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1970, pp. 69-74. https://doi.org/10.56577/FFC-21.69

in:

Tyrone, Big Hatchet Mountain, Florida Mountains Region, Woodward, L. A.; [ed.], New Mexico Geological Society 21st Annual Fall Field Conference Guidebook, 176 p. https://doi.org/10.56577/FFC-21

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THRUST FAULTS OF FLORIDA MOUNTAINS, NEW MEXICO AND THEIR REGIONAL TECTONIC SIGNIFICANCE

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INTRODUCTION

The Florida Mountains are in the Basin and Range Province in south-central Luna County, New Mexico, about 8 miles southeast of Deming. Block faulting during the Tertiary created the present mountains by uplift along range-marginal faults; however, the internal structures within the mountains, principally thrust faults of Laramide age, are the subjects of this report. Higher peaks in the mountains exceed 7,000 feet in elevation, rising about 2,800 feet above the adjacent bolsons.

Some of the major structures within the range were observed by Darton (1917) during reconnaissance mapping for the Deming Folio. Complex thrusts within the Montoya-Fusselman stratigraphic interval were noted by Kottlowski (1957). Lochman-Balk (1958) mapped and described the area near Capitol Dome in the northern part of the Florida Mountains. The paleotectonic setting of the region during Pennsylvanian time was described by Kottlowski (1958).

This report is based mainly on a Ph.D. dissertation at the University of New Mexico by Corbitt under the supervision of Woodward. Financial support and air photos were provided by Forest Oil Corporation through the courtesy of Mr. J. L. Hitt.

STRATIGRAPHY

With respect to late Cretaceous-early Tertiary Laramide deformation, the preorogenic rocks range in age from Precambrian to at least Permian and possibly Mesozoic (Figs. 1 and 6). Approximately 3,000 feet of Paleozoic strata are preserved above the crystalline Precambrian rocks. Because of complex thrusting in the middle and upper Paleozoic part of the section precise stratigraphic thicknesses cannot be determined. The Paleozoic strata are mostly shelf carbonates; the Bliss Formation of Late Cambrian and Early Ordovician age and the Upper Devonian Percha Shale are the only major Paleozoic clastic units present.

Intrusive into the Precambrian and Paleozoic rocks is a pluton composed principally of syenite. It is tentatively considered to be of Mesozoic age as it is unconformably overlain by the Lobo Formation. The syenite is cut by thrusts and is therefore preorogenic.

An unnamed Lower Cretaceous (?) conglomerate is present in a few small outcrops where it is unconformable on Paleozoic strata. The conglomerate is deformed by a fault which is unconformably overlain by the Lobo Formation; the unnamed conglomerate is therefore older than the Lobo and the thrusts.

AGE			STRATIGRAPHIC UNITS	THICKNESS (FEET)	LITHOLOGY
CRETACEOUS (?) — TERTIARY					
					WHITE RHYOLITE DIKES
				1600	ANDESITE TUFF AND AGGLOMERATE
			LOBO	350–500	LIMESTONE CONGLOMERATE, SILTSTONE, SILTY LIMESTONE, RED, GRAY, MAROON, PURPLE
	LOWER		UNNAMED	75	CHERT CONGLOMERATE
	LOWER				SYENITE, GRANITE, GABBRO, AND ANORTHOSITE INTRUSIVES
PERMIAN	WOLFCAMPIAN		HUECO fault	500	LIMESTONE, GRAY, THICK TO MASSIVE BEDDED
MISSISSIPPIAN	LOWER		LAKE VALLEY	200	LIMESTONE AND SHALE, THIN BEDDED, LENTICULAR AND NODULAR CHERT
DEVONIAN	UPPER		PERCHA SHALE	250	SHALE, DARK GRAY TO OLIVE, FISSILE.
SILURIAN	MIDDLE		FUSSELMAN DOLOMITE	1000	DOLOMITE, MASSIVE BEDDED, ALTERNATING DARK AND LIGHT GRAY
ORDOVICIAN	UPPER	MONTOYA	CUTTER	200	DOLOMITE AND CHERT, BIOSTROMAL LIMESTONE
ORDOVICIAN	UPPER	MONTOYA	ALEMAN	200	LIMESTONE AND CHERT, ALTERNATING IN THIN BEDS
ORDOVICIAN	UPPER	MONTOYA	UPHAM	85	DOLOMITE, DARK BROWN
ORDOVICIAN	UPPER	MONTOYA	CABLE CANYON	5	DOLOMITE, SANDY
ORDOVICIAN	LOWER	EL PASO	UPPER	750	LIMESTONE, 20–30% CHERT
ORDOVICIAN	LOWER	EL PASO	MIDDLE	150	LIMESTONE, WHITE TO BLUE GRAY
ORDOVICIAN	LOWER	EL PASO	LOWER	155	DOLOMITE, DARK GRAY
CAMBRIAN			BLISS FORMATION	5–200	ARKOSIC TO QUARTZOSE SANDSTONE WITH CONGLOMERATE AND LIMESTONE.
PRECAMBRIAN					GRANITE, GNEISS, SCHIST, DIAMICTITE

