300 grains were counted). **Mxl**, monocrystalline; **Pxl**, polycrystalline; **K**, potassium; **P**, plagioclase; **Cht**, chert; **Crf**, carbonate; **Srf**, sandstone; **Vrf**, volcanic; **Prf**, plutonic.

Ft above	Grain size					Quartz		Feldspar		Rock fragments				
base	mud	fin	med	crs	cgl	Mxl	Pxl	K	P	Cht	Crf	Srf	Vrf	Prf
385	x					0	0	0	0	0	0	0	0	
370			x			9	0	27	1	24	28	3	8	0
315		x				30	3	24	1	12	27	0	3	0
275			x			22	3	26	1	10	28	3	7	0
250			x			19	4	24	1	12	31	1	8	0
230			x			22	1	28	0	12	25	2	10	0
215		x				33	4	12	3	11	25	1	11	0
165			x			28	1	45	1	1	18	4	0	2
145			x			40	3	41	2	4	6	4	0	0
125			x			33	8	35	1	4	13	5	0	1
110			x			27	3	56	0	1	4	5	0	4
95			x			29	4	54	0	1	2	4	0	6
67			x			60	8	14	0	3	2	2	0	11
45				x		42	3	42	0	1	3	7	0	2
35			x			44	3	30	0	0	16	4	0	3
20				x		29	1	57	0	0	6	3	0	4

Appendix E–1

Capitol Dome (Bliss Sandstone channel) measured section

The section was measured in the low saddle west–southwest of Capitol Dome in the NE¼SW¼SE¼ sec. 10 T25S R8W during May 1980. Measured section line is indicated on Sheet 3. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 15 thin sections was completed and rock names were assigned according to Folk's (1954, 1974) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock-color chart* published by the Geological Society of America (1963). Within the table rock names and colors follow the distance, which is given above the base of the Bliss Sandstone.

Description	Thickness ft
Bliss Sandstone	160 +
Arkose and subarkose: thin- to medium-bedded; crossbedded; original clay(?) matrix converted to sericite; zircons common in all thin sections; interpenetration of quartz grains common; base rests nonconformably on Precambrian(?) granite; top is faulted and overlain by brecciated Bliss and El Paso Formation blocks.	
160 ft Coarse sandstone: calcitic immature arkose; very light gray (N8); weathers light moderate brown (5YR4/6).	
148 ft Coarse sandstone: calcitic immature subarkose; light olive gray (5Y611); weathers pale yellowish brown (10YR6/2); poorly exposed with faults above and possibly below.	
120 ft Medium sandstone: siliceous immature sericitic subarkose; moderate grayish orange pink (5YR8/2); weathers pale yellow brown (10YR612).	
118 ft Very coarse sandstone: siliceous submature subarkose; pale yellowish brown (l0YR6/2); weathers moderate yellowish brown (10YR 514).	
95 ft Coarse sandstone: siliceous submature arkose, same colors as at 118 ft above.	
80 ft Very coarse sandstone: siliceous hematitic submature subarkose; light olive gray (5Y 6/1); weathers light brown (5YR5/4).	
65 ft Very coarse sandstone: siliceous submature subarkose; moderate orange pink (5YR8/4); weathers pale yellowish brown (l0YR6/2).	
57 ft Very coarse sandstone: hematitic immature sericitic arkose; grayish brown (5YR3/2); weathers moderate brown (5YR3/4).	
46 ft Bimodal fine and coarse sandstone: hematitic immature sericitic arkose; pale grayish orange (l0YR6/4); weathers yellowish brown (l0YR4/4).	
38 ft Coarse sandstone: sericitic immature subarkose; moderate yellowish orange (l0YR5/6); weathers light brown (5YR5/6).	
27 ft Bimodal fine and very coarse sandstone: hematitic immature sericitic arkose; dusky brown (5YR2/2); weathers moderate brown (5YR3/4).	
19 ft Coarse sandstone: hematitic submature sericitic arkose; grayish brown (5YR3/2); weathers moderate brown (5YR4/4).	
8 ft Coarse sandstone: sericitic hematitic immature arkose; light brown (5YR6/4); weathers moderate brown (10YR5/4).	
0 ft Slightly pebbly coarse sandstone: sericitic immature arkose; dark yellowish brown (10YR6/4); weathers moderate yellowish brown (l0YR5/4).	

Appendix E–2

Capitol Dome (Bliss Sandstone – Montoya Formation) measured section

The section was measured on the northwest slope of Capitol Dome (along the northern edge of SE¼ sec. 10 T25S R8W) during May 1982 and March 1983. Measured section location lines are indicated on the large scale geologic map (Sheet 3). The Bliss Sandstone, the Hitt Canyon, and most of the McKelligon Canyon Member of the El Paso Formation were measured up the ridge until traversed by a normal fault that dropped the southeast block. About 50 ft of McKelligon Canyon Member is not exposed there. Starting at the fault in the arroyo south of the ridge, the uppermost McKelligon Canyon Member and Padre Member were measured to the base of the Montoya Formation. The Montoya Formation was measured up the head of the tributary arroyo about 800 ft south of the main arroyo. The section was measured using a Jacob's staff. Petrographic study of 170 thin sections was completed and rock names were assigned according to Folk's (1962, 1974) and Dunham's (1962) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock-color chart* published by the Geological Society of America (1963). More lumping of strata than found in typical measured sections is evident. Column units are based on lithologies clearly distinct from those above or below. Descriptions of representative samples within each column unit follow the given distance, which is *above* the base of the preceding, numbered unit. The allochems are listed in order of decreasing abundance, and a trace is considered to be less than 1% of the total allochems.

Unit	Description	Thickness ft
	Lobo Formation	
	Montoya Formation	245
	Cutter Member	90
19	Dolomite: fine-crystalline, brecciated, medium gray (N5); weathers light brownish gray (5YR 6/1);top eroded.	25
18	Limestone and dolomitic limestone; thin-bedded; upper 10 ft have twig-like features on weathered surfaces because of differential coloration of dolomitic burrow fillings.	40
	35 ft Fossiliferous dolomitic micrite (wackestone): medium gray (N5); weathers grayish orange (10YR7/4); echinoderms, gastropods, brachiopods, bryozoa; few ostracods, trilobites; abundant intersecting spar veins.	
	30 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium light gray (N6); echinoderms, bryozoa, brachiopods; few trilobites, ostracods, gastropods; spar veins and stylolites.	
	25 ft Sparse dolomitic biomicrudite (wackestone): medium-gray (N5); weathers medium light gray (N6); brachiopods, bryozoa, echinoderms; bioturbated; spar veins and stylolites, fine crystalline, light brown dolomite rhombs replace burrow-filling matrix.	
	20 ft Packed dolomitic biomicrudite (packstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); brachiopods, bryozoa, echinoderms; few trilobites; like 18–25 above; few cubic outlines of hematite after pyrite.	
	15 ft Sparse dolomitic biomicrite (wackestone): medium gray (N5); weathers moderate yellowish brown (10YR5/2); same allochems and textural features as 18–25 above.	
	13 ft Packed dolomitic biomicrudite (packstone): medium dark gray (N4); weathers light olive gray (5YR6/1); same allochems and textural features as 18–20 above, minor chert replacement of brachiopods.	
	6 ft Rounded biosparite (grainstone): medium gray (N5); weathers medium dark gray (N4); echinoderms (mostly echinoids), bryozoa, brachiopods; few trilobites; some chert replacement of echinoderms and brachiopods; syntaxial overgrowths on echinoderms and chert replacement preceded styolite formation.	
17	Dolomite, limestone, and chert; interbedded 1–4 in beds, resembles Aleman lothology.	15
	9 ft Sparse biomicrite (wackestone): medium gray (N4); weathers pale yellowish brown (10R5/4); echinoderms (mostly echinoids), bryozoa; few gastropods, brachiopods and trilobites; finely laminated.	
	5 ft Same as 17–9 above, except this portion is bioturbated.	
16	Limestone and dolomite; thick-bedded.	10
	10 ft Coarse-crystalline dolomite: light gray (N7); weathers light olive gray (5YR6/1); ghosts of echinoderms and bryozoa; bryozoa; 10% coarse spar filling intercrystal dolomite vugs.	
	5 ft Neomorphosed biosparite (grainstone): medium gray (N5); weathers medium light gray (N6); echinoderms, bryozoa, brachiopods, syntaxial overgrowths on echinoderms; some chert replacement of allochems, stylolites.	
	1 ft Coarse-crystalline dolomite: medium light gray (N6); weathers grayish orange (10YR7/4); few fossil allochem ghosts.	
	Aleman Member	90
15	Chert, dolomite, and limestone: chert and dolomite 0.25–1 inch beds interbedded at base gradational up to 1–3 inch beds at 15 ft; few limestone interbeds at 50–70 ft; lensoid chert nodules in massive dolomite at top .	
	65 ft Sparse biomicrosparite (wackestone): medium dark gray (N4); weathers olive gray (5YR5/1); ghosts of ostracods echinoderms; few trilobites, brachiopods, and spicules(?).	
	Upham Member	50
14	Dolomite: medium-crystalline; massive-bedded; abundant small irregular vugs; dark gray (N3); weathers dark brownish gay (5YR4/1).	
	Cable Canyon Sandstone Member	15
13	Sandy dolomite: medium to coarse, subrounded to well-rounded quartz grains comprising up to	

Unit	Description	Thickness ft
	40% in medium-crystalline dolomite matrix; few bluish quartz grains; medium gray (N5); weathers moderate yellowish brown (10YR5/4); basal 3-ft crinoidal dolomite without quartz grains.	
	El Paso Formation	
	Padre Member	130
12	Limestone and dolomitic limestone: mostly thin to medium-bedded with few thick beds; abundant chert in upper part; dolomitized branching burrow fillings give weathered surfaces "twiggy" appearance; most samples show bioturbation, stylolites, and spar veins.	
	130 ft Poorly washed biosparite (packstone/grainstone): medium light gray (N6); weathers yellowish gray (5YR8/1); echinoderms, trilobites, brachiopods, intraclasts; few *Nuia*; chert replaced some echinoderms.	
	125 ft Intrasparrudite (grainstone): same colors as 12–130 above; brachiopods, intraclasts, echinoids, trilobites; chert replaced some brachiopods.	
	120 ft Intrasparrudite (grainstone): medium gray (N5); weathers grayish orange (10YR7/4); intraclasts, echinoderms, trilobites, brachiopods; chert makes up 60% of some zones; hematite after pyrite(?) cubes in some micrite areas.	
	115 ft Sparse biomicrite (lime mudstone): medium gray (N5); weathers medium dark gray (N4); small (avg. 0.1 mm) unidentified fragments, spicules(?), echinoderms, trilobites; minor medium quartz silt, well laminated, chert replaced most allochems.	
	110 ft Dolomitic dismicrite (lime mudstone): light olive gray (5YR6/1); weathers light brown (5YR5/6); similar composition to 12–115 above; very fine crystalline dolomite replaced much micrite matrix.	
	106 ft Dismicrite (lime mudstone): medium gray (N5); weathers light gray (N7); composition similar to 12–110 above without dolomite.	
	105 ft Intrasparrudite (grainstone): colors like 12–106 above; intraclasts of biomicrites.	
	100 ft Poorly washed, dolomitic biosparite (packstone/grainstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); gastropods, spicules; few brachiopods, trilobites, ostracods, echinoderms; approximately 20% dolomite.	
	90 ft Sparse biodismicrite (wackestone): medium light gray (N6); weathers light brown (5YR5/6); spicules, brachiopods, gastropods, echinoderms, trilobites.	
	85 ft Sparse dolomitic biomicrite (wackestone): same colors as 12–90 above; spicules with few brachiopods, trilobites, and echinoderms; approximately 30% dolomite; abundant small chert nodules.	
	75 ft Sparse biodismicrite (wackestone): medium gray (N5); weathers pale yellowish orange (10YR6/4); spicules with few trilobites, gastropods, and echinoderms.	
	73 ft Biosparite (grainstone):medium dark gray (N4), weathers pale yellowish brown (10YR6Q); neomorphosed *Nuia* with thick micritized rims and few echinoderms, trilobites, and intraclasts; overlain by nodular, bedded chert zone.	
	65 ft Fossiliferous micrite (wackestone): medium gray (N5); weathers very pale orange (10YR8/2); spicules, gastropods echinoderms, trilobites; microspar in burrow fillings.	
	53 ft Fossiliferous dolomitic micrite (wackestone): medium dark gray (N4); weathers light brown (5YR5/6); spicules with few trilobites and algae(?); abundant peloids; fine-crystalline, dark brown dolomite rhombs replaced part of micrite matrix.	
	45 ft Sparse biomicrite (wackestone): medium gray (N5); weathers light brown (5YR5/6); trilobites, gastropods, echinoderms, spicules, brachiopods, chert replaced some brachiopods; spicules uniformly distributed; other allochems concentrated in burrow fillings(?).	
	39 ft Sparse biomicrite (wackestone): brownish gray (5YR4/1); weathers dark yellowish brown (10YR4/2); unidentified fragments average less than 0.1 mm; scattered, fine dolomite rhombs in some laminae.	
	35 ft Intrasparrudite (grainstone): medium gray (N5), weathers very light gray (N8); biomicrite intraclasts, trilobites, gastropods, echinoderms.	
	25 ft Fossiliferous dolomitic micrite (mudstone): medium dark gray (N4); weathers moderate yellowish brown (10YR5/ 4); few trilobites and spicules, bioturbated zones are dolomitized.	
	20 ft Sparse biomicrite (wackestone): same colors as 12–25 above; trilobites, gastropods, echinoderms, brachiopods, spicules; minor quartz silt grains.	
	19 ft Fine-crystalline dolomite: pale brown (5YR5/2); weathers light yellowish brown (5YR6/6); ghosts of echinoderms, trilobites, brachiopods, *Nuia*, gastropods, and spicules(?); trace of quartz silt.	
	18 ft Sparse dolomitic biomicrite (wackestone): light olive gray (5Y6/1); weathers light brown (5Y5/6); echinoderms, trilobites, spicules, brachiopods, gastropods(?); chert replaced some echinoderms.	
	10 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium light gray (N6); gastropods, trilobites, echinoderms, spicules, brachiopods, intraclasts; chert replaced some echinoderms; interbedded with intrasparrudites.	
	5 ft Fossiliferous microsparite (lime mudstone): grayish black (N2); weathers medium dark gray (N4); small unidentified shell fragments; peloids, ostracods, trilobites, gastropods; approximately 2% very fine quartz sand; this 6-ft-thick bed is a good marker bed around Capitol Dome.	