FIGURE 1.
Summary of rock units of Florida Mountains, New Mexico.

The Lobo Formation rests unconformably on the Precambrian, the Paleozoic, the syenitic intrusive rocks, and the thrusts. Although the age of the Lobo is uncertain, it is commonly considered to be Cretaceous (?) or Tertiary (?) (Dane and Bachman, 1965) . Regardless of its absolute age it is postorogenic with respect to thrust faults in the Florida Mountains.

Other postorogenic rocks include an andesite agglomerate that disconformably overlies the Lobo Formation and rhyolite dikes that cut the agglomerate.

PALEOTECTONIC SETTING

From Cambrian through Mississippian time the Florida Mountains area was part of a stable shelf to the south of the Transcontinental Arch. At least three episodes of epeirogenic uplift during the Middle Ordovician, Early Silurian, and Late Silurian-Devonian are recorded by stratigraphic breaks. In Pennsylvanian time this shelf was epeirogenically deformed into a number of basins and uplifts and Kottlowski (1958) suggested the Florida Mountains area was a minor uplift between the Orogrande Basin to the northeast and the Pedregosa Basin to the south. It seems likely, however, that the Pennsylvanian strata are absent in the Florida Mountains because of tectonic elimination along Laramide faults rather than because of pre-Hueco erosion. The Permian Hueco Formation indicates that shelf conditions again prevailed during Wolfcamp time.

During the Mesozoic the Florida Mountains area was a southeastern extension of the Burro uplift described by Elston (1958). These positive elements comprised part of the more extensive Deming axis (Turner, 1962) . Elston (1958) suggested that the Burro uplift was formed during the Early Cretaceous; Turner (1962), however, indicated that the Deming axis was probably positive throughout much of Mesozoic time. Syenitic and related intrusive rocks were probably emplaced in the Florida Mountains during the later part of the Mesozoic. The Deming axis appears to have been the northern margin of the Mexican geosyncline.

Northward-yielding thrust faults and overturned folds developed during Laramide time within and along the northern margin of the Mexican geosyncline. These structures are considered in greater detail in the section concerning regional tectonics. Some of the elastic Lower Cretaceous rocks of southwestern New Mexico, including the Mojado Formation (Zeller, 1965), may represent synorogenic detritus derived from the deformed and uplifted Mexican geosyncline to the south.

LARAMIDE STRUCTURES OF FLORIDA MOUNTAINS

Thrusts and steep reverse faults that cut or deform rocks as young as the Lower Cretaceous (?) conglomerate and the syenitic intrusives of probable Mesozoic (?) age are in turn unconformably overlain by the Lobo Formation of Cretaceous (?) -Tertiary (?) age. Thus, these faults appear to be Laramide.