Unit	Description	Thickness ft
11	**McKelligon Member**	141
	Limestone and dolomitic limestone: mostly medium- to thick-bedded with few massive beds; dolomitized, branching burrow fillings give weathered surfaces "twiggy" appearance; most samples show bioturbation, stylolites and spar veins.	
	141 ft Poorly washed biosparite (packstone/grainstone): brownish gray (5YR4/1); weathers pale yellowish orange (10YR 6/4), *Nuia*, echinoderms, trilobites; few gastropods, brachiopods, intraclasts; 1 ft thick bed.	
	140 ft Fine sandy, fine crystalline dolomite (sandy wackestone): pale yellowish brown (10YR6/2); weathers moderate yellowish brown (10YR5/4); *Nuia*, echinoderms, and trilobites in micrite matrix compose approximately 20% of rock and very fine quartz sand another 10%; well laminated.	
	135 ft Sparse biomicrite (wackestone): medium light gray (N6); weathers pale grayish orange (10YR8/4); spicules, *Nuia*, trilobites, echinoderms; few brachiopods, gastropods, intraclasts; approximately 1% quartz silt concentrated in burrow fillings.	
	130 ft Sparse biomicrite (wackestone): same colors as 11–135 above; same components as 11–135 except has scattered cephalopods and no silt.	
	125 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers moderate yellowish brown (10YR5/4); gastropods, spicules and sponge fragments, *Nuia*, brachiopods, trilobites, echinoderms; approximately 1% quartz silt; some chert replaced echinoderms.	
	120 ft Sparse biomicrite (wackestone): medium light gray (N6); weathers grayish orange (10YR7/4); same components as 11–125 above, but fewer brachiopods and less silt.	
	119 ft Fine-crystalline dolomite (dolomitized wackestone): moderate light brown (5YR514); weathers pale yellowish orange (10YR6/4); few allochem ghosts; probably similar originally to 11–113 below.	
	113 ft Packed dolomitic biomicrite (packstone): moderate brown (5YR3/4) and medium gray (N5) mottled; weathers moderate yellowish brown (10YR5/4); *Nuia*, echinoderms, spicules; few brachiopods, trilobites, gastropods.	
	107 ft Poorly washed intrasparite (packstone/grainstone): medium light gray (N6); weathers light gray (N7); biomicrite intraclasts, *Nuia*, echinoderms, gastropods, trilobites, brachiopods; some chert replaced echinoderms.	
	104 ft Intrasparite (grainstone): medium light gray (N6); weathers dark yellowish brown (10YR4Q); same allochems as 11–107 above (most in intraclasts); some brown dolomite rhombs replaced intraclasts.	
	100 ft Sparse biodismicrite (wackestone): medium gray (N5); weathers dark yellowish orange (10YR6/6); spicules, echinoderms, brachiopods, *Nuia;* fine-crystalline dolomite replaced most burrow fillings; much chert replaced echinoderms.	
	96 ft Fine-crystalline, dolomitic biomicrite (wackestone): pale brown (5YR5/2); weathers moderate yellowish brown (10YR5/4); *Nuia;* few echinoderms, trilobites, spicules; trace of quartz silt.	
	91 ft Fossiliferous dismicrite (wackestone): medium light gray (N6); weathers very pale orange (10YR812); spicules, trilobites, brachiopods, gastropods.	
	85 ft Intrasparite (grainstone): same color as 11–91 above; spicule micrite intraclasts, echinoderms, trilobites, brachiopods; chert replaced some echinoderms; medium-crystalline, brown dolomite rhombs replaced burrow fillings.	
	81 ft Sparse biomicrosparite (wackestone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); neomorphosed spicules(?), echinoderms, *Nuia*(?); medium-crystalline, brown dolomite replaced burrow fillings.	
	75 ft Fossiliferous micrite (lime mudstone): same colors as 11–81 above; spicules, echinoderms, trilobites.	
	70 ft Poorly washed intrasparite (packstone/grainstone): same colors as 11–81 and 11–75 above; *Nuia* micrite and spicule micrite intraclasts, trilobites, echinoderms, gastropods; medium-crystalline, brown dolomite replaced burrow fillings.	
	66 ft Intramicrosparite (wackestone): medium dark gray (N4); weathers grayish orange (10YR7/4); trilobites, echinoderms, brachiopods; medium-crystalline, dark-brown dolomite rhombs replaced burrow fillings.	
	63 ft Dolomitic biomicrite (wackestone): moderate brown (5YR4/4); weathers moderate yellowish brown (10YR5/4); *Nuia*, echinoderms, trilobites, brachiopods; medium-crystalline, brown-rimmed dolomite rhombs replaced bioturbated matrix.	
	60 ft Poorly washed intrasparite (packstone/grainstone): medium light gray (N6); weathers pale yellowish brown (10YR 6/2), biomicrite intraclasts, echinoderms, gastropods, trilobites; echinoderms have micritized rims and are partly replaced with chert; few scattered dolomite rhombs in matrix.	
	55 ft Intrasparite (grainstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); biomicrite intraclasts, trilobites, *Nuia;* fine-crystalline, brown dolomite replaced some micrite in intraclasts.	
	50 ft Poorly washed intrasparite (packstone/grainstone): same colors as 11–55 above; biomicrite intraclasts, *Nuia*, brachiopods, echinoderms; echinoderms have micri-	

Unit	Description	Thickness ft
	tized rims; dolomite same as 11–55 above.	
	48 ft Fossiliferous dismicrite (lime mudstone): same colors as 11–55 above; spicules, echinoderms, trilobites; dolomite replaced burrow fillings.	
	43 ft Sparse dolomitic biomicrite (lime mudstone): pale brown (5YR5/2); weathers light yellowish brown (5YR6/6); echinoderms(?), trilobites, spicules, peloids; 4–9 mm laminae; fine-crystalline, brown dolomite replaced micrite.	
	40 ft Sparse biodismicrite (wackestone): medium dark gray (N4); weathers grayish orange-pink (5YR7/2); spicules, trilobites, micrite intraclasts; few algae(?), gastropods(?), and echinoderms(?); medium-crystalline, zoned, brown dolomite rhombs replaced part of burrow fillings.	
	35 ft Biosparite (grainstone): light gray (N7); weathers grayish orange (10YE7/4); *Nuia*, trilobites, echinoderms, spicules, brachiopods; trace of quartz silt; overlies fine laminated biomicrite.	
	32 ft Intrasparite (grainstone) and sparse biomicrite (wackestone): medium light gray (N6); weathers moderate yellowish brown (10YR5/4); biomicrite intraclasts in spar matrix fill in scoured biomicrite with *Nuia*, echinoderms, gastropods, spicules, trilobites, and brachiopods; medium-crystalline, brown dolomite replaced bioturbated micrite.	
	30 ft Dolomitic biomicrite (wackestone): light brownish gray (5YR6/1); weathers pale yellowish orange (10YR6/4); approximately 50% medium-crystalline, brown-rimmed dolomite rhombs; *Nuia*, brachiopods, echinoderms, trilobites, spicules, gastropods.	
	25 ft Packed dolomitic biomicrite (packstone): medium light gray (N6); weathers moderate yellowish brown (10YR 5/4); *Nuia*, gastropods, brachiopods, echinoderms, spicules; approximately 20% dolomite as in 11–30 above.	
	20 ft Packed dolomitic biomicrite (packstone): same colors and composition as 11–25 above.	
	14 ft Sparse biodismicrite (wackestone): medium dark gray (N4); weathers pale yellowish orange (10YR6/4); *Nuia* with few spicules, gastropods, echinoderms, intraclasts, peloids; trace of brown-rimmed dolomite rhombs.	
	10 ft Packed biomicrite (packstone): same colors as 11–14 above, *Nuia;* few trilobites, echinoderms, brachiopods, spicules, peloids; some chert replaced echinoderms; dolomite as in 11–14 above.	
	5 ft Packed biomicrite (packstone): same colors as 11–14 above; trilobites, echinoderms, spicules, gastropods, intraclasts, brachiopods; medium-crystalline, brown-rimmed dolomite rhombs replaced some of burrow fillings.	
	1 ft Sparse biomicrite (wackestone): same colors as 11–14 above; spicules, trilobites, echinoderms, peloids; small chert nodules result from chert replacing part of spicular(?) pelneosparite layers; normal fault (strikes N45°E, dips 65°SE); lower part of El Paso Formation measured on ridge northwest of arroyo.	
10	**McKelligon Member (continued)**	405
	405 ft Sparse biomicrite (wackestone): medium dark gray (N4), weathers brownish gray (5YR4/1); sponges, *Nuia*, intraclasts, echinoderms, trilobites, gastropods; chert replaced some echinoderms and sponges.	
	370 ft Sparse biomicrite (wackestone): medium gray (N5); weathers medium light gray (N6); sponges, *Nuia;* few trilobites, echinoderms, gastropods, intraclasts.	
	350 ft Sparse biomicrite (wackestone): same colors as 10–370 above except burrow fillings weather moderate yellowish brown (10YR5/4); spicules, gastropods, brachiopods, trilobites, echinoderms, intraclasts; chalcedony replaced some echinoderms.	
	330 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium gray (N5); spicules, echinoderms, *Nuia*, gastropods, trilobites .	
	300 ft Packed biomicrite (packstone): same colors as 10–330 above; stromatolites(?); intraclasts, spicules, gastropods, echinoderms; few *Nuia* and trilobites.	
	250 ft Packed biomicrite (packstone): same colors as 10–330 above; spicules, intraclasts, *Nuia*, trilobites, echinoderms.	
	225 ft Poorly washed biosparite (packstone/grainstone): medium gray (N5); weathers light brownish gray (5YR5/1); *Nuia*, gastropods, spicules, intraclasts, brachiopods, echinoderms, trilobites.	
	215 ft Unsorted biosparrudite (grainstone): medium gray (N5); weathers medium light gray (N6); gastropods, intraclasts, echinoderms.	
	205 ft Intrasparite (grainstone) and sparse biomicrite (wackestone): same colors as 10–215 above; intraclast-spar layer above micrite with *Nuia*, gastropods, trilobites, echinoderms, brachiopods, spicules.	
	200 ft Packed biomicrite (packstone): same colors as 10–215 above; *Nuia*, trilobites, gastropods, echinoderms, spicules; up to 30% spar cement.	
	190 ft Sparse biomicrite (wackestone): same colors as 10–215 above; brachiopods, gastropods, spicules, trilobites, echinoderms; few intraclasts in spar cement.	
	180 ft Cherty biomicrosparite (wackestone): medium gray (N5); weathers light brownish gray (5YR6/1); small echinoderm(?) fragments, peloids, trilobites; spicule ghosts abundant in chert lens.	
	165 ft Poorly washed biosparite (packstone/grainstone): medium gray (N5); weathers	

Unit	Description	Thickness ft
	dark yellowish orange (10YR6/6); trilobites, echinoderms, spicules; few gastropods, *Nuia*, peloids; fine-crystalline, brown dolomite rhombs concentrated in burrows and along stylolite seams.	
160 ft	Poorly washed biosparite (packstone/grainstone): medium dark gray (N4); weathers grayish orange (10YR7/4); trilobites, *Nuia*, intraclasts, echinoderms; medium crystalline, zoned, brown dolomite rhombs in burrows.	
153 ft	Packed biomicrite (wackestone): medium light gray (N6); weathers grayish orange (10YR7/4); trilobites, echinoderms, spicules, gastropods, intraclasts; few brachiopods and trace of *Nuia*; dolomite rhombs as in 10–165 above.	
147 ft	Packed biomicrite/intrasparrudite (wackestone/grainstone): same colors as 10–153 above; allochems like 10–153 except more brachiopods and a few cephalopods; chert replaced some echinoderms; sample includes contact between wackestone and grainstone layers; dolomite similar to 10–165 above.	
140 ft	Sparse biomicrite (wackestone): medium dark gray (N4); weathers grayish orange (10YR7/4); allochems like 10–147 above, but not as abundant; chert replaced some brachiopods; dolomite similar to 10–165 above.	
135 ft	Poorly washed biosparite (packstone): colors same as 10–153 above; allochems and dolomite like 10–147 above.	
130 ft	Sparse biomicrite (wackestone): medium gray (N5); weathers grayish orange-pink (5YR7/2); gastropods, brachiopods, echinoderms, few spicules, *Nuia*, trilobites; brown dolomite rhombs concentrated in burrows.	
125 ft	Sparse biomicrite (wackestone): same as 10–130 above except weathers moderate yellowish brown because it contains more dolomite.	
120 ft	Packed biomicrite (wackestone): medium dark gray (N4); weathers moderate yellowish brown (10YR5/4); predominantly *Nuia*; few gastropods, trilobites, echinoderms, spicules; brown dolomite rhombs in microsparite burrow fillings	
115 ft	Sparse biomicrite (wackestone): same colors as 10–120 above; gastropods, echinoderms, brachiopods, *Nuia*, spicules; brown dolomite rhombs in burrows.	
110 ft	Packed biomicrite (wackestone): same colors as 10–120 above; trilobites, spicules, echinoderms, brachiopods, gastropods, *Nuia*; few intraclasts, cephalopods; chert replaced some echinoderms; brown dolomite rhombs in burrows.	
105 ft	Packed biomicrite (wackestone): same colors as 10–120 above; allochems similar to 10–110 above except spicules are more abundant and there are fewer echinoderms, *Nuia*, and gastropods.	
103 ft	Packed dolomitic biomicrite (wackestone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); trilobites, *Nuia*, spicules, echinoderms; few brachiopods; brown dolomite rhombs with light rims in burrows.	
98 ft	Intrasparrudite (grainstone): medium light gray (N6); weathers pale yellowish orange (10YR6/4); biomicrite intraclasts from subjacent beds; two stages of cementation represented by fibrous and blocky spar.	
90 ft	Sparse dolomitic biomicrite (wackestone): medium light gray (N6); weathers grayish orange (10YR7/4); *Nuia*, trilobites, gastropods, echinoderms; few brachiopods and intraclasts; few zones contain up to 50% fine-crystalline dolomite.	
85 ft	Packed biomicrite (wackestone): medium gray (N6), weathers light brown (5YR5/6); gastropods, trilobites, echinoderms, spicules; few brachiopods, cephalopods; some coarse quartz silt in burrows with fine-crystalline, brown dolomite rhombs.	
80 ft	Same as 10–85 above except medium light gray (N6); weathers pale yellowish orange (10YR6/4).	
75 ft	Sparse biomicrite (wackestone): medium dark gray (N4); weathers grayish orange (10YR7/4); gastropods, trilobites, echinoderms; few spicules, cephalopods, brachiopods; chert replaced some echinoderms; minor fine-crystalline, brown dolomite rhombs in burrows; possibly top of Snake Hills unit.	
70 ft	Similar to 10–75 above except medium light gray (N6), weathers moderate yellowish brown (10YR5/4), and more allochems with a few *Nuia*.	
65 ft	Packed microsparite (wackestone): medium dark gray (N4); weathers grayish orange (10YR7/4); gastropods, trilobites, echinoderms; few brachiopods, cephalopods, spicules; trace of quartz silt; brown dolomite rhombs in burrows.	
60 ft	Packed biomicrudite (wackestone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); trilobites, *Nuia*, gastropods, spicules, echinoderms; few brachiopods, intraclasts; dolomite rhombs with brown rims replaced some burrow fillings.	
55 ft	Packed biomicrite (wackestone): same colors as 10–60 above and same, but smaller, allochems and dolomite rhombs.	
45 ft	Packed biomicrite (wackestone): medium dark gray (N4); weathers grayish orange (10YR7/4); gastropods, trilobites, *Nuia*, echinoderms; few spicules, intraclasts; brown dolomite rhombs replaced some burrow fillings.	
40 ft	Sparse dolomitic biomicrite (wackestone): same colors as 10–45 above and same, but fewer, allochems; up to 15% brown dolomite replaced burrow fillings and some micrite matrix.	