The most conspicuous fault is a northwest-trending, steeply dipping, reverse fault that has brought syenitic intrusive rocks over the Paleozoic strata in the southern part of the mountains. This fault is steep at deep structural levels, but flattens upward (Fig. 2). There is at least 2,000 feet of stratigraphic separation on this fault and it appears that the vertical component of movement is greater than the horizontal component.

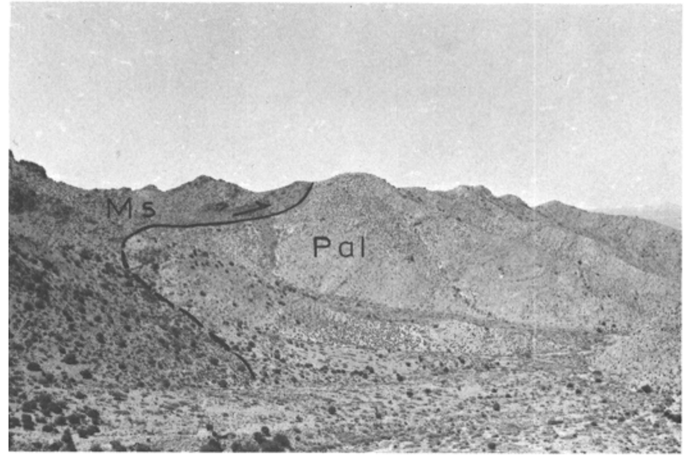

FIGURE 2.
View west showing Mesozoic(?) syenite (Ms) in fault contact with lower Paleozoic El Paso, Montoya, and Fusselman strata (Pal). Fault trace is shown by a solid line at high structural level where it flattens and by dashed line at deep structural level where it is steep.

In the Paleozic strata beneath this fault, on the northeast side, is a complex of imbricate thrust slices that are particularly well exposed in the second ridge south of Mahoney Park in sections 34 and 35 of T. 25 S., R. 8 W. (Fig. 3). At this location undulating to gently dipping thrusts have repeated parts of the Montoya-Fusselman section three times (Fig. 4) . There is also tectonic elimination of strata as well as repetition along some of the faults. The thrusts and the strata dip at an average of about 15° SE. The fault surfaces are commonly marked by brecciated zones up to 60 feet thick. Some of the breccia zones are locally silicified (Fig. 5) . A precise calculation of slip on these faults cannot be made, but there must be at least 4,000 feet of horizontal yielding in a northerly direction. Presumably these imbricate slices are genetically related to the steeper fault described above where the syenite has been brought over the Paleozoics; it is possible that the imbricate thrusts are slightly older than the steep fault and have been offset by the latter fault. However, the absence of Paleozoic rocks on the south side of the steep fault precludes proving this possibility. At any rate, it seems likely that all these thrusts and steep reverse faults formed during the same general orogenic episode.

Complex thrusting in the Paleozoic rocks beneath the major steep reverse fault is also seen at Gym Peak. Here the thrusts mainly involve tectonic elimination of strata although locally there is repetition of strata. In the canyon south of Gym Peak, below the major reverse fault, a thrust

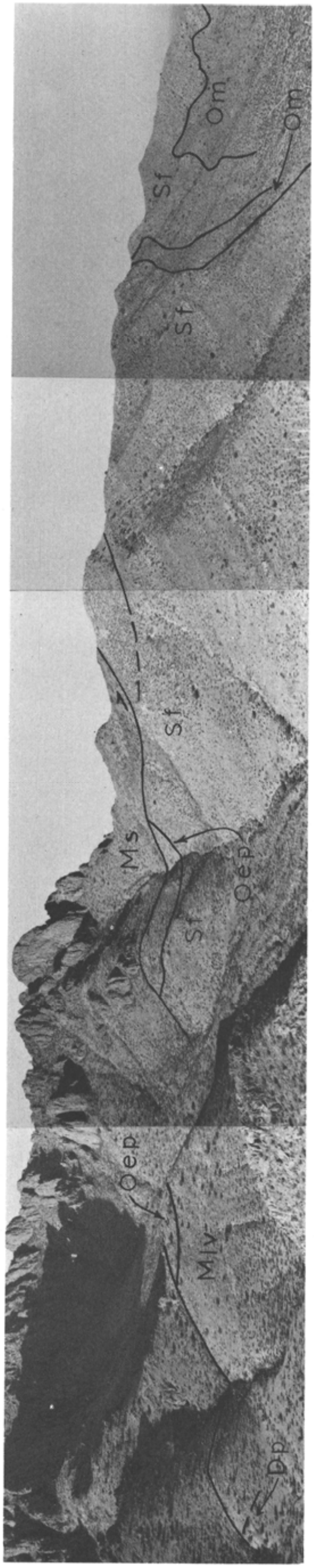

FIGURE 3.

View southwest of second ridge south of Mahoney Park showing imbricate thrust slices of Ordovician El Paso (Oep), Montoya Group (Om), and Silurian Fusselman Formation (Sf) beneath fault with Mesozoic(?) syenite (Ms) in hanging wall. Mississippian Lake Valley Limestone (Mlv) and Devonian Percha Shale (Dp) to left.

plate of Permian Hueco Limestone and Devonian Percha Shale overlies the Mississippian Lake Valley Formation. These faults have been tilted by Basin-Range deformation and their present attitudes do not indicate their original orientations. Mostly the faults are subparallel to bedding. Exact amounts of movement on these faults cannot be determined, but it is likely that the movement was on the order of at least several thousand feet.

On the hill north of Victorio Canyon on the east side of the range the Ordovician El Paso has been thrust onto strata ranging from the El Paso to the Silurian Fusselman, with a maximum stratigraphic separation of 1,300 feet. The horizontal component of movement is at least a few thousand feet. Some of these stratigraphic units have been tectonically thinned here.

REGIONAL TECTONICS

The thrust faults in the Florida Mountains are interpreted as the southeastern continuation of the Cordilleran foldbelt of western North America (King, 1969). These faults mark the northern erosional limit of thrusting associated with Laramide deformation of the Mexican Cordilleran geosyncline.

Isolated exposures of preorogenic rocks in southwestern New Mexico and part of adjacent Mexico are shown on Figure 6. Analysis of the structures within these rocks allows definition of the contact between the deformed foldbelt and its foreland to the northeast (Fig. 6). North of this contact a different structural style is seen, contrasting with the thrusts and overturned folds of the foldbelt. The foreland is deformed in the Saxonic or Germano-type of Stille (1924), whereas Alpino-type deformation characterizes the foldbelt. The northern margin of the foldbelt approximates the limit of thrusting shown on Figure 6, except that the East Potrillo Mountains are included in the foldbelt.

The evidence for the interpretations stated above is discussed below for each of the critical areas shown on Figure 6, beginning with the Juarez Mountains on the east.

(1) Northeast-yielding thrusting in the Juarez Mountains has been noted by Strain (1958). Cordoba (1968) has also reported recumbent folds trending northwest.

(2) In the East Potrillo Mountains Wengerd (1969) described a large anticline that has minor thrust movement toward the east along the northern end of the crest of the fold.

(3) Two wells drilled by Sunray and Skelly in T. 28 S., R. 5 W., southeast of the Florida Mountains appear to have encountered tectonically mixed rocks with both repetition and elimination of strata along possible thrust faults (Kottlowski and others, 1969, p. 193-194). In view of the poor quality of the data concerning these wells there is much uncertainty concerning both stratigraphic and structural interpretations. However, structural complexity appears to be likely to us and therefore we include these wells within the foldbelt.

(4) The thrust faults within the Florida Mountains have been described previously.