Unit	Description	Thickness ft
	30 ft Intrasparrudite (grainstone): medium dark gray (N4); weathers grayish brown (5YR3/2); intraclasts of biomicrites in spar matrix.	
	25 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers pale yellowish brown (10YR6/2); *Nuia*, gastropods, trilobites, spicules, echinoderms, few intraclasts.	
	15 ft Sparse dolomitic biomicrite (wackestone): medium light gray (N6); weathers pale yellowish orange (10YR6/4); brachiopods, trilobites, echinoderms, gastropods; few *Nuia*, spicules; up to 60% brown dolomite replaced matrix and some allochems.	
	10 ft Sparse biomicrite (wackestone): same colors as 10–15 above; *Nuia*, spicules, echinoderms, stromatolite(?), trilobites, scattered brown dolomite rhombs replaced micrite matrix; probable base of Snake Hills unit.	
9	Limestone: thin- to medium-bedded; abundant stromatolite mounds 3–5 inches wide and up to 12 inches high; most samples show bioturbation and dolomitized burrow fillings; stylolites and spar veins are common; probable equivalent of Mud Springs unit; top at confluence of two arroyos.	20
	20 ft Biomicrite (wackestone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); trilobites, gastropods; few echinoderms, *Nuia*, intraclasts.	
	15 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers brownish gray (5YR4/1); stromatolites, echinoderms; few *Nuia*, trilobites, gastropods, spicules(?).	
	10 ft Biomicrite/intrasparite (wackestone/packstone): medium gray (N5); weathers dark yellowish orange (10YR6/6); trilobites, gastropods, spicules, echinoderms, intraclasts; few *Nuia*.	
	5 ft Intrasparite/biomicrite (packstone/wackestone): same colors and allochems as 9–10 above except intraclasts in spar are dominant in this sample.	
	1 ft Intrasparite/intramicrosparite (packstone/wackestone): medium light gray (N6); weathers moderate yellowish brown (10YR5/4); intraclasts, trilobites; few *Nuia*.	
8	Limestone: thin-bedded; very similar to unit above except lacking stromatolites and not as consistently a ledge-former; transitional unit of Lynn (1975).	25
	25 ft Intrasparite/biomicrite (packstone/wackestone): medium gray (N5); weathers medium gray (N5) and grayish orange (10YR7/4); trilobites, intraclasts, gastropods, spicules, echinoderms; few *Nuia*.	
	20 ft Packed biomicrite (wackestone): medium gray (N5) with light brown (5YR5/6) burrow fillings; weathers medium light gray (N6) and grayish orange (10YR7/4); trilobites, spicules, intraclasts, gastropods; few echinoderms; burrow fillings are dolomitic biomicrosparite.	
	15 ft Packed biomicrite (wackestone): same as 8–20 above except burrow fillings are moderate reddish brown (10YR4/6).	
	10 ft Sparse biomicrite (wackestone): same as 8–15 above, but with few brachiopods.	
	3 ft Poorly washed biosparite (wackestone/packstone); same colors as 8–20 above.	
	1 ft Poorly washed biosparite (wackestone/packstone); same colors as 8–15 and same allochems as 8–20 above.	
Jose Member		16
7	Limestone and dolomitic limestone: thin- to medium-bedded; dolomitized peloids and burrow fillings give weathered surfaces "spotty" and "twiggy" appearance; generally darker than enclosing beds; bioturbation, stylolites, and spar veins common, slightly sandy lens; equivalent of Jose Formation of Flower (1969) and LeMone (1969a) and upper sandy member of Hitt Canyon Formation of Hayes (1975a).	16
	12 ft Poorly washed biosparite (packstone): dark gray (N3) with moderate yellowish brown (10YR5/4) bioturbated areas; weathers medium dark gray (N4) and dark yellowish brown (10YR4/2); trilobites, echinoderms, intraclasts; about 4% medium quartz sand.	
	10 ft Sparse biomicrite (wackestone): medium gray (N5); weathers medium light gray (N6) and grayish orange (10YR7/4); trilobites, spicules, gastropods, echinoderms, intraclasts; trace of hematite cubic pseudomorphs after pyrite.	
	1 ft Poorly washed biosparite (packstone/wackestone): medium dark gray (N4); weathers medium dark gray (N4) and grayish orange (10YR7/4); trilobites (most with micritized rims), echinoderms, *Nuia*, spicules, peloids, dolomitized ooids(?); interbedded with dark gray (N4) intrasparrudite.	
Hitt Canyon Member		259
6	Limestone and dolomitic limestone: thin- to medium-bedded; mottled colorations and "twiggy" features because of bioturbation and dolomite preferentially replacing burrow fillings, interbedded biomicrites and intrasparrudites.	74
	74 ft Sparse biodismicrite (wackestone): medium gray (N5) and light brown (5YR5/6); spicules, gastropods; few trilobites, echinoderms; irregular-shaped spar-filled cavities.	
	70 ft Poorly washed biosparite (wackestone/grainstone): medium dark gray (N4); weathers medium gray (N5); sponges and spicules, *Nuia*, trilobites, echinoderms; few gastropods and intraclasts; echinoderms have micritized rims and some chalcedony replacement.	
	68 ft Poorly washed biosparite (wackestone/grainstone): medium dark gray (N4) and moderate brown (5YR4/4); weathers medium gray (N5) and moderate yellowish brown (10YR5/4); *Nuia*, trilobites, gastropods, spicules (in micrite), echino-	

Unit	Description	Thickness ft
	derms, intraclasts; few brachiopods; trace of quartz silt.	
	65 ft Intrasparite (grainstone): medium light gray (N6); weathers pale yellowish orange (10YR6/4); same allochems as 6–68 above except no brachiopods, 10% fine quartz sand in one lamina.	
	59 ft Mixed intrasparite/sparse biomicrite (grainstone/wackestone): same colors and allochems as 6–65 above.	
	50 ft Rounded intrasparite (grainstone): medium gray (N5), weathers medium light gray (N6); biomicrite intraclasts, *Nuia*, echinoderms.	
	40 ft Intrasparrudite (grainstone): medium light gray (N6), weathers moderate yellowish brown (10YR5/4); biomicrite intraclasts partly replaced by dolomite.	
	29 ft Packed biomicrite (packstone): medium gray (N5) and moderate brown (5YR4/4); weathers medium light gray (N6) and grayish orange (10YR5/4); trilobites, spicules, echinoderms; few *Nuia*, intraclasts, gastropods.	
	25 ft Unsorted intrasparite (grainstone): same colors as 6–29 above; biomicrite intraclasts, trilobites, echinoderms, *Nuia;* chalcedony replaced some echinoderms.	
	15 ft Packed biomicrite (packstone): medium gray (N5); weathers light gray (N7); trilobites, echinoderms, *Nuia*, intraclasts, gastropods, spicules.	
	10 ft Poorly washed intrasparite (grainstone): medium gray (N5); weathers medium light gray (N6); same allochems as 6–15 above except intraclasts dominant; first exposed bed above covered interval.	
5	Covered: probably includes a near bedding-plane thrust fault that cuts down section both to the south and northeast.	10
	Dolomite and sandy dolomite: thin- to medium-bedded; medium- to coarse-crystalline; oncolites common throughout most of section; approximate equivalent of Sierrite Formation of Flower (1969) and LeMone (1969a) and lower sandy member of Hitt Canyon Formation of Hayes (1975a).	175
4	Dolomite: thin-bedded; vuggy; crudely laminated; medium-crystalline; medium gray (N5); weathers moderate yellowish brown (10YR5/4); few *Nuia*(?) ghosts.	40
3	Dolomite: thin- to medium-bedded; medium- to coarse-crystalline; medium light gray (N6) to medium dark gray (N4); weathers moderate yellowish brown (10YR5/4) to dark yellowish brown (10YR4/2).	80
	65 ft Medium-crystalline dolomite: minor chert fills interstices; 0.5–1.5 cm oncolites.	
	49 ft Coarse-crystalline dolomite: light-colored rims on dolomite rhombs, few allochem ghosts; oncolites similar to 3–65 above.	
	43 ft Medium-crystalline dolomite: *Nuia*(?) ghosts; oncolites similar to 3–65 above.	
	31–20 ft Repeated sequences of coarse-crystalline, yellowish brown (10YR4/2) dolomite separated by sharp contact from overlying medium-crystalline, medium gray, oncolite-bearing dolomite; vaguely resembles graded bedding.	
	16 ft Medium-crystalline dolomite: crinoid(?) and trilobite(?) ghosts; light rims on dolomite rhombs.	
	5 ft Medium-crystalline dolomite: ghosts of *Nuia*(?) averaging 0.4 mm diameter between oncolites (0.5–1.5 cm).	
	1 ft Medium-crystalline dolomite: finely laminated.	
2	Dolomite and silty dolomite: thin-bedded; coarse-crystalline; medium gray (N5); weathers dark yellowish brown (10YR4/2); up to 3% very fine quartz sand at base grading up to only trace of quartz silt at top.	55
	Bliss Sandstone	101
1	Sandstone and dolomite (top 31 ft) and sandstone and minor limestone (middle 40 ft): 10 ft covered above basal 20 ft of coarse sandstone; thin- to medium-bedded.	
	101 ft Medium sandstone: calcitic submature quartz arenite; medium light gray (N6); weathers light olive gray (5Y5/2).	
	96 ft Fine, sandy, medium-crystalline dolomite: pale yellowish brown (10YR6/2); weathers light brown (5YR5/6).	
	72 ft Fine, sandy, coarse-crystalline dolomite: light brown (5YR6/4); weathers dark yellowish brown (10YR4/2).	
	58 ft Coarse sandstone: dolomitic submature subarkose; pinkish gray (5YR8/1); weathers moderate brown (5YR4/4.)	
	53 ft Coarse sandstone: calcitic submature subarkose; pale yellowish brown (10YR6/2); weathers moderate brown (5YR4/4).	
	50 ft Packed biomicrosparite (packstone): grayish orange-pink (5YR7/2); weathers pale to moderate yellowish brown (10YR6/2–10YR5/4); *Nuia*, peloids, trilobites, gastropods, cephalopods; approximately 1% each quartz and perthite sand grains.	
	48 ft Mixed biomicrosparite/fine arkose: same colors as 1–50; peloids, *Nuia*, echinoderms, gastropods, trilobites(?); arkose consists of 60% quartz, 40% perthite, and trace of zircons and opaques.	
	45 ft Packed biomicrosparite (packstone): colors as 1–50; same allochems as 1–50 except no perthite and few brachiopods(?).	
	41 ft Sparse biomicrosparite (wackestone): grayish orange-pink (5YR7/2); weathers very pale orange (10YR8/2); trilobites, peloids, many unidentified fossil allochems, trace of *Nuia*.	
	37 ft Fossiliferous medium-sandy microsparite: pale yellowish brown (10YR 6/2); weathers moderate brown (5YR 4/4); approximately 35% quartz, 5% perthite; few echinoderms, *Nuia*, unidentified fossil allochems.	
	33 ft Packed biomicrosparite (packstone): medi-	

Unit	Description	Thickness ft
	um dark gray (N4); weathers medium gray (N5), peloids, echinoderms, gastropods, abundant unidentified fossil allochems; prominent stylolites and spar veinlets.	
20 ft	Medium sandstone: calcareous submature arkose; moderate yellowish brown (10YR5/4); weathers dark yellowish brown (10YR4/2).	
7 ft	Coarse sandstone: calcareous submature quartz arenite; brownish gray (5YR5/1); weathers grayish brown (5YR4/ 2).	
2 ft	Very coarse sandstone: hematitic immature arkose; moderate yellowish brown (10YR5/4); weathers moderate brown (5YR3/4).	
Precambrian granite		

Appendix E–3

Mahoney Park (Montoya Formation–Fusselman Dolomite) measured section

The section was measured on the western slope of the hill in NW¼ sec. 35 T25S R8W on the southwest side of Mahoney Park during August 1982. Measured section lines are indicated on the large-scale geologic map (Sheet 3). The Cable Canyon and Upham Members of the Montoya Formation were measured north of the two small normal faults. The section is offset about 300 ft southeast where the Aleman and Cutter Members of the Montoya Formation and the lower part of the Fusselman Dolomite were measured. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 65 thin sections was completed and rock names were assigned according to Folk's (1962, 1974) and Dunham's (1962) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock–color chart* published by the Geological Society of America (1963). Descriptions of representative samples within each column unit follow the given distance, which is above the base of the preceding, numbered unit. The allochems are listed in order of decreasing abundance, and a trace is considered to be less than 1% of the total allochems.

Unit Description	Thickness ft
Fusselman Dolomite (top faulted)	260+
Lower light-gray unit	110+
9 Dolomite: medium-crystalline; thick- to massive bedded; "birds eye" vugs common; medium dark gray (N5) to medium light gray (N6); weathers medium brownish gray (5YR5/1).	
Lower dark-gray unit	150
8 Dolomite: fine- to medium-crystalline; medium gray (N5) to dark gray (N3); weathers olive gray (5Y5/1) to dark yellowish brown (10YR4/2).	
140 ft Medium-dark gray mottled colorations: conspicuous zone of unidentified, tiny (less than 1 mm) white specks; may be interstitial chert seen in thin sections.	
95 ft Dark-medium gray laminations: dark laminae are fine crystalline and more calcitic; light laminae are medium- to coarse-crystalline dolomite.	
90 ft Dark-gray 12-inch-thick zone of broken solitary corals: probable equivalent of bed 125 or 142 ft above base at Victorio Canyon section.	
75 ft Dark gray; few coral ghosts.	
30 ft Medium gray; trace of quartz silt.	
5 ft Dark gray; brecciated locally; sporadic concentration of silicified solitary and colonial corals in basal beds; trace of quartz silt.	
Montoya Formation	350
Cutter Member	173
7 Dolomite: medium- to thick-bedded; abundant light-gray chert nodules and irregular lenses weather yellowish brown in upper part of unit; large (30 am) dark-gray chert nodules common in middle part.	
53 ft Fine crystalline: medium gray (N5); weathers dark yellowish brown (10YR 4/2).	
50 ft Fine crystalline: medium dark gray (N4); weathers olive gray (5Y6/1); vaguely laminated.	
40 ft Fine crystalline: medium dark gray (N4); weathers dark yellowish brown (10YR 4/2).	
30 ft Fine crystalline: colors same as 7–50 above; silicified corals and brachiopods.	
20 ft Medium crystalline: dark gray (N3); weathers pale yellowish brown (10YR 6/2); few allochem ghosts; brecciated.	
10 ft Fine crystalline: medium dark gray (N4); weathers moderate yellowish brown (10YR5/4); few allochem ghosts; brecciated.	
6 Dolomitic limestones and limestones: thin- to medium-bedded, mottled light-medium gray colorations caused by bioturbation and differential replacement of burrow fillings; abundant stylolites and crosscutting spar veinlets; brachiopods and echinoderms partly replaced with chalcedony and chert.	
120 ft Fossiliferous dolomitic dismicrite (lime mudstone): medium dark gray (N4); weathers moderate yellowish brown (10YR5/4); spicules, ostracods, echinoderms, bryozoa, gastropods, brachiopods, trilobites; approximately 10% fine dolomite.	
110 ft Fossiliferous dolomitic micrite (lime mudstone): medium light gray (N6); weathers grayish orange (10YR7/4); trace of ostracods and spicules; approximately 20% fine dolomite.	
109 ft Fossiliferous dolomitic micrite (lime mudstone): medium dark gray (N4); weathers light yellowish brown (10YR5/2); spicules, ostracods, echinoderms; approximately 30% fine dolomite.	
100 ft Similar to 6–109 above except contains also brachiopods.	
90 ft Dolomitic dismicrite (lime mudstone): same colors as 6–109 above.	
80 ft Packed biomicrite (packstone): medium gray (N5); weathers grayish orange (10YR7/4); brachiopods, bryozoa, echinoderms, trace of ostracods and trilobites.	
75 ft Packed dolomitic biomicrudite (packstone): same colors as 6–80 above; brachiopods, echinoderms, bryozoa, trilobites, echinoderms; approximately 20% fine dolomite.	
65 ft Fossiliferous dolomitic micrite (lime mudstone): same colors as 6–80 above; ostracods, brachiopods, trilobites, echinoderms; approximately 10% fine dolomite.	
55 ft Dolomitic dismicrite (lime mudstone): medium light gray (N6); weathers moderate yellowish brown (10YR5/4).	

Unit Description	Thickness ft
45 ft Micrite (lime mudstone): medium dark gray (N4); weathers medium light gray (N6).	
40 ft Dolomitic micrite (lime mudstone): same colors as 6–45 above.	
35 ft Fossiliferous micrite (lime mudstone): same colors as 6–45 above; spicules, ostracods.	
30 ft Unsorted dolomitic biosparite (grainstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); echinoderms, intraclasts, bryozoa, brachiopods, trilobites, gastropods; approximately 15% fine dolomite.	
25 ft Poorly washed dolomitic biosparite (packstone–grainstone): medium light gray (N6); weathers pale yellowish orange (10YR6/4); bryozoa, brachiopods, echinoderms, intraclasts; approximately 25% fine dolomite.	
20 ft Fossiliferous micrite (lime mudstone): medium dark gray (N3); weathers medium light gray (N6); echinoderms, ostracods, trilobites.	
12 ft Sparse biomicrite (wackestone): medium light gray (N6); weathers grayish orange (10YR7/4); echinoderms, ostracods, trilobites; trace of hematite pseudomorphs after pyrite.	
11 ft Poorly washed biosparite (packstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); bryozoa, echinoderms, trilobites, brachiopods, gastropods.	
10 ft Packed biomicrudite (packstone): medium gray (N5); weathers grayish orange-pink (5YR7/2); gastropods, trilobites, brachiopods, echinoderms, ostracods, trace of peloids.	
7 ft Packed dolomitic biomicrudite (packstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); brachiopods, bryozoa, echinoderms, gastropods, trilobites, trace of ostracods; approximately 20% fine dolomite.	
5 ft Similar to 6–7 above except contains no ostracods.	
1 ft Conglomeratic sandstone (calcitic immature sedarenite): medium light gray (N6); weathers dusky yellowish brown (10YR 2/2); very poorly sorted, angular, carbonate-rock and chert fragments 0.120 mm in size; probably derived from underlying Aleman units.	
Aleman Member	113
5 Dolomite, limestone, chert: laminated to thin-bedded; carbonate to chert ratio ranges from 1:1 to 3:1 throughout sections; stylolites common; abundant transverse spar veinlets.	
110 ft Packed biosparite (grainstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); echinoderms, trilobites, brachiopods, bryozoa, ostracods, intraclasts.	
100 ft Fossiliferous dolomitic microsparite (lime mudstone): medium dark gray (N4); weathers grayish orange (10YR 7N); echinoderms, spicules, ostracods.	
85 ft Packed biomicrosparite (packstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); echinoderms, spicules, trilobites, bryozoa, ostracods.	
80 ft Sparse biomicrosparite (wackestone): medium dark gray (N4); weathers pale grayish orange (10YR8/4); spicules, ostracods, echinoderms.	
70 ft Chert/sparse biomicrosparite (wackestone): colors same as 5–80 above; spicules, unidentified tiny fragments, ostracods, echinoderms, trilobites, brachiopods.	
60 ft Fossiliferous microsparite (lime mudstone): medium dark gray (N4); weathers yellowish brown (10YR5/4); unidentified tiny fragments, ostracods, echinoderms.	
50 ft Sparse biomicrosparite (wackestone): medium gray (N5); weathers light gray (N7); unidentified fragments less than 0.1 mm; ostracods, echinoderms, brachiopods, trilobites.	
45 ft Similar to 5–50 above except weathers medium gray (N5).	
40 ft. Similar to 5–50 above except dark gray (N3), weathers dark yellowish brown (10YR4/2), and contains some chert.	
35 ft Same as 5–50 above.	
30 ft Chert–microsparite (lime mudstone): medium gray (N5); weathers pale yellowish orange (10YR6/4); spicules, trilobites.	
25 ft Chert–fossiliferous microsparite (lime mudstone): medium dark gray (N4); weathers moderate brown (5YR3/4); unidentified fragments less than 0.1 mm; brachiopods.	
20 ft Dolomitic microsparite (lime mudstone); same colors as 5–25 above; unidentified fragments less than 0.1 mm.	
15 ft Dolomitic chert–microsparite (lime mudstone): medium dark gray (N4); weathers pale grayish orange (10YR8/4); no recognizable allochems.	
10 ft Medium-crystalline dolomite: medium dark gray (N4); weathers moderate yellowish brown (10YR5/4).	
5 ft Calcareous chert: brownish gray (5Y4/1); weathers moderate yellowish brown (10YR5/4); 85% chert, 15% microspar; color laminated dark-light.	
1 ft Medium-crystalline dolomite: medium dark gray (N4); weathers medium olive gray (5Y5/1).	
Upham Member	36
4 Dolomite and dolomitic limestone: thick- to massive-bedded; abundant stylolites.	
35 ft Medium-crystalline dolomite: medium dark gray (N4); weathers moderate yel-	

Unit	Description	Thickness ft
	lowish brown (10YR5/4); few echinoderm(?) ghosts.	
	22 ft Same as 4–35 above.	
	12 ft Similar to 4–35 above with approximately 1% very fine quartz sand.	
	7 ft Similar to 4–35 above with abundant echinoderm ghosts; few still single-spar crystals and trilobite(?) and gastropod(?) ghosts; approximately 1% very fine quartz sand.	
	2 ft Sparse dolomitic biomicrosparite (wackestone): medium dark gray (N4); weathers dark yellowish brown (10YR4/2); echinoderms, gastropods, trilobites, brachiopods; approximately 18% medium dolomite and 5% fine quartz sand.	
	Cable Canyon Member	28
3	Sandy dolomite and dolomitic sandstone: massive-bedded; sand is poorly sorted, ranging from 0.05 to 2.0 mm and averaging about 0.3 mm (medium sand); quartz grains are subangular to well rounded; quartz has moderate to strong undulose extinction, many vacuoles; few grains. contain rutile needles.	21
	20 ft Medium-crystalline dolomite: dark gray (N3); weathers dark yellowish brown (10YR4/2); approximately 10% quartz grains and trace of chert grains.	
	13 ft Medium-crystalline dolomite: medium dark gray (N4); weathers moderate yellowish brown (10YR5/4); approximately 20% quartz grains.	
	2 ft Medium-crystalline dolomite: same colors as 3–13 above; approximately 45% quartz grains and traces of magnetite and zircon; some zones contain up to 60% quartz grains.	
2	Limestone and dolomitic limestone: massive-bedded; mottled colorations probably because of bioturbation; brownish dolomite stands out in relief relative to dark gray limestone; abundant stylolites.	7
	6 ft Sparse dolomitic biomicrosparite (wackestone): medium dark gray (N4); weathers moderate brown (5YR4/4) and medium gray (N5); echinoderms, brachiopods, trilobites; approximately 40% medium quartz sand.	
	1 ft Packed biomicrosparite (packstone): dark gray (N3); weathers grayish red (5YR4/2); echinoderms, brachiopods, trilobites, trace of ostracods; approximately 5% fine quartz sand.	
	El Paso Formation	
	Padre Member (base not exposed)	
1	Upper 10 ft contain rounded biosparites and unsorted biosparites (grainstone): medium gray (N5s); weathers grayish orange (10YR7/4); brachiopods, *Nuia*, echinoderms, trilobites, intraclasts, gastropods.	

Appendix E–4

Victorio Canyon–Birchfield mine (Bliss Sandstone–Fusselman Dolomite) measured section

The section was measured along the northeast side of Victorio Canyon (NE¼ sec. 6 T26S R7W) during October 1982. Measured section location lines are indicated on the geologic map (Sheets la, b). I spent a day in March 1982 going through this section with Rousseau Flower, Sam Thompson, and Glen Brown. I gratefully acknowledge Rousseau Flower's assistance in pointing out the approximate boundaries of the faunal zones and formations as defined by Flower (1964, 1969) and LeMone (1969a). The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 200 thin sections was completed and rock names were assigned according to Folk's (1962, 1974) and Dunham's (1962) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock-color chart* published by the Geological Society of America (1963). Descriptions of representative samples within each column unit follow the given distance, which is above the base of the preceding, numbered unit. Allochems are listed in order of decreasing abundance and a trace is considered to be less than 1% of the total allochem.

Unit	Description	Thickness ft
	Fusselman Dolomite (middle dark-gray and middle light-gray units faulted and poorly exposed)	240
	Lower light-gray unit	50 +
18	Dolomite: medium-crystalline; thick- to massive bedded; "birds eye" vugs common; medium dark gray (N5) to medium light gray (N6); weathers medium brownish gray (5YR5/1).	
	Lower dark-gray unit	190
17	Dolomite: fine- to medium-crystalline; medium gray (N5) to dark gray (N3); weathers olive gray (5Y5/1) to dark yellowish brown (10YR4/2).	
	165–190 ft Mottled dark-medium gray colorations: 6–18-inch beds.	
	150–165 ft Light-dark gray laminations: minor, thin chert lens; silicified chain corals and sparse brachiopods.	
	130–150 ft Dark gray, medium- to thick-bedded: 12-inch solitary coral zone at 142 ft.	
	125–130 ft Light-dark gray laminations: 18-inch solitary coral zone at 125 ft.	
	0–125 ft Dark gray; thick- to massive-bedded.	
	Montoya Formation	395
	Cutter Member	220
16	Dolomite: fine- to medium-crystalline; medium gray (N5) to medium dark gray (N4); weathers light olive gray (5Y6/1).	150
	140–150 ft Abundant neomorphosed allochems.	
	120–140 ft Abundant large chert nodules and lenses that weather reddish brown; matrix is well laminated, fine-crystalline dolomite.	
	110–120 ft Abundant fossil allochem ghosts.	
	10–110 ft Mottled gray colorations because of bioturbation(?); few allochem ghosts; sparse chert nodules at 80 ft; few silicified solitary corals.	
15	Limestone and dolomite limestone: thin- to medium-bedded; mottled colorations 40–55 ft above base because of bioturbation; upper 15 ft packed with brachiopods; abundant stylolites and calcite veinlets.	70
	56 ft Packed biomicrite (packstone) : medium gray (N5); weathers medium light gray (N6); brachiopods, bryozoa, echinoderms, trilobites, ostracods, gastropods; brachiopods partly silicified.	
	55 ft Fossiliferous fine-dolomitic micrite (lime mudstone): medium olive gray (5YR5/1); weathers light olive gray (5Y6/1); peloids brachiopods, trilobites, echinoderms, ostracods.	
	45 ft Fine-dolomitic pelmicrite (lime mudstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); peloids, ostracods; few scattered, small chert nodules.	
	40 ft Packed fine-dolomitic biomicrudite (packstone): brownish gray (5YR4/1); weathers light brown (5YR6/4); brachiopods, bryozoa, trilobites, echinoderms, ostracods, gastropods; poorly exposed, thin beds.	
	25 ft Rounded biosparite (grainstone): medium gray (N5); weathers yellowish brown (10YR3/2); echinoderms, bryozoa, brachiopods, trilobites, trace of ostracods; echinoderms and brachiopods partly silicified.	
	20 ft Packed biomicrosparrudite (packstone): medium dark gray (N4); weathers medium gray (N5); brachiopods, spicules, echinoderms, trilobites, gastropods, bryozoa, ostracods, peloids; brachiopods and echinoderms partly silicified; minor, small chert nodules.	
	10 ft Packed biomicrudite (packstone): brownish gray (5YR4/1); weathers moderate yellowish brown (10YR5/4); brachiopods, bryozoa, echinoderms, trilobites, gastropods, spicules; discontinuous, thin, chert lenses are common.	
	1 ft Rounded biosparite (pelmatozoan grainstone): medium light gray (N6); weathers moderate brown (5YR3/4): echinoderms, bryozoa, trace of brachiopods.	
	Aleman Member	110
14	Limestone, dolomite, and interbedded chert: laminated to thin-bedded; typically 0.5–3.0 inch interbedded chert and dolomite in lower 20 ft and 1–4 inch interbedded chert and limestone in upper 90 ft.	
	95 ft Cherty biomicrite (wackestone): brownish gray (5YR4/1); weathers medium dark gray (N6); spicules, peloids, ostracods, brachiopods, echinoderms.	
	75 ft Cherty biopelmicrite (spicule wackestone): medium dark gray (N4); weathers dark yellowish brown; spicules, peloids, brachiopods, echinoderms, brachiopods	

Unit	Description	Thickness ft
	mostly silicified; well laminated.	
	65 ft Biopelmicrosparite (spicule wackestone): medium gray (N5); weathers medium light gray (N6); spicules, peloids, echinoderms; well laminated.	
	50 ft Biopelmicrite (packstone): same colors as 14–65 above; spicules, peloids; well laminated.	
	30 ft Cherty dolomitic microsparite (lime mudstone?): same colors as 14–65 above; no allochems recognized.	
	1 ft Fine-crystalline dolomite: same colors as 14–65 above; equicrystalline; uniform color.	
	Upham Member	40
13	Medium-crystalline dolomite: thick- to massive bedded; medium dark gray (N4) at base to olive gray (5Y4/1) at top; weathers pale brown (5YR5/2) to medium gray (N5); abundant stylolites; up to 1% fine quartz sand and trace of hastingsite at base.	
	Cable Canyon Member	25
12	Medium sandy, medium-crystalline dolomite: thick- to massive-bedded, dark yellowish brown (10YR4/2); weathers moderate yellowish brown (10YR5/4); average sand content is approximately 40%; subrounded to well-rounded quartz; poorly sorted; few small overgrowths.	
	El Paso Formation (base not exposed)	1,100
	Padre Member	270
11	Limestone and dolomitic limestone: thin- to medium-bedded; many beds weather dark gray or reddish brown; mottled colorations and twig-like structures on surfaces because of bioturbation; stylolites abundant; Florida Mountains Formation stratotype from LeMone (1974).	50
	48 ft Unsorted biosparrudite (grainstone): medium dark gray (N4); weathers dark yellowish brown (10YR4/2); echinoderms, trilobites, gastropods, intraclasts, brachiopods.	
	44 ft Biosparite (grainstone): medium gray (N5); weathers medium light gray (N6); echinoderms, trilobites, gastropods, intraclasts; thick micrite rims on allochems; neomorphosed.	
	38 ft Poorly washed biosparite (grainstone): brownish gray (5YR4/1); weathers medium gray (N5); echinoderms, trilobites, gastropods, brachiopods peloids, intraclasts.	
	35 ft Poorly washed biosparite (grainstone): medium gray (N6); weathers grayish orange-pink (5YR7/2); echinoderms, peloids, intraclasts, gastropods, brachiopods, trilobites.	
	30 ft Poorly washed dolomitic biosparite (packstone): brownish gray (5YR4/1); weathers same; echinoderms, trilobites, gastropods, *Nuia*, intraclasts, brachiopods, spicules; approximately 15% dolomite.	
	25 ft Sparse biomicrite (wackestone): medium brownish gray (5YR5/1); weathers light gray (N7); spicules, echinoderms, brachiopods, trilobites, gastropods.	
	23 ft Rounded biosparite (grainstone): dark gray (N3); weathers dark yellowish orange (10YR6/6); echinoderms, trilobites, ooids, intraclasts, gastropods, brachiopods, ostracods; chalcedony partly replaced some echinoderms.	
	19 ft Microsparite (lime mudstone): medium dark gray (N4); weathers medium gray (N5); trace of trilobites and spicules.	
	15 ft Unsorted intrasparrudite (grainstone): dark gray (N3); weathers medium gray (N5); echinoderms, intraclasts, peloids, trilobites, brachiopods, trace of *Nuia*, micrite rims on trilobites.	
	13 ft Unsorted intrasparrudite (grainstone): light brownish gray (5YR6/1); weathers dark yellowish brown (10YR4/2); intraclasts, peloids, echinoderms, spicules, trilobites, ostracods, trace of fine quartz sand.	
	10 ft Same as 11–13 above except allochems are intraclasts, trilobites, brachiopods.	
	2 ft Biomicrosparite (packstone): dark gray (N3); weathers medium dark gray (N4); peloids, trilobites, intraclasts, echinoderms, spicules, brachiopods, trace of fine quartz sand.	
10	Limestone and dolomitic limestone: thin- to medium-bedded; chart nodules and lenses common; prominent twig-like structures and mottled colorations are due to bioturbation, stylolites abundant; echinoderms and brachiopods typically replaced in part by chalcedony; intrasparites and intrasparrudites are interbedded throughout unit; approximate equivalent to Scenic Drive Formation, but lower 95 ft may belong in McKelligon Canyon Formation of Flower (1969) and LeMone (1969a).	220
	215 ft Sparse biomicrite (spicule wackestone): brownish gray (5YR4/1); weathers moderate yellowish brown (10YR5/4); spicules are only allochems seen.	
	208 ft Cherty and chalcedonic biomicrosparite (wackestone): dark gray (N3); weathers same; peloids, echinoderms, spicules, ostracods.	
	203 ft Packed biomicrite (packstone) and microsparite: brownish gray (5YR4/1); weathers medium brownish gray (5YR5/1); peloids, echinoderms, spicules, ostracods, trilobites.	
	198 ft Dolomitic biodismicrite (spicule packstone): dark brownish gray (5YR3/1); weathers medium dark gray (N4); spicules, echinoderms, trace of brachiopods; approximately 15% dolomite replaced burrow fillings.	
	190 ft Dolomitic biomicrite (wackestone): brownish gray (5YR4/1); weathers medium gray (N5); echinoderms, trilobites, gastropods, spicules, brachiopods, ostracods; approximately 30% fine dolomite replaced burrow fillings.	
	185 ft Same as 10–190 above except approximate-	