(5) In the Tres Hermanas Mountains one of the struc-

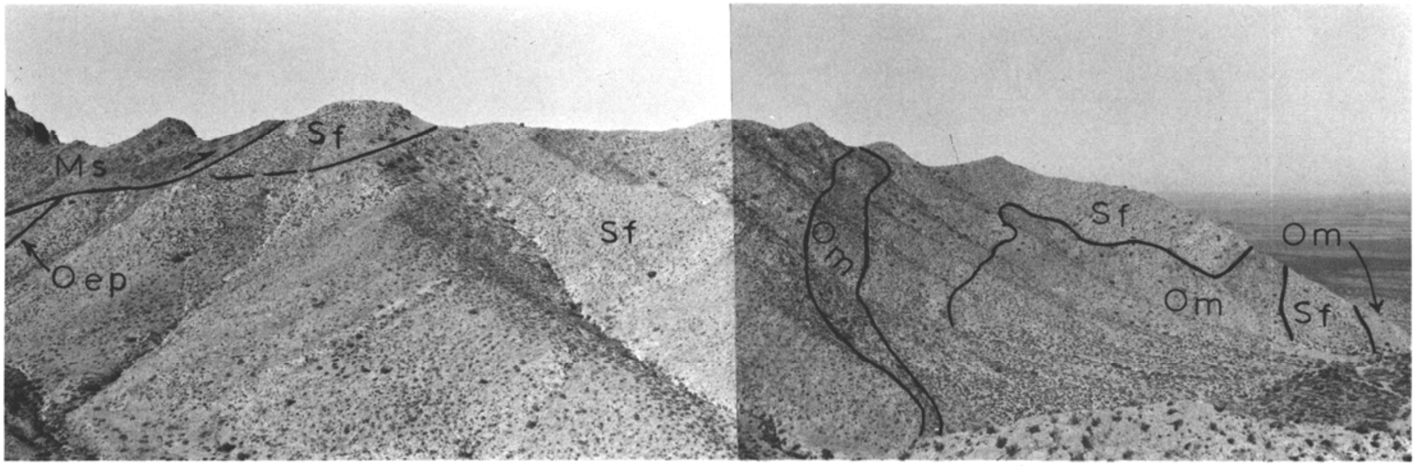

FIGURE 4.
Close-up view southwest of second ridge south of Mahoney Park showing complex imbricate thrust slices of Silurian Fusselman Dolomite (Sf), Ordovician Montoya Group (Om), and Ordovician El Paso.

FIGURE 5.
View of silicified part of a breccia zone where strata have been tectonically eliminated along a thrust. Silurian Fusselman above and Ordovician Montova below.

tural interpretations from Balk's map and structure sections (1961) is that Silurian Fusselman Dolomite was thrust northeastward over the Permian Hucco Formation prior to intrusion of the large body of Tertiary quartz monzonite.

(6) About 4 miles northwest of the Tres Hermanas Mountains are two small outcrops that consists of Silurian Fusselman Dolomite and Permo-Pennsylvanian strata. The outcrop patterns suggest that the Fusselman overlies the Permo-Pennsylvanian rocks; a thrust contact is inferred there.

(7) Lower Paleozoic carbonates have been thrust northeastward onto Lower Cretaceous elastic rocks in the Snake Hills.

(8) In the Victorio Mountains a reverse fault that has brought Ordovician El Paso strata northward over Lower Cretaceous elastic rocks was mapped by Kottlowski (in Griswold, 1961). This fault is interpreted as an overthrust marking the tectonic contact between the foldbelt and the foreland.

(9) A small outcrop of tectonically mixed Fusselman, Montoya, and Lower Cretaceous conglomerate is present about 10 miles northwest of the Victorio Mountains. The structural complexity of these rocks is interpreted as the result of thrusting.

(10) Zeller (1958a) described several thrusts in the Sierra Rica that trend northwest and dip toward the southwest. The main thrust has brought Paleozoic strata over the Cretaceous Mojado Formation. This thrust has 18,000 feet of stratigraphic throw and Zeller (1958a, p. 163) estimates that the thrust plate has moved on the order of miles and yielded toward the northeast. Several associated klippen and a fenster are described by Zeller. Other thrusts and reverse faults of smaller magnitude are also present in the Sierra Rica.