Unit	Description	Thickness ft
	ly 50% fine dolomite replaced burrow fillings.	
180 ft	Similar to 10–190 above except weathers moderate yellowish orange (10YR6/6), approximately 40% fine dolomite replaced bioturbated zones, and contains trace of *Nuia*.	
170 ft	Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium gray (N5); spicules, echinoderms, brachiopods, trilobites, intraclasts, gastropods, trace of ostracods.	
155 ft	Dolomitic biodismicrite (packstone): medium dark gray (N4); weathers light brown (5YR6/4); echinoderms, spicules and sponges, trilobites, peloids, gastropods, intraclasts, brachiopods; approximately 50% fine dolomite replaced burrow fillings.	
145 ft	Dolomitic biomicrite (packstone): brownish gray (5YR4/1); weathers medium gray (N5); gastropods, spicules and sponges, trilobites, echinoderms, peloids, brachiopods, trace of ostracods; approximately 10% fine dolomite replaced burrow fillings.	
140 ft	Poorly washed biosparite (grainstone): medium dark gray (N4); weathers medium gray (N5); gastropods, spicules and sponges, trilobites, echinoderms, intraclasts, peloids, brachiopods.	
130 ft	Sparse biomicrite (wackestone): dark gray (N3); weathers olive black (5Y2/1); spicules and sponges, peloids, trilobites, echinoderms, brachiopods, intraclasts; approximately 1% well-rounded, very fine quartz sand; micrite rims on trilobites.	
120 ft	Sparse dolomitic biomicrite (spicule wackestone): brownish gray (5YR4/1); weathers dark, dusky, yellowish brown (10YR3/2); spicules, trilobites, echinoderms.	
108 ft	Dismicrite (lime mudstone): brownish gray (5YR4/1); weathers pale yellowish brown (10YR6/2); few spicules and traces of trilobites and gastropods.	
100 ft	Packed biomicrite (packstone): medium dark gray (N4); weathers light brown (5YR6/4); gastropods, trilobites, spicules, echinoderms, intraclasts, trace of brachiopods.	
95 ft	Unsorted intrasparrudite (grainstone): same colors as 10–100 above; intraclasts, trilobites, echinoderms, gastropods; micrite rims on trilobites and gastropods.	
91 ft	Packed biomicrite (packstone): medium dark gray (N4); weathers grayish orange-pink (5YR7/2); gastropods, trilobites, spicules, echinoderms, cephalopods.	
87 ft	Packed biomicrite (packstone): medium dark gray (N4); weathers medium light gray (N6); spicules, peloids, gastropods, trilobites, intraclasts, echinoderms, brachiopods; trace of quartz silt.	
85 ft	Packed biomicrudite (gastropod packstone): same colors as 10–87 above; gastropods, trilobites, spicules, intraclasts, trace of quartz silt.	
80 ft	Dolomitic dismicrosparite (lime mudstone): medium dark gray (N4); weathers light brown (5YR6/4); spicules, gastropods; trace of quartz silt.	
75 ft	Packed biomicrite (packstone): brownish gray (5YR4/1); weathers medium brownish gray (5YR5/1); spicules, gastropods, trilobites, echinoderms, brachiopods, cephalopods, trace of intraclasts; approximately 1% coarse quartz silt.	
70 ft	Poorly washed biosparite (grainstone): medium dark gray (N4); weathers medium light gray (N6); gastropods, echinoderms, trilobites, cephalopods, spicules; approximately 1% very fine quartz sand.	
65 ft	Fossiliferous micrite (wackestone): same colors as 10–70 above; spicules, gastropods, echinoderms, trilobites, cephalopods.	
60 ft	Packed biomicrite (packstone): medium gray (N5); weathers grayish orange (10YR7/4); spicules, echinoderms, gastropods, trilobites, cephalopods.	
55 ft	Biomicrosparite (packstone): medium dark gray (N4); weathers medium yellowish orange (10YR6/6); peloids (micritized *Nuia*?), trilobites, intraclasts, echinoderms, gastropods, brachiopods; approximately 4% very fine quartz sand.	
50 ft	Biomicrosparite (wackestone): medium dark gray (N4); weathers medium gray (N5); trilobites, echinoderms, brachiopods, gastropods, intraclasts, peloids (*Nuia*?); approximately 2% very fine quartz sand.	
45 ft	Biomicrosparite (wackestone): medium dark gray (N4); weathers moderate brown (5YR4/4); peloids (*Nuia*?), intraclasts, echinoderms, trace of trilobites; approximately 1% very fine quartz sand.	
40 ft	Biomicrosparite (packstone) : dark gray (N3); weathers medium dark gray (N4): peloids (*Nuia*?), trilobites; trace of coarse quartz silt.	
32 ft	Sorted dolomitic biosparite (*Nuia* grainstone): medium dark gray (N4); weathers medium gray (N5); *Nuia*, echinoderms, trilobites; trace of fine quartz sand.	
23 ft	Packed biomicrite (packstone): brownish gray (5YR1/l); weathers medium light gray (N6); echinoderms, spicules, *Nuia*, gastropods, trilobites; trace of fine quartz sand.	
15 ft	Dolomitic biomicrite (wackestone): brownish gray (5YR4/1); weathers light brownish gray (5YR6/1); echinoderms, *Nuia*, gastropods, spicules, trilobites; approximately 1% fine quartz sand and 15% dolomite.	
10 ft	Packed biomicrite (packstone): medium gray (N5); weathers medium light gray (N6); spicules, *Nuia*, echinoderms, gas-	

Unit	Description	Thickness ft
	tropods, trilobites, brachiopods, cephalopods.	
5 ft	Sorted intrasparite (grainstone): medium gray (N5); weathers grayish orange (10YR7/4); intraclasts, gastropods, *Nuia*, echinoderms; micritized rims on fossil allochems; micrite intraclasts partly replaced with fine dolomite.	
4 ft	Dolomitic biomicrite (wackestone): moderate reddish brown (10R4/4); weathers grayish orange-pink (5YR7/2); spicules, *Nuia*, echinoderms, gastropods, trilobites; approximately 50% fine dolomite.	
	McKelligon Member	560
9	Limestone and dolomitic limestone: medium- to thickbedded; prominent twig-like structures and mottled colorations are due to bioturbation; stylolites abundant; echinoderms and brachiopods partly replaced with chalcedony; intrasparites and intrasparrudites interbedded throughout unit; approximate equivalent of mckelligon Canyon Formation of Flower (1969) and LeMone (1969a).	355
353 ft	Dolomitic biomicrite (wackestone): medium brownish gray (5YR5/1); weathers light brownish gray (5YR6/1); *Nuia*, spicules, gastropods, echinoderms, trilobites; approximately 20% fine dolomite.	
350 ft	Packed biomicrite (packstone): same colors as 9–353 above; *Nuia*, spicules, gastropods, echinoderms, trilobites.	
340 ft	Sparse biomicrite-intrasparite (wackestone–grainstone): medium gray (N5); weathers light gray (N6); gastropods, intraclasts, spicules, *Nuia*, echinoderms, trilobites.	
335 ft	Dolomitic biomicrite (wackestone): moderate reddish orange (10R5/6); weathers grayish red (10R4/2); spicules, echinoderms, gastropods, *Nuia*, trilobites; approximately 15% fine dolomite.	
330 ft	Packed biomicrite (packstone): medium brownish gray (5YR5/1); weathers light brownish gray (5YR6/1); gastropods, echinoderms, trilobites, spicules, *Nuia*.	
317 ft	Similar to 9–340 above except gastropods and spicules are less abundant and contains no *Nuia*.	
300 ft	Fossiliferous biomicrite (wackestone): medium dark gray (N4); weathers medium gray (N5); spicules, intraclasts, echinoderms, *Nuia*, trilobites.	
285 ft	Sorted intrasparite (grainstone): medium light gray (N6); weathers light olive gray (5Y6/1); intraclasts, *Nuia*, echinoderms, trilobites, gastropods, cephalopods; *Nuia* largely micritized.	
280 ft	Unsorted intrasparrudite (grainstone): medium gray (N5); weathers medium light gray (N6); intraclasts, echinoderms, *Nuia*, trilobites, gastropods.	
275 ft	Fossiliferous micrite (lime mudstone): same colors as 9–280 above; spicules, trilobites, echinoderms, gastropods.	
265 ft	Sparse biomicrite (spicule wackestone): light brownish gray (5YR6/1); weathers light grayish orange (10YR8/4); spicules, echinoderms, trilobites, *Nuia*, brachiopods.	
250 ft	Sparse biomicrite wackestone): same colors as 9–265 above; echinoderms, spicules, trilobites, gastropods, *Nuia*.	
245 ft	Packed biomicrite intrasparrudite (packstone–grainstone): medium gray (N5); weathers light brownish gray (5YR6/1); spicules, intraclasts, *Nuia*, trilobites, echinoderms.	
240 ft	Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium gray (N5); spicules, echinoderms, gastropods, *Nuia*, trilobites.	
216 ft	Packed biomicrite (packstone): same colors as 9–240 above; spicules, echinoderms, gastropods, trilobites, brachiopods, *Nuia*.	
215 ft	Rounded intrasparite (grainstone): same colors as 9–240 above; intraclasts, micritized *Nuia*, echinoderms, trilobites.	
214 ft	Packed biomicrite (packstone): moderate brownish gray (5YR5/1); weathers light gray (N7); spicules, gastropods, echinoderms, trilobites, brachiopods, *Nuia*.	
199 ft	Sorted biosparite (*Nuia* grainstone): medium gray (N5); weathers light brownish gray (5YR6/1); *Nuia*, trilobites, echinoderms.	
190 ft	Packed cherty biomicrite (packstone): same colors as 9–199 above; spicules, *Nuia*, gastropods, trilobites, echinoderms; part of 2ft irregular, nodular chert zone.	
185 ft	Packed biomicrite (packstone): medium light gray (N6); weathers moderate yellowish brown (10YR5/4); spicules, *Nuia*, gastropods, trilobites, echinoderms.	
175 ft	Intrasparite–sparse biomicrite (grainstone/wackestone): medium brownish gray (5YR 5/1); weathers pale yellowish brown (10YR 6/2); spicules, *Nuia*, echinoderms, trilobites, gastropods, cephalopods.	
153 ft	Sparse biomicrite (wackestone): medium gray (N5); weathers light olive gray (5Y6/1); spicules and sponges, echinoderms, *Nuia*, gastropods, trilobites, brachiopods.	
120 ft	Similar to 9–153 above except gastropods more abundant.	
102 ft	Similar to 9–153 above except gastropods more abundant and lacks *Nuia*.	
90 ft	Unsorted intrasparite (grainstone): medium brownish gray (5YR5/1); weathers medium light gray (N6); *Nuia*, intraclasts, spicules, brachiopods, echinoderms, trilobites, gastropods.	
85 ft	Sparse biomicrite (wackestone): brownish gray (5YR4/1); weathers very light gray (N8); gastropods, brachiopods, echinoderms, spicules, trilobites, *Nuia*.	
76 ft	Rounded intrasparite (grainstone): light brownish gray (5YR6/1); weathers medium light gray (N6); *Nuia*, intraclasts, bra-	

Unit	Description	Thickness ft
	chiopods, echinoderms, trilobites, gastropods, spicules.	
	62 ft Packed biomicrite (packstone): same colors as 9–76 above; echinoderms, gastropods, *Nuia*, spicules, trilobites, brachiopods.	
	52 ft Packed biomicrudite (packstone): medium dark gray (N4); weathers medium light gray (N6); gastropods, trilobites, echinoderms, spicules, *Nuia*, brachiopods.	
	40 ft Sparse biomicrite (wackestone): olive gray (5Y4/1); weathers light olive gray (5Y6/1); gastropods, trilobites, brachiopods, echinoderms.	
	35 ft Dolomitic biomicrite (wackestone): grayish red (10R4/2); weathers light brown (5YR6/ 4); gastropods, *Nuia*, trilobites, echinoderms, brachiopods; approximately 30% dolomite.	
	30 ft Poorly washed intrasparite (packstone–grainstone): medium dark gray (N4); weathers medium light gray (N6); intraclasts, spicules, gastropods, brachiopods, echinoderms, trilobites.	
	20 ft Sparse biomicrite (wackestone): same colors as 9–30 above; spicules, echinoderms, trilobites, gastropods, brachiopods.	
	10 ft Packed biomicrite (packstone): same colors as 9–30 above; gastropods, spicules, trilobites, echinoderms.	
8	Limestone and dolomitic limestone: very much like unit 9 except is generally thinner bedded; approximate equivalent of Snake Hills Formation of Flower (1969) and LeMone (1969a).	135
	133 ft Packed biomicrite (packstone): medium gray (N5); weathers pale yellowish brown (10YR6/2); gastropods, spicules, trilobites, echinoderms; scattered, small, brown-weathering chert nodules.	
	125 ft Packed dolomitic biomicrudite (packstone): brownish gray (5YR4/1); weathers grayish orange-pink (5YR7/2); gastropods, spicules, trilobites, echinoderms; approximately 20% fine dolomite.	
	115 ft Packed biomicrudite (packstone): same colors as 8–125 above; gastropods, echinoderms, spicules, trilobites, cephalopods, *Nuia*.	
	110 ft Packed biomicrite (packstone): medium gray (N5); weathers medium light gray (N6); gastropods, echinoderms, spicules, trilobites.	
	95 ft Similar to 8–110 above except medium dark gray (N4) and also contains *Nuia* and cephalopods.	
	88 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium light gray (N6); gastropods, spicules, trilobites, echinoderms.	
	78 ft Same as 8–88 above except also contains cephalopods.	
	70 ft Same as 8–88 above except also contains cephalopods, brachiopods, and few peloids.	
	60 ft Packed biomicrite (packstone) brownish gray (5YR4/1); weathers medium light gray (N6); gastropods, *Nuia*, echinoderms, trilobites, spicules, peloids; approximately 2% fine dolomite.	
	50 ft Packed biomicrite (packstone): medium dark gray (N4); weathers medium light gray (N6); gastropods, spicules, echinoderms, trilobites.	
	40 ft Sparse dolomitic biomicrite (wackestone): pale red (10R6/2); weathers light brown (5YR6/4); trilobites, peloids, echinoderms, brachiopods; approximately 25% fine dolomite.	
	35 ft Packed biomicrite (packstone): medium dark gray (N4); weathers medium light gray (N6); gastropods, *Nuia*, spicules, trilobites, echinoderms.	
	30 ft Packed biomicrite (packstone): medium gray (N5); weathers grayish orange-pink (5YR7/2); gastropods, spicules, echinoderms, trilobites, intraclasts, *Nuia*; approximately 10% fine dolomite.	
	25 ft Packed biomicrudite (packstone): brownish gray (5YR4/1); weathers yellowish gray (5Y7/2); gastropods, spicules, trilobites, echinoderms, brachiopods, peloids; approximately 10% fine dolomite.	
	20 ft Packed biomicrite (packstone): medium dark gray (N4); weathers medium gray (N5); spicules, gastropods, echinoderms, trilobites, intraclasts, *Nuia*.	
	10 ft Poorly washed biosparite (grainstone/ packstone): brownish gray (5YR4/1); weathers light brownish gray (5YR6/1); gastropods, spicules, intraclasts, trilobites, echinoderms.	
	4 ft Packed biomicrite (packstone): medium dark gray (N4); weathers very pale orange (10RY8/2); gastropods, trilobites, echinoderms, spicules, cephalopods; approximately 5% fine dolomite.	
	1 ft Similar to 8–4 above except brownish gray (5YR4/1); weathers grayish orange-pink (5YR7/2).	
7	Limestone and dolomitic limestone: very similar to units 8 and 9 except mostly thin-bedded and contains stromatolites in upper part; approximate equivalent of Mud Springs Formation of Flower (1969) and LeMone (1969a).	70
	60 ft Packed biomicrite (packstone): medium gray (N5); weathers light olive gray (5Y6/1); gastropods, trilobites, echinoderms, spicules; approximately 5% medium dolomite.	
	50 ft Poorly washed biosparite (grainstone): medium gray (N5); weathers medium light gray (N6); trilobites, echinoderms, gastropods, intraclasts.	
	42 ft Packed biomicrudite (packstone): same colors as 7–50 above; weathers medium light gray (N6); trilobites, echinoderms, gastropods.	
	39 ft Pelsparite (grainstone): medium gray (N5),	

Unit	Description	Thickness ft
	weathers moderate brown (5YR4/ 4); neomorphosed peloids and fossil fragments(?).	
	30 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers grayish orange (10YR7/4); echinoderms, spicules, trilobites, brachiopods, gastropods; approximately 15% medium dolomite replacing burrow fillings.	
	20 ft Sparse dolomitic biomicrite (wackestone): brownish gray (5YR4/1); weathers light brown (5YR5/6); spicules and sponges, trilobites, gastropods, brachiopods; approximately 25% medium dolomite replacing burrow fillings.	
	10 ft Intrasparite (grainstone): medium dark gray (N4); weathers medium light gray (N6); intraclasts of biomicrite, trilobites, echinoderms.	
	5 ft Sparse dolomitic biomicrite (wackestone): same colors as 7–10 above; echinoderms, spicules, trilobites, brachiopods; approximately 15% medium dolomite replacing burrow fillings.	
	1 ft Sparse dolomitic biomicrite (wackestone): medium dark gray (N4); weathers light brown (5YR5/6); trilobites, echinoderms, spicules, gastropods; approximately 10% medium dolomite replacing burrow fillings.	
	Jose Member	10
6	Limestones and dolomitic limestones: thin- to medium-bedded; several beds weather darker colors than beds above and below the Jose; several darker beds contain conspicuous small (0.5–2.0 mm), yellowish-brown, weathered ooids characteristic of the Jose in southern New Mexico; most beds are bioturbated; abundant stylolites; equivalent of Jose Formation of Flower (1969) and LeMone (1969a); approximate equivalent of upper sandy member of Hitt Canyon Formation of Hayes (1975a).	
	10 ft Oosparite (grainstone): medium dark gray (N4); weathers moderate brown (5YR4/4); ooids, trilobites, echinoderms, intraclasts, neomorphosed *Nuia*(?); approximately 1% fine quartz sand and trace of sodic plagioclase grains, many ooids replaced with medium dolomite, others have thick micrite rims or are totally neomorphosed, few possess fossil allochem nuclei.	
	8 ft Intrasparrudite (grainstone): medium dark gray (N4); weathers medium gray (N5); intraclasts, trilobites, echinoderms, gastropods.	
	5 ft Fossiliferous dismicrosparite (lime mudstone): dark gray (N3); weathers dark yellowish brown (10YR4/2); spicules, peloids, trilobites.	
	3 ft Intrasparrudite (grainstone): medium dark gray (N4); weathers yellowish orange (10YR6/6); intraclasts, ooids, trilobites, echinoderms; trace of fine quartz.	
	2 ft Packed dolomitic biomicrosparite (packstone): medium dark gray (N4); weathers medium gray (N5); trilobites, echinoderms, gastropods, spicules and sponges.	
	1 ft Sparse biomicrite (wackestone): same colors as 6–2 above; trilobites, echinoderms, gastropods.	
	0 ft Oosparite (grainstone): dark gray (N3); weathers medium dark gray (N4); ooids, trilobites, echinoderms, sandy micrite intraclasts, neomorphosed *Nuia*(?); approximately 1% fine quartz sand and trace of plagioclase grains; ooids like 6–10 above.	
	Hitt Canyon Member (base not exposed)	260+
5	Limestone and dolomitic limestone: medium- to thick-bedded, similar to unit 9 except more yellow–brown weathering; insoluble residues along stylolites stand out in relief on weathered surfaces; approximate equivalent of Victorio Hills Formation of Flower (1969) and LeMone (1969 a).	100
	99 ft Sparse dolomitic biomicrite (wackestone): medium gray (N5); weathers dark yellowish brown (10YR4/2); trilobites, brachiopods, echinoderms, spicules, *Nuia*.	
	96 ft Packed dolomitic biomicrite (packstone): similar colors to 5–99 above; *Nuia*, echinoderms, spicules, gastropods, trilobites, brachiopods, trace of ostracods; approximately 1% fine quartz sand.	
	91 ft Sparse biomicrite (wackestone): medium gray (N5); weathers medium olive gray (5Y5/1); same allochems as 5–96 above except no brachiopods or ostracods.	
	87 ft Packed dolomitic biomicrite (packstone): medium dark gray (N4); weathers moderate yellowish brown (10YR 5/4); *Nuia*, echinoderms, trilobites, brachiopods, gastropods, spicules; approximately 20% medium dolomite and 1% fine quartz sand.	
	82 ft Intrasparrudite (grainstone): medium gray (N5); weathers dark yellowish brown (10YR4/2); sandy biomicrite, intraclasts, echinoderms, *Nuia*.	
	78 ft Poorly washed biosparite (packstone/ grainstone): brownish gray (5YR4/1); weathers grayish brown (5YR3/2); *Nuia*, spicules and sponges, trilobites, echinoderms, gastropods; approximately 3% fine quartz sand.	
	75 ft Poorly washed dolomitic biosparite (wackestone–grainstone): medium brownish gray (5YR5/1); weathers yellowish orange (10YR6/4); *Nuia*, echinoderms, spicules and sponges, trilobites, gastropods, intraclasts; approximately 30% medium dolomite.	
	70 ft Dolomitic intrasparite (grainstone): medium gray (N5); weathers moderate brown (5YR4/4); intraclasts, echinoderms, gastropods, digitate algae(?), trilobites; approximately 50% medium dolomite.	
	65 ft Sorted biosparite (*Nuia* grainstone): same	

Unit	Description	Thickness ft
	colors as 5–70 above; *Nuia,* intraclasts, trilobites; *Nuia* partly to totally neomorphosed and most resembling micrite intraclasts or ooliths.	
	60 ft Dolomitic biosparite (*Nuia* grainstone): dark yellowish brown (10YR4/2); weathers medium light gray (N6); *Nuia,* trilobites, echinoderms, gastropods; approximately 10% fine dolomite.	
	55 ft Sparse dolomitic biomicrite (wackestone): medium gray (N5); weathers light yellowish brown (10YR6/4); *Nuia,* trilobites, echinoderms, spicules; approximately 15% fine dolomite.	
	54 ft Unsorted intrasparrudite (grainstone): olive gray (5Y4/1); weathers grayish orange (10YR7/4); biomicrite intraclasts, *Nuia,* echinoderms, gastropods.	
	50 ft Sparse dolomitic biodismicrite (wackestone): light brownish gray (5YR6/1); weathers medium gray (N5); spicules, *Nuia,* trilobites, digitate algae(?); approximately 10% medium dolomite.	
	45 ft Unsorted intrasparite (grainstone): medium dark gray (N4); weathers light gray (N7); biomicrite intraclasts, echinoderms, *Nuia.*	
	35 ft Fossiliferous dismicrite (wackestone): same colors as 5–45 above; trilobites brachiopods, echinoderms, spicules.	
	18 ft Fossiliferous micrite (lime mudstone): medium light gray (N6); weathers medium yellowish orange (10YR6/4); trilobites, echinoderms, brachiopods.	
	13 ft Rounded biointrasparite (*Nuia* grainstone): medium dark gray (N4); weathers moderate yellowish brown (10YR5/4); *Nuia,* intraclasts, echinoderms, trilobites, gastropods.	
	5 ft Fine-crystalline dolomite: pale brown (5YR512); weathers medium yellowish orange (10YR614); few allochem ghosts.	
	1 ft Sparse biomicrite (wackestone): medium brownish gray (5YR5/1); weathers moderate yellowish brown (10YR5/4); sponges and spicules, trilobites, echinoderms, gastropods, *Nuia,* brachiopods, cephalopods.	
4	Limestone and dolomitic limestone: closely resembles unit 5; approximate equivalent of Cooke's Peak Formation of Flower (1969) and LeMone (1969a).	50
	42 ft Unsorted biosparite (grainstone): medium light gray (N6); weathers light gray (N7); gastropods, echinoderms, trilobites, intraclasts, cephalopods, *Nuia,* brachiopods.	
	38 ft Sparse biomicrite (wackestone): medium dark gray (N4); weathers medium gray (N5); spicules, *Nuia,* echinoderms, trilobites.	
	34 ft Poorly washed intrasparrudite (grainstone): medium gray (N5); weathers moderate yellowish brown (10YR5/4); biomicrite intraclasts, echinoderms, trilobites.	
	30 ft Sparse biodismicrite (wackestone): grayish brown (5YR3/2); weathers medium light gray (N6); trilobites, echinoderms, intraclasts, spicules, gastropods, brachiopods.	
	25 ft Poorly washed biosparite (packstone grainstone): medium gray (N5); weathers light brownish gray (5YR6/1); *Nuia,* trilobites, intraclasts, echinoderms, spicules.	
	22 ft Unsorted biointrasparite (grainstone): medium brownish gray (5YR5/1); weathers pale yellowish brown (10YR6/2); echinoderms, intraclasts, *Nuia,* trilobites.	
	20 ft Poorly washed cherty biosparite (grainstone): light brownish gray (5YR6/1); weathers moderate yellowish brown (10YR5/4); trilobites, *Nuia,* echinoderms, spicules, gastropods, intraclasts.	
	17 ft Packed biomicrite (packstone): medium dark gray (N4); weathers light olive gray (5Y6/1); same allochems as 4–20 above.	
	13 ft Poorly washed dolomitic biosparite (packstone–grainstone): light brownish gray (5YR6/1); weathers light brown (5YR6/4); trilobites, gastropods, echinoderms intraclasts, spicules, *Nuia,* brachiopods; approximately 25% fine dolomite.	
	10 ft Same as 4-13 above except no gastropods.	
	5 ft Sparse dolomitic biomicrite (wackestone): same colors as 4–13 above; trilobites, echinoderms, gastropods, intraclasts, trace of brachiopods, *Nuia,* spicules, peloids; approximately 20% fine dolomite.	
	4 ft Sparse biomicrite (wackestone): light brownish gray (5YR6/1); weathers very light gray (N8); spicules, gastropods, trilobites, echinoderms; approximately 5% fine dolomite replacing burrow-filling matrix.	
3	Dolomite: thin-bedded, fine- to medium-crystalline; medium- to dark-gray and brownish-gray weathered surfaces; small *Girvanella*(?) oncolites abundant in many beds; abundant stylolites; approximate equivalent of Sierrite Formation of Flower (1969) and LeMone (1969a) and lower sandy member of Hitt Canyon. Formation of Hayes (1975a); base covered.	110+
	108 ft Fine-crystalline dolomite: pale red (10R6/2); weathers moderate yellowish brown (10YR5/4).	
	85 ft Fine-crystalline dolomite: brownish gray (5YR4/1); weathers moderate yellowish brown (10YR5/4); trace of very fine quartz sand.	
	70 ft Medium-crystalline dolomite: medium light gray (N6); weathers pale yellowish brown (10YR6/2).	
	50 ft Medium-crystalline dolomite breccia: medium light gray (N6); weathers pale yellowish brown (10YR6/2) with abundant, very light gray (N8), tiny feldspar fragments; approximately 3% quartz medium sand.	
	25 ft Fine-crystalline dolomite: pale brown (5YR5/2); weathers light olive gray (5Y6/1); abundant oncolites 2–25 mm diameter; trace of quartz silt.	

Unit	Description	Thickness ft
	5 ft Medium-crystalline dolomite: light brownish gray (5YR6/1); weathers light olive gray (5Y6/1); trace of very fine quartz sand.	
2	Covered interval: probably contains a fault.	60
	Bliss Sandstone (top faulted)	
1	Medium- to coarse-grained sandstone: arkosic thick-bedded; pale yellowish brown (10YR6/2), weathers brownish gray (5YR4/1).	23
	20 ft Coarse sandstone: silicic submature subarkose arkose.	
	10 ft Medium sandstone: silicic submature subarkose.	
	5 ft Coarse sandstone: silicic submature arkose.	
	Cambrian syenite	

Appendix E–5

Gym Peak–Mine Canyon (Bliss Sandstone–Hueco Formation) measured section

This section was measured on the northeast and southwest slopes of Gym Peak and continued southeast across Mine Canyon (SW¼ sec. 6 and sec. 7 and NE'¼ sec. 18, T26S R7W). Measured section location lines are indicated on the large scale geologic map (Sheet 2). Tectonic complications necessitated the section to be measured in two segments. The Bliss Sandstone (Cambrian–Ordovician) to the base of the Aleman Member (Upper Ordovician) was measured on the northeast slopes of Gym Peak, and the Aleman Member through Hueco Limestone (Permian) was measured southeast of Gym Peak. The section was measured by G. A. Brown and R. E. Clemons during July–August 1981 using standard pace, Brunton compass, and Jacob's staff techniques. Petrographic examination of 125 thin sections was completed and rock names were assigned according to Folk's (1962, 1974) and Dunham's (1962) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock-color chart* published by the Geological Society of America (1963). Allochems are listed in order of decreasing abundance.

Unit	Description	Thickness ft
	Top (fault contact)	
	Hueco Limestone (incomplete thickness)	403
67	Biomicrite (packstone): dark gray (N3), weathers light gray (N6); contains few scattered brown chert nodules; medium- to thick-bedded; burrowed bed 12 ft above base; light-gray (N5) bed 16 ft above base; common silicified fossils and large gastropod molds filled with white calcite.	47
66	Medium siltstone: pale reddish brown (10R5/4); weathers light brown (5YR5/6); calcareous; crossbedded.	8
65	Sparse biopelmicrosparite (wackestone): medium dark gray (N4), weathers medium light gray (N6); a few pale reddish-brown (10R5/4) laminations and thin beds; thin- to medium-bedded; burrowed bed 8 ft above base; contains forams, ostracods, and peloids.	18
64	Biomicrosparite (packstone): dark gray (N3); weathers medium gray (N5) medium- to thick-bedded; scattered brown silicified fossils and chert laminations; scattered large gastropods; allochems seen in thin section include gastropods, echinoderms, forams, phylloid algae(?), and peloids; brown chert nodules up to 20 cm in size 180 ft above base.	130
63	Covered interval: probably shaly limestone.	18
62	Biomicrite (packstone): dark gray (N3); weathers light gray (N7) to medium gray (N5), poorly developed, wavy bedding planes between 10–20 cm beds; a few brown chert nodules; abundant silicified fossils include high-spired and bellerophonid gastropods, solitary corals, brachiopods and echinoid spines and plates; other allochems seen in thin section are peloids, ostracods, trilobites, and dasycladacean algae; probable fault zone parallel to bedding 36 ft above the base locally steepens dip to 60°.	86
61	Biomicrite (packstone): grayish black (N2); weathers light brownish gray (5YR6/1); massive-bedded; abundant brown, silicified, thin shell fragments and bellerophonid gastropods; white calcite fracture fillings; brown chert nodules 5–20 cm in size 22 ft above base.	59
60	Biosparite (grainstone): dark gray (N3); weathers brownish gray (5YR4/1); medium-bedded; scattered bellerophon gastropods, ostracods, forams, and a few trilobite and brachiopod fragments; a few dark-gray beds are partly covered.	27
59	Coarse siltstone: grayish red (5R4/2); weathers moderate yellowish brown (10YR5/4); calcareous; crossbedded; mostly covered slopeformer.	5
58	Biopelmicrosparite (packstone): medium dark gray (N4), weathers light olive gray (5Y6/1); thick-bedded; abundant small fragments of echinoderms, gastropods, ostracods, forams, and a few trilobite fragments; rounded pebbles and cobbles of probable Rancheria limestone in basal bed (section offset .25 mi southwest to the base of the Hueco).	5
	Rancheria Formation	221
57	Biomicrosparite, pelmicrosparite (spicule and peloid packstones): medium dark gray (N4); weathers medium light gray (N6) to medium gray (N5); thin-bedded; laminations visible on weathered surfaces; 2–10 cm, lenticular, medium light gray (N6) chert beds weather very light gray (N8) and increase upward to compose 50% of the unit at the top; silty, microsparite, grayish red (5R4/2), weathers moderate yellowish brown (10YR5/4), and occurs near top in a partly covered zone.	21
56	Pelsparite (grainstone): medium gray (N5); weathers light olive gray (5Y6/1); thin- to medium-bedded; contains some sand; pseudocrossbeds at base; contains light-gray (N7) chert bands; about 8% crinoid fragments.	10
55	Pelbioneosparite (spicule packstone): medium gray (N5); weathers light gray (N7); contains light-gray (N7) chert that weathers very light gray (N8) in nodules; 7–38 cm beds with wavy bedding planes; minor silt.	23
54	Silty pelneosparite (peloid packstone): medium brownish gray (5YR5/1); weathers grayish orange (10YR7/4); medium-bedded at base and thin-bedded at top; 5–7 cm gray, lenticular chert beds at base; black chert at top; partly covered slope-former.	45
53	Biomicrite: black (N1); weathers medium gray (N5); abundant gray (N6) chert, weathers brown (5YR4/4); interbeds; shaly; thin-bedded; biomicrite (wackestone) beds 9 ft above base are laminated pale red (5R6/2) and weather medium light gray (N6); black chert bands and lenses 1–10 cm thick in upper part; biomicrosparite (spicule packstone) at top is dark gray (N3) and weathers light gray (N7).	67
52	Silty biomicrite (spicule wackestone): medium dark gray (N4); weathers medium gray (N5); shaly, partly covered slope-former; gradational into unit 53.	9
51	Biomicrite and bioneosparite (crinoid packstone, spicule wackestone): medium dark gray (N4) at	