(11) In the Little Hatchet Mountains Lasky (1947) reported bedding-plane faults and folds of Laramide age. The folds trend northwest. Also, the anomalous thickness of 21,000-25,000 feet of Lower Cretaceous strata reported by Lasky (1947) as well as repetition of nearly identical lithologies in this part of the section suggest that there may be low-angle thrusts present. Northwest of Granite Pass Paleozoic strata appear to have been thrust to the northeast over Lower Cretaceous rocks.

(12) A thrust at Hatchet Gap was estimated to have over 25,000 feet of stratigraphic throw by Lasky (1947). This fault dips about 60° to the south and has placed upper Paleozoic strata on granitic rocks.

Zeller (1958a) described several imbricate thrusts in the southwestern part of the Big Hatchet Mountains. These thrusts generally dip gently to the northeast and associated drag folds and overturned anticlines and synclines indicate yielding toward the southwest. Some of these thrusts locally steepen to high-angle reverse faults. Zeller (1958a, p. 57) indicated that these thrusts were of local extent and of relatively small movement. At any rate, the direction of yield-

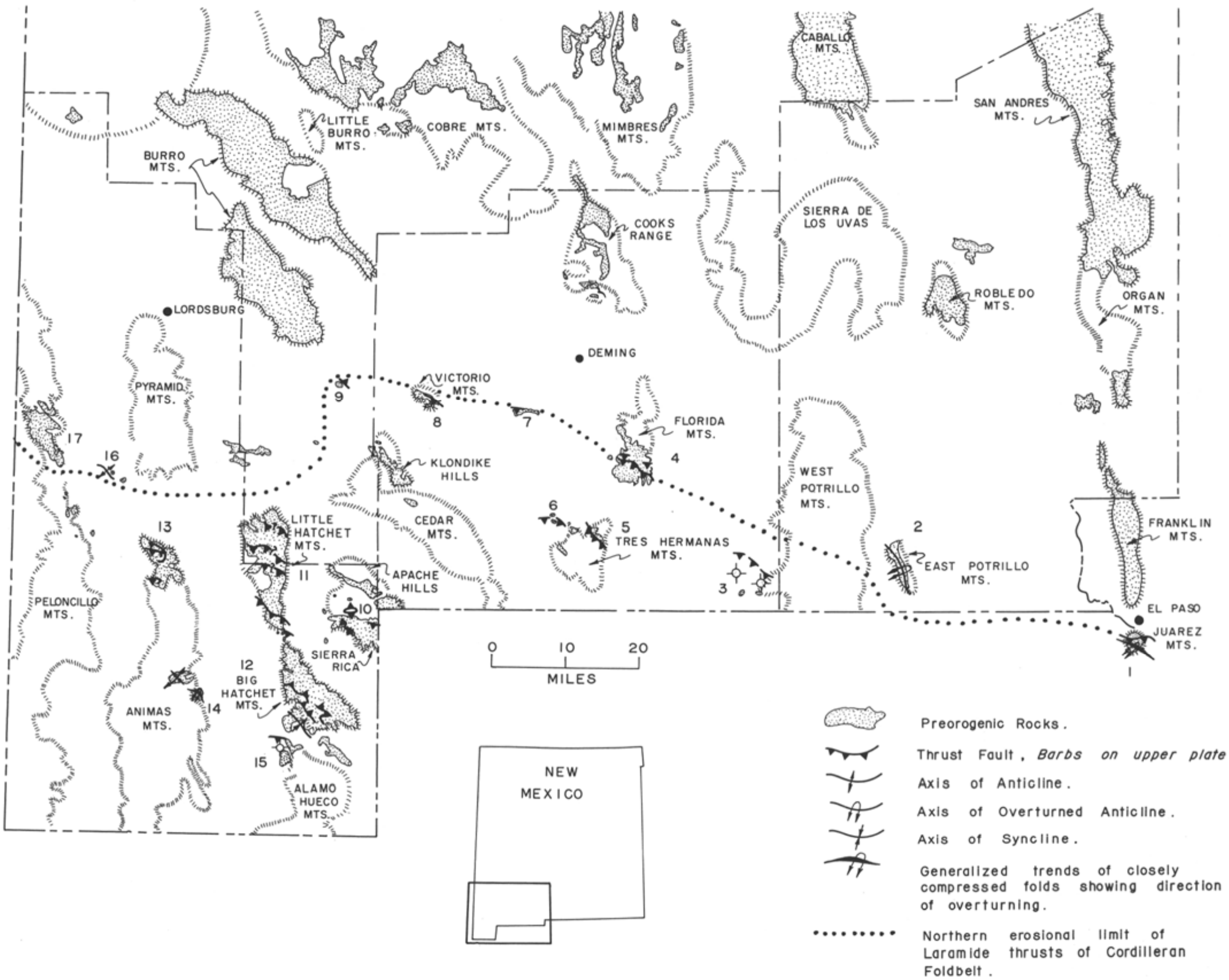

FIGURE 6.

Tectonic map of southwestern New Mexico and part of adjacent Mexico showing structures of Cordilleran foldbelt. Northern margin of foldbelt approximately coincides with erosional limit of thrusts. Numbers refer to localities mentioned in text.

ing is anomalous in view of the otherwise consistent yielding of the foldbelt toward the foreland to the north and east.

(13) Zeller's map of the Playas quadrangle (1958b) shows three thrust slices at the north end of the Animas Mountains. These thrusts dip to the southwest and the lowest fault has brought Mississippian through Permian strata over Cretaceous sandstone. The middle thrust plate contains Precambrian through Devonian rocks that rest on Mississippian to Permian strata below. The uppermost thrust has brought Cretaceous strata over lower Paleozoic beds. Zeller (1958b) did not indicate the direction of yielding along these faults. We interpret northeast movement on these thrusts.

(14) In the east-central Animas Mountains Zeller and Alper (1965) mapped closely compressed, northwest-trending folds in the Lower Cretaceous U-Bar Formation.

(15) Sam Thompson III *(in* Zeller, 1965, p. 116) reported that in the Humble No. 1 N.M. State "BA" test well Ordovician El Paso strata were thrust onto Mississippian rocks at a depth of 14,120 feet. Thompson also indicated a reverse fault that repeated part of the Permian Epitaph Formation.

(16) In the central Animas Valley two small outcrops of upper Paleozoic strata show northwest-trending fold axes with overturning toward the northeast.

(17) In the central Peloncillo Mountains the broad, northwest-trending Peloncillo arch and the faults that cut the arch appear to be younger than the Laramide. Gillerman (1958) suggested that the northwest-trending faults

are characterized by strike-slip movement. He also inferred that the northwest-trending folds that are slightly diagonal to the faults resulted from secondary compression associated with strike-slip movement on the faults. Thus, the central Peloncillo Mountains appear to lie north of the Cordilleran foldbelt.

Northeast-yielding thrusts are also reported along tectonic strike to the west in the Chiricahua and Dos Cabezas Mountains of eastern Arizona (Sabins, 1957) .

SUMMARY AND CONCLUSIONS

The thrust faults observed in the Florida Mountains indicate a salient of the Cordilleran foldbelt that extends northward toward the foreland. Yielding along the margin of the foldbelt is northward toward the foreland.

In view of the regional distribution of thrusts and folds it is likely that thrusts will be encountered throughout the foldbelt even though considerable parts of the section at any one locality may have escaped deformation. Extensive rocks unconformably covering the older rocks mask much of the structure so that only some of the tectonic framework can be seen from surface exposures. Basin-Range deformation is younger than the Laramide and therefore Laramide structures should be expected in the prcorogenic rocks that occur at depth in the basins between the present day ranges.

By analogy with other foldbelt areas it seems that anomalous minor structures may be superimposed on the foldbelt. These structures might include folds, thrusts, or gravity-slide plates derived from intrusive doming or from block uplift during Basin-Range deformation.

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