Unit	Description	Thickness ft
	base, dark gray (N3) at top; weathers medium light gray (N6); coarsely recrystallized at base, gradational upward to finely crystalline and shaly at top; scattered black chert lenses at base increase upward as bedding becomes better defined; common crinoid, bryozoan spicule, ostracod fragments.	23
50	Covered interval.	18
49	Silty fine-crystalline dolomite: medium dark gray (N4), weathers moderate yellowish brown (10YR5/4); medium- to thick-bedded with light-dark laminations; base not well exposed.	5
	Percha Shale	249
48	Mostly covered shale: olive gray (5Y3/2) to black; slope-former.	238
47	Biomicrite (tentaculite packstone): dark gray (N3); weathers dark brownish gray (5YR3/1); laminations visible on weathered surfaces; extremely fossiliferous.	1
46	Mostly covered shale: olive gray (5Y3/2) to black; slope-former.	10
	Fusselman Dolomite	1480
	Upper light-gray unit	80
45	Slightly sandy medium-crystalline dolomite: medium dark gray (N4); weathers medium brownish gray (5YR5/1); thin-bedded; abundant lenticular, light-gray (N7) chert nodules that weather very light gray (N8); about 2% very fine sand in upper part; minor calcite patches; porous.	10
44	Very fine-crystalline dolomite: medium dark gray (N4) at base, grades upward to medium gray (N5) at top; weathers light gray (N7); thick-bedded, an 18-inch medium sandy, intraclastic dolomite at base contains about 45% well-rounded quartz grains.	70
	Upper dark-gray unit	165
43	Very fine- to medium-crystalline dolomite: medium gray (N5) to dark gray (N3); weathers medium light gray (N6) to medium dark gray (N4); medium- to massive-bedded; wavy light-dark alternating laminations are visible on weathered surfaces.	100
42	Medium- to coarse-crystalline dolomite: light gray (N7); weathers very light gray (N8); thin- to medium-bedded; abundant small fragments of silicified solitary corals about 0.5–2.5 mm in diameter.	5
41	Fine- to medium-crystalline dolomite: medium dark gray (N4); weathers medium light gray (N6); thin-bedded; upper 10 ft laminated and slightly silty; stylolites.	60
	Middle light-gray unit	610
40	Medium- to coarse-crystalline dolomite: light olive gray (5Y6/1) and light gray (N7); weathers yellowish gray (5Y8/1) and light to medium gray (N5–7); few dark-gray (N3) weathering interbeds; thick-bedded; mottled colorations on weathered surfaces; abundant small, irregular, elongate vugs parallel to bedding possibly represent "birds eye" texture; good porosity; stylolites.	310
39	Fine- to medium-crystalline dolomite: light olive gray (5Y6/1); weathers yellowish gray (5Y8/1); few medium gray (N5) interbeds; upper part contains vugs similar to unit 40, good porosity in medium-crystalline beds; stylolites; mottled appearance in thin section probably is due to allochem ghosts interpreted as intraclasts.	300
	Middle dark-gray unit	160
38	Fine-crystalline dolomite: dark gray (N3); weathers medium light gray (N6) to medium gray (N5); massive-bedded; few scattered, silicified chain corals; small cavities filled with white calcite; some mottled coloration on weathered surfaces.	50
37	Medium-crystalline dolomite: medium gray (N5); weathers medium dark gray (N4) and light brownish gray (5YR6/1); thick-bedded; stylolites.	110
	Lower light-gray unit	305
36	Medium-crystalline biogenic dolomite: medium light gray (N6); weathers light olive gray (5YR6/1); massive-bedded; scattered, silicified fossil fragments and thin, light-gray chert laminations; occasional burrows(?); mottled colorations on some weathered surfaces; stylolites; abundant elongate vugs 100 ft above base.	170
35	Fine-crystalline biogenic dolomite: medium dark gray (N5); weathers medium brownish gray (5YR5/1) or medium light gray (N6); thick- to massive-bedded; mottled appearance on weathered surfaces; abundant silicified chain corals; some chert; elongate vugs with "birds eye" texture common.	135
	Lower dark-gray unit	160
34	Fine-crystalline biogenic dolomite: dark gray (N3); weathers medium gray (N5), chert laminations weather yellowish brown (10YR5/2), grade upward to lenses and nodules; stylolites; upper 14 ft has mottled colorations on weathered surfaces; 4-ft thick coral-rich zoneat top.	65
33	Medium-crystalline biogenic dolomite: alternating light gray (N7) and medium gray (N5) laminations; weathers to same colors, lighter layers more calcareous; some chert laminations; solitary coral zones at 7, 19, 25, and 30 ft above base.	30
32	Medium-crystalline biogenic dolomite: medium gray to medium dark gray (N5–N4); weathers light brownish gray (5YR6/1) to medium dark gray (N4); thick- to massive-bedded; minor chert bands and nodules; abundant silicified solitary and colonial corals; stylolites; good porosity.	65
	Montoya Formation	375
	Cutter Member	181
31	Very fine-crystalline dolomite: light brownish gray (5YR6/1); weathers light gray (N7); thick-bedded; abundant low-amplitude stylolites.	3
30	Very fine-crystalline dolomite: dark gray (N3); weathers medium gray (N5); thick-bedded with wavy bedding planes; very abundant thin, spicular chert lenses and nodules near base becoming continuous lenticular beds at top; chert is light gray (N7); weathers white (N9) to yellowish gray (5Y7/2).	36
29	Fine-crystalline dolomite: dark gray (N3); weath-	

Unit	Description	Thickness ft
	ers light brownish gray (5YR6/1) to medium gray (N5); medium-bedded; mottled appearance; upper part speckled with white weathering fragments of chain corals(?).	8
28	Fine-crystalline dolomite: medium dark gray (N4); weathers light brownish gray (5YR6/1); medium-bedded; abundant gray chert nodules weather white (N9) to grayish yellow (5Y8/4); stylolites.	8
27	Fine- and coarse-crystalline biogenic dolomite: medium dark gray (N4); weathers light brownish gray (5YR6/1) to medium gray (N5); massive-bedded; mottled appearance; scattered chert lenses and flattened nodules; a few scattered shell fragments and abundant silicified brachiopods in chert zones; stylolites.	38
26	Dolomitic biomicrite (packstone): medium dark gray (N4); weathers medium light gray (N6); massive bedded; crinoid and bryozoan fragments common; few ostracod, brachiopod, and trilobite fragments; weathered surface is mottled due to dolomitized intraclasts(?) and burrow fillings(?) that weather light brownish gray in relief (5YR7/1).	22
25	Biomicrosparite (packstone): medium gray (N5); weathers same color; thick-bedded at base, grading to massive-bedded at top; 2-ft-thick fossil shell bed at base; contains crinoids, bryozoa, brachiopods, and few trilobite fragments; interbedded 5–15-cm fossil-rich beds contain some dolomite matrix.	32
24	Finely crystalline, sparse dolomitic biomicrosparite (wackestone): medium dark gray (N4); weathers medium light gray (N6) to light olive gray (5Y6/1); few small echinoderm fragments; medium- to massive-bedded.	11
23	Dolomitic sparse biomicrite (wackestone): mottled medium gray (N5) to pale red (5R6/2); dolomite is red, calcite is gray; laminated to thin-bedded; very abundant thin-shelled brachiopods and sparse bryozoan fragments.	13
22	Covered interval: probably fossiliferous shaly limestone.	6
21	Dolomitic biosparite (grainstone): medium gray (N5); weathers medium brownish gray (5YR-5/1); medium-bedded; coarsely recrystallized; abundant echinoderm, bryozoan, brachiopod fragments and sparse trilobite fragments; low-amplitude stylolites; a few scattered gray chert nodules that weather moderate brown (5YR4/4).	4
	Aleman Member	148
20	Dolomitic pelmicrite, biomicrite, and dolomitic biosparite and chert (dolomitic wackestones and packstones): limestones are medium gray (N5); weather medium light gray (N6); chert is dark gray (N3), weathers light brown (5YR6/4); laminated to thin-bedded; a few thin biogenic dolomite beds about 100 ft above the base; very abundant silicified brachiopods; poorly preserved echinoderm, ostracod, trilobite(?), and bryozoan(?) fragments.	120
19	Fine-crystalline dolomite: medium gray (N5); weathers light brownish gray (5YR6/1); laminated to thin-bedded; abundant gray chert in lenticular beds and nodules; chert weathers light brown (5YR5/6); abundant low-amplitude stylolites; base rests disconformably on Upham Dolomite.	28
	Section is continued 0.5 mi to the northeast because of thrust-fault complications.	
	Upham Member	36
18	Medium- to coarse-crystalline biogenic dolomite: dark gray (N3) to medium dark gray (N4); weathers medium gray (N5) to olive gray (5YR4/1); massive-bedded; pitted and mottled surfaces ; minor, moderate yellowish-brown (10YR5/4) chert near top.	36
	Cable Canyon Sandstone Member	20
17	Sandy medium-crystalline dolomite and limestone: medium dark gray (N4), weathers light olive gray (5Y6/1); thin- to massive-bedded; very sandy at base, becoming less sandy and more dolomitic near top.	16
16	Sandy limestone and conglomerate: medium dark gray (N4); weathers medium gray (N5); basal sandy conglomerate containing Padre clasts overlain by sandy crinoidal limestone.	4
	El Paso Formation	1260
	Padre Member	245
15	Biomicrosparite (packstone), intrasparrudite (grainstone): medium gray (N5) with patches of pale reddish brown (10R6/6); thin, wavy bedding; contains no chert; abundant trilobite and echinoderm fragments; few algal, mollusk fragments.	28
14	Packed biomicrite (packstone), fossiliferous intrasparrudite (grainstone): medium gray (N5) to medium dark gray (N4); weathers medium gray (N5) to medium light gray (N6); thin-bedded; light brown (5YR5/6) chert increases from base to 80 ft, forming abundant lenses and flat nodules; abundant trilobite, gastropod, echinoderm, and spicule(?) fragments, few *Nuia* and peloid fragments; dolomitic burrow fillings are light brown; base gradational with middle El Paso (McKelligon Member) below.	165
13	Sparse biomicrosparite (lime mudstone): medium dark gray (N4); weathers light olive gray (5Y6/1); thin- to medium-bedded; recrystallized and darker at base; 5–10-cm intraclast conglomerate beds 36 ft above base; abundant twig-like chert nodules and laminations increase toward top.	52
	McKelligon Member	690
12	Biomicrosparite (wackestone): medium gray (N5); weathers light gray (N7); contains minor brown (5YR6/4) chert; thin- to medium-bedded; grades upward to beds similar to unit 13.	129
11	Fossiliferous intrasparite (grainstone), biomicrite, (wackestone), micrite (limestone mudstone): interbedded; medium dark gray (N4) to medium gray (N5); weathers medium gray (N5) to light gray (N7); thin- to medium-bedded; very abundant chert 28–56 ft above base; minor, flattened, brown chert nodules and twig-like burrow fillings 236–316 ft above base; laminar chert and pale-red beds 468–484 ft above base to top	

Unit	Description	Thickness ft
	of unit, scour and fill surfaces 364 ft above base; black micrite bed 20 cm thick with burrows 424 ft above the base; burrows are yellowish brown on weathered surfaces; intraclasts(?) are micrite and biomicrite from interbeds; abundant trilobite, echinoderm, gastropod, spicule(?), brachiopod, and algal fragments.	453
10	Biosparite (grainstone): medium dark gray (N4) to medium light gray (N6); weathers medium light gray (N6) to medium gray (N5); thin-bedded; abundant crinoid and trilobite fragments, few gastropod fragments near top.	32
9	Fossiliferous dismicrite (lime mudstone): medium dark gray (N4); weathers medium light gray (N6); thin- to thick-bedded; abundant chert laminations and stylolites; similar to unit 8 below.	12
8	Sparse biomicrite (wackestone): fossiliferous intrasparite (grainstone): medium gray (N5); weathers medium light gray (N6) to light olive gray (5Y6/1); massive bedding with pale-red interbeds; intrasparite near top; few algal, trilobite, echinoderm fragments; brown dolomite rhombs concentrated in burrows.	64
	Jose Member	16
7	Limestone and dolomitic limestones: thin- to medium-bedded; several beds weather darker colors than beds above and below the Jose; dark-gray (N3) beds contain conspicuous small (0.5–2.0 mm), yellowish-brown weathered ooids, most beds are bioturbated; abundant intraclasts(?), *Nuia*, trilobite, echinoderm, and gastropod fragments, with some sponge spicules andquartz-feldspar fine sand grains.	16
	Hitt Canyon Member	294
6	Biosparite, biomicrite (grainstone, packstone): medium dark gray (N4) to medium gray (N6); weathers medium gray (N5) to light gray (N7); thin- to medium-bedded; abundant *Nuia* fragments; few gastropod, trilobite, crinoid fragments; minor chert laminae and stylolites at 60 ft above base some scour and fill on bedding planes; twig-like burrow fillings and fossiliferous brown chert constitute more than half of some beds 85 ft above base; 1–2.5 cm pale-red chert lenses and small nodiles are present to 120 ft above the base.	132
5	Dolomite: fine- to medium-crystalline; medium to dark gray (N4–N5); weathers brownish gray (5YR41); thin- to medium-bedded; small *Girvanella*(?) oncolites abundant in upper part; sand decreases upward and is scarce 50 ft above base; lower beds also contain abundant *Nuia*, with some peloids, gastropod, trilobite, and echinoderm fragments; conformable, somewhat gradational contact with underlying Bliss Sandstone.	162
	Bliss Sandstone	96
4	Calcareous sandstone: coarse-grained.	4
3	Dolomitic pelmicrosparite: medium gray (N5); weathers moderate yellowish brown (10YR5/4); slightly sandy; brachiopod fragments; interbedded with calcareous sandstone; partly covered.	13
2	Arkose: pale reddish brown (10R5/4) to pale yellowish brown (10YR6/2); weathers grayish red (10YR5/4) to yellowish gray (5Y8/1); slightly granular, coarse sandstone at base grades upward to medium sandstone; few hematite oolites 54 ft above base; mostly iron-oxide cement with minor silica; 10–45-cm beds; some low-angle crossbedding; scattered white quartz pebbles near base; 64 ft above base unit grades upward into 60-cm-thick, sandy dolomitic pelmicrosparite and then into 2 ft of arkose above.	75
1	Cobble conglomerate: dark reddish brown; coarse sandy matrix with rock clasts derived from underlying syenite; Bliss Sandstone is nonconformable on Cambrian syenite below.	4

Appendix E–6

Northwest Capitol Dome (Lobo Formation) measured section

The section was measured up the arroyo on the northwest slope of Capitol Dome (NW¼NW¼SW¼ sec. 11 T25S R8W) during May 1980. Measured section line is indicated on Sheet 3. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 30 thin sections was completed and rock names were assigned according to Folk's (1954, 1974) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock color chart* published by the Geological Society of America (1963).

Unit	Description	Thickness ft
	Rubio Peak Formation	
	—unconformity—	
	Lobo Formation	340
13	Interbedded mudstone, very fine- to coarse-grained sandstone and granule-to-pebble conglomerates: calcitic, lithic arkoses and feldspathic sedarenites; grayish red (5R4/2) and pale yellowish brown (10YR6/2); weather moderate brown (5YR4/4) and dark yellowish-brown (10YR-4/2); thin to medium-bedded; conglomerate lenses are channel fills.	63
12	Granular medium sandstone: calcitic, feldspathic sedarenite; pale yellowish-brown (10YR6/2); weathers dark yellowish brown (10YR4/2); thin-bedded; partly covered.	25
11	Coarse sandy cobble conglomerate: calcitic sedarenite; abundant clasts of Bliss, El Paso, and Montoya Formations and few small granite clasts.	4
10	Conglomeratic fine sandstone: calcitic, felspathic sedarenite; grading upward to slightly conglomeratic mudstone; grayish orange (10YR7/4); weathers pale brown (5YR6/2); thin-bedded.	19
9	Covered.	20
8	Slightly conglomeratic, very fine to fine sandstone: calcitic feldspar and chert-bearing calclithite; pale yellowish brown (10YR6/2); weathers moderate yellowish brown (10YR5/4); thin-bedded.	35
7	Interbedded sandstones like units 8 and 12 with few granule conglomerates: pale red (5R5/2) and grayish red (10R4/2); weather moderate yellowish brown (10YR5/4) and moderate red (5R6/4); thin- to medium-bedded; burrows common in upper beds.	65
6	Very fine sandstone grading upward to siltstone: calcitic, feldspathic sedarenites; greenish gray (5GY6/1); weathers grayish orange (10YR7/4) and pale–moderate red (5R6/4) below, and moderate yellowish brown (10YR5/4) above; laminated to thin-bedded.	13
5	Fine sandstone: calcitic chert-bearing calclithite grading up to feldspathic sedarenite; colors similar to unit 6 above; laminated to thin-bedded.	30
4	Interbedded fine sandstone and granule conglomerate: calcitic chert-bearing calclithites, greenish gray (5GY6/1); weather moderate yellowish brown (10YR5/4); thin-bedded.	10
3	Silty micrite: grayish red (5R4/2); weathers pale red (5R6/2); thin-bedded.	6
2	Sandy cobble conglomerate: calcitic calclithite; few boulders to 2 ft; subangular to rounded casts of Montoya, El Paso, and Bliss Formations; thick- to massive-bedded.	23
1	Muddy cobble conglomerate: calcitic calclithite; many pebbles and boulders; mud matrix is grayish red (5R4/2), weathers reddish-brown (10R4/4); rounded limestone casts are light to medium gray (N5–N7); probable filling of karst topographic surface developed on Montoya Formation.	28

Appendix E–7

Tubb Spring (Lobo Formation) measured section

The section was measured on the south slope of Capitol Dome (SW¼ sec. 11 T25 S R8W) during May 1980. Measured section line is indicated on Sheet 3. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 40 thin sections was completed and rock names were assigned according to Folk's (1954, 1974) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock color chart* published by the Geological Society of America (1963).

Unit	Description	Thickness ft
	Rubio Peak Formation	
	—unconformity—	
	Lobo Formation	610
14	Interbedded siltstone and mudstone: grayish red (5Y4/2); weathers moderate brown (5YR4/4); thin-bedded; poorly exposed.	
13	Interbedded siltstone and mudstone like unit 14, with medium sandstone: calcitic, lithic arkoses and feldspathic calclithites; dark brownish gray (5YR3/1); weathers dark yellowish brown (10YR3/4); thin- to medium-bedded; few pebble conglomerate channel-fill lenses.	85
12	Interbedded, slightly conglomeratic mudstone, siltstone, and fine to medium sandstone: calcitic, felspathic sedarenites; grayish red (5R4/2) and light olive gray (5Y6/1); weather pale grayish red (5R5/2) and moderate yellowish brown (10YR5/4); numerous pebble and cobble conglomerate channel-fill lenses.	111
11	Coarse sandy pebble conglomerate: crossbedded; massive.	10
10	Interbedded mudstone, siltstone, and slightly conglomeratic, fine, medium, and coarse sandstone: calcitic subsedarenites, feldspar sedarenites, and sedarenites; grayish red (5R5/2) and light olive gray (5Y6/1); weather yellowish brown (10YR5/2) to moderate yellowish brown (10YR5/4); several pebble and cobble conglomerate channel-fill lenses; thin- to thick-bedded.	65
9	Interbedded mudstone, siltstone, and granular, very fine to medium sandstone: calcitic, feldspathic chert arenites and sedarenites; grayish red (5R4R) and pale brown (5YR5R); weather moderate yellowish brown (10YR4/4); few granule and small pebble channel-fill lenses; laminated at base to thin-bedded at top.	65
8	Sandy granule conglomerate and fine sandstone: calcitic, submature, feldspathic sedarenites; grayish red (10R4R); weather moderate brown (5YR3/4); thin-bedded; low-angle crossbeds; horizontal burrows	7
7	Pebble conglomerate with boulder (to 30 cm) layer in middle; subrounded to well-rounded clasts of Bliss, El Paso, and Montoya Formations.	7
6	Very fine and fine sandstone: calcitic, submature calclithites, sedarenites, and feldspathic sedarenites; yellowish-brown (10YR512); weather moderate yellowish brown (10YR5/4); thin-bedded, partly covered.	53
5	Fine sandstone: calcitic, submature sedarenite; grayish orange–pink (5YR7/2); weathers grayish orange (10YR7/4); thin-bedded with common clay partings; several crossbedded, coarse, sandstone lenses; horizontal burrows.	
4	Interbedded mudstone and very fine sandstone: calcitic, immature sedarenites; dusky red (SR3/4); weather moderate brown (5YR3/4); laminated to thin-bedded.	11
3	Very fine to fine sandstone: calcitic, submature calclithites, chert arenites, and sedarenites; grayish red (10R4/2) and pale yellowish brown (10YR6/2); weather pale yellowish brown (10YR6/2) and moderate brown (5YR4/4); few granule to small pebble conglomerate channel-fill lenses; thin-bedded.	60
2	Interbedded pebble–cobble conglomerate, mudstone, and very fine to medium sandstone: calcitic, immature calclithites and sedarenites; pale red (5R6/2); weather pale to moderate brown (5YR2–4/4); thick- to massive-bedded.	26
1	Interbedded mudstone and muddy conglomerate: very dark red (5R2/6) to grayish red (5R4/2); weather grayish red (10R4/2) to moderate brown (5YR4/4); angular to subrounded to boulder-size casts include Bliss, El Paso, and Montoya Formation debris; thick- to massive-bedded.	56
	—unconformity—	
	Montoya Formation	

Appendix E–8

West Florida Mountains (Lobo Formation) measured section

The section was measured eastward up an arroyo from the prospect in the southeast corner of sec. 14 T25S R8W during September 1980. Measured section line is indicated on Sheet 1a. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 45 thin sections was completed and rock names were assigned according to Folk's (1954, 1974) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock color chart* published by the Geological Society of America (1963). Sill thicknesses are not included in the total thickness of the Lobo Formation.

Unit	Description	Thickness ft
	Rubio Peak Formation	
	—unconformity—	
	Lobo Formation	530
16	Interbedded mudstones, siltstones, and slightly conglomeratic fine sandstone: calcitic, immature volcanic-rock-bearing calclithite; grayish red (5R4/2) and greenish gray (5GY6/1) weather pale yellowish brown (10YR6/2) and grayish orange (10YR7/4); thin-bedded.	96
15	Basaltic andesite sill: 44 ft thick.	
14	Similar to unit 16 above except a lithic arkose unit.	11
13	Basaltic andesite sill: 11 ft thick.	
12	Interbedded mudstones , siltstones, and medium sandstone: calcitic, immature lithic arkose; colors like unit 16 above; several pebble-conglomerate lenses in middle part are channel fills; thin- to medium-bedded.	83
11	Siltstone, at base grading up to coarse sandstone: calcitic, immature, sedimentary rock-bearing lithic arkose and pebble conglomerate lenses in middle part are channel fills, thin- to medium-bedded.	35
10	Mudstone with few sand and granule lenses: pale brown (5YR5/2); weathers pale yellowish brown (10YR6/2).	15
9	Granular coarse sandstone: calcitic, immature, perthite-bearing sedarenite; approximately equal amounts of sandstone and limestone rock fragments; medium greenish gray (5GY5/1); weathers moderate yellowish brown (10YR4/2).	
8	Basaltic andesite sill: 4 ft thick.	
7	Interbedded mudstone and granular, fine and coarse sandstone: calcitic, immature lithic arkoses; grayish brown (5YR4/2); weathers pale brown (5YR5/2); thin- to medium-bedded.	29
6	Interbedded siltstone, granular sandstone lens, and fine to medium sandstone: calcitic, immature, perthite arkoses; moderate greenish gray (5GY5/1); weather moderate yellowish brown (10YR5/4); abundant horizontal burrows in upper part; thin-bedded.	60
5	Cobble conglomerate with coarse sandstone lenses 25 ft above base; well-rounded clasts of Bliss, El Paso, and Montoya Formations; few syenite clasts; few boulders to 2 ft.	29
4	Fine to medium sandstone: calcitic, immature perthite arkose; olive gray (5Y4/1); weathers dark yellowish brown (10YR3/2); abundant horizontal burrows; small channel fill of conglomeratic coarse sandstone, medium-bedded.	12
3	Basaltic andesite sill: 5 ft thick.	
2	Interbedded mudstone, siltstone, and very fine to medium sandstone: calcitic, submature arkoses, subarkoses, and quartz arenites; very fine sandstones are quartz arenites and as size increases compositional trend is through subarkoses to arkoses to lithic arkose in a coarse sandstone lens; dark greenish gray (5GY4/1); weather pale to moderate yellowish brown (10YR4/4); vertical burrows common in upper part; horizontal burrows 85–90 ft above base; typically fine-laminated thick to massive beds; low-angle, scour and-fill crossbedding throughout.	135
1	Boulder conglomerates at base grading upward to cobble and pebble conglomerates with coarse sandstone lens; well-rounded clasts of Bliss, El Paso, and Montoya Formations, syenite, and granite; massive.	22

Appendix E–9

Lobo Draw (Lobo Formation type section) measured section

The section was measured up a south-trending tributary arroyo of Lobo Draw in the SW¼ sec. 19 T25S R7W during September 1983. Measured section line is indicated on Sheet 1a. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 24 thin sections was completed and rock names assigned according to Folk's (1954, 1974) classification. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock color chart* published by the Geological Society of America (1963).

Unit	Description	Thickness ft
	Rubio Peak Formation	
	—unconformity—	
	Lobo Formation	385
6	Poorly exposed reddish-brown shale, calcareous siltstone, and fine sandstone: channel fill at 370 ft is a granular medium sandstone and calcitic, submature volcanic-rock-bearing feldspathic sedarenite; medium gray (N5); weather moderate yellowish brown (10YR5/4); thin-bedded; average of 10 largest clasts is 0.6 cm.	60
5	Interbedded, at approximately 3 ft intervals, calcareous siltstones and slightly granular fine to medium sandstones: calcitic, submature volcanic-rock-bearing sedarenites; medium gray (N5) to brownish gray (5YR5/1); weather moderate yellowish brown (10YR5/4); medium- to thick-bedded; averages of 10 largest clasts at 5 and 25 ft above base are 0.5 and 0.6 cm, respectively.	115
4	Interbedded calcareous siltstone and shale: grayish red (5R4/2) and pale yellowish brown (10YR4/2); weather moderate brown (5YR4/4) and dark yellowish brown (10YR4/2); massive to blocky; average of 10 largest casts in lens at base is 1.2 cm.	35
3	Interbedded siltstones, sandstones, and conglomerates: calcitic, immature to submature lithic arkoses; pale yellowish brown (10YR6/2) to grayish red (10R4/2); weather moderate brown (5YR3/4); lithic casts are limestone, dolomite, and chert; sandstone is horizontally laminated with thin (less than 2 cm) gravel lenses; siltstone layers contain burrows, mottling, and carbonate nodules; averages of 10 largest clasts at 15, 35, and 48 ft above base are 5.0, 1.3, and 5.9 cm, respectively.	65
	Basaltic andesite sill: 6 ft thick; not included in thickness of Lobo section.	
2	Slightly conglomeratic medium sandstone: calcitic, submature arkose; pale brown (5YR5/2); weathers moderate yellowish brown (10YR-5/2), thick-bedded; local bioturbation.	10
1	Interbedded sandstones and conglomerates: calcitic, immature to submature sedimentary- and plutonic-rock-bearing arkoses; medium dark gray (N4) to dusky red (5R3/4); weather moderate brown (5YR4/4) to dark reddish brown (10R3/4); basal 3 ft of angular, conglomerate, syenite clasts to 10 cm diameter; fines upward to fine to medium sandstone that is massive to horizontally laminated with few crossbeds and small (less than 10 am thick) granule channel fills; from 20 to 100 ft very coarse sandstone to pebble conglomerate layers 2–15 cm thick are interbedded with horizontally laminated medium and very fine sandstone with minor conglomerate channel fills; averages of 10 largest clasts 3, 45, 60, 74, 80, and 95 ft above base are 8.4, 4.8, 10.8, 4.8, 2.7, and 1.4 cm, respectively; very fine sandstone beds have burrows and roots(?).	100
	Nonconformable contact with underlying coarse crystalline syenite.	

Appendix E–10

Florida Peak (Rubio Peak Formation) measured section

The section was measured up the west slope of Florida Peak approximately parallel to and near the southern side of sec. 13 T25S R8W during September 1982. Measured section line is indicated on Sheet 1. The section was measured using a Jacob's staff and Brunton compass. Petrographic study of 12 thin sections was completed and rock names were assigned according to Folk's (1954, 1974) classifications. Rock colors of dry, fresh, and weathered surfaces were assigned through use of the *Rock color chart* published by the Geological Society of America (1963).

Unit	Description	Thickness ft
	Rubio Peak Formation (top of section is top of Florida Peak)	1650+
6	Medium sandstone: siliceous, immature, volcanic-rock-bearing plagioclase arenite; very poorly sorted; light gray (N7) to yellowish gray (5Y7/2); weathers grayish orange (10YR7/4) to pale yellowish brown (10YR6/2); thick- to massive-bedded; most plagioclase (oligoclase?) and volcanic rock fragments intensely altered; dips 22°N 40°E.	200
5	Medium sandstone: siliceous, immature, volcanic-rock-bearing plagioclase arenite; very poorly sorted; pale greenish yellow (10Y8/2) to yellowish gray (5Y8/1); weathers grayish yellow (5Y8/4) to light olive gray (5Y6/1); thick- to massive-bedded; few lenses (channels?) of pebble conglomerate; abundant epidote concretions; epidote and chlorite replaced most volcanic rock fragments; dips 21°N35°E.	900
4	Coarse and medium sandstone, like units 5 and 6, are interbedded with pebble and cobble conglomerates: siliceous, immature, volcanic arenites; light greenish gray (5GY8/1) to grayish pink (5R8/2); weather grayish yellow (5Y8/4) to moderate yellowish brown (10YR5/4); thick- to massive-bedded; epidote concretions; conglomerate percentage decreases upward; dips 25°N50°E.	150
3	Cobble conglomerate: immature, muddy, sandy volcanic arenite; dark yellowish brown (10YR4/2) to pale grayish red–purple (5RP5/2); weathers pale brown (5YR5/2); massive-bedded, subangular to subrounded to boulder-size clasts of porphyritic andesite, latite, and dacite.	50
2	Sandstones and conglomerates like unit 4 above: grayish red–purple (5RP4/2) to dusky yellowish-green (5GY5/2); weather moderate to dark yellowish brown (10YR5/4–4/2); medium- to thick-bedded; sandstones are mostly altered oligoclase(?); crystals and ghosts of volcanic-rock fragments in matrix of iron oxides, epidote, carbonate, chlorite, and clays; abundant epidote concretions; subrounded to rounded to boulder-size clasts include volcanic rocks like unit 3 above and few limestones, dolomites, and sandstones; dips 18°N35°E.	325
1	Medium sandy cobble conglomerate: immature, volcanic- and plutonic-rock-bearing sedarenite; colors similar to unit 2 above; massive-bedded; rounded casts are mostly limestones, dolomites, sandstones, and chert, with common andesites, latites, granite, and syenite; imbricated pebbles dip southeastward where section was measured, but imbrication is not well developed elsewhere.	25

Selected conversion factors*

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

Editors: Jiri Zidek
Deborah Shaw
Nancy Gilson

Drafters: Linda Wells-McCowan
Kathy Glesener

Typeface: Palatino

Presswork: Komori Lithrone 40" 4-Color Offset Press

Binding: Perfect bound

Paper: Cover on 12-pt. Kivar
Text on 70-lb White Matte

Ink: Cover—PMS 320, black
Text—Black

Quantity: 1,000

CONTENTS OF POCKET

SHEETS Ia & Ib—Geology of the Florida Mountains, Luna County, New Mexico

SHEET 2—Geologic map of Mahoney mine—Gym Peak area

SHEET 3—Geologic maps of Mahoney Park area and of Capitol Dome area

SHEET 4—Cross sections of the Florida Mountains and explanation

Please be advised that the map sheets accompanying this memoir were printed in 1993 and bear that date. However, the year of issue of the entire memoir is 1998, and, therefore, the real date of issue of the map sheets in this pocket also is 1998. In order to avoid confusion, we suggest that you yourself re-date the map sheets.

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES