Florida Mountains section of southwest New Mexico overthrust belt--A re-evaluation

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Introduction

The Florida Mountains, 10 mi southeast of Deming in Luna County, New Mexico, are an elongate north-trending range, 10 by 5 mi in dimensions (fig. 1). High-relief terrain, combined with arid vegetation, provides excellent geologic exposures of complex structural relations.

Previous study in the Florida Mountains includes: 1) geologic mapping by Darton (1917) and Corbitt (1971, 1974); 2) stratigraphic studies by Kelley and Bogart (1952), Bogart (1953), Kottlowski (1958), Lochman–Balk (1958, 1974), Woodward (1970), Brookins (1974a, 1974b, 1980a, 1980b), Brookins and Corbitt (1974), LeMone (1974), Loring and Armstrong (1980), Clemons (1982a, 1982b), and Lemley (1982); and 3) economic considerations were studied by Lindgren and others (1910), Kottlowski (1957), Griswold (1961, 1974), McAnulty (1978), and Brookins and others (1978).

A comprehensive geologic and mineral-resource investigation of the Florida Mountains is near completion (Clemons, 1982a, 1982b, in press; Clemons and Brown, in press). A more detailed study of the Mahoney mine–Gym Peak area of the Florida Mountains was completed as a master of science thesis study at New Mexico State University, Las Cruces, by Brown (1982). This paper summarizes the thesis and emphasizes evidence from the Mahoney mine–Gym Peak area. The reader is referred to Brown (1982) and Clemons and Brown (in press) for more detailed accounts of relations presented.

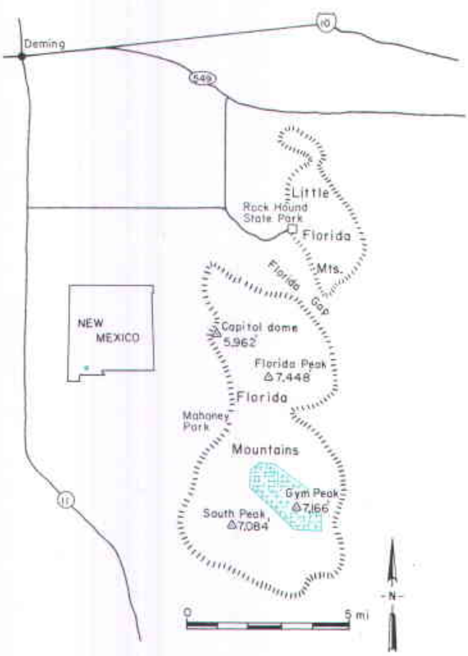

FIGURE 1—Index map of study area southeast of Deming.

Stratigraphy and regional geology

The stratigraphy of the Florida Mountains, summarized in fig. 2, includes: 1) Precambrian alkali-feldspar granite to alkali-feldspar syenite basement; 2) Paleozoic carbonate and subordinate clastic rocks that range in age from Late Cambrian to Early Permian with all systems but Pennsylvanian represented; 3) Upper Cretaceous-lower Tertiary Lobo Formation (which has been interpreted by Lemley [1982] as a syntectonic clastic wedge related to Laramide deformation); 4) Tertiary diorite/andesite intrusives; and 5) Quaternary colluvial and alluvial deposits.

System	Stratigraphic units	Thick. (ft)	Description
Quaternary	colluvial and alluvial deposits	0–200	Present day arroyo deposits. Silt, sand, gravel; locally carbonate cemented, fan and bajada deposits.
	angular unconformity		
Tertiary	diorite/andesite	—	Intrusive dikes and small plugs.
	angular unconformity		
Lower Tertiary Upper Cretaceous	Lobo Formation	500	Conglomerate; reddish, cobble to boulder; minor sandstone.
	angular unconformity		
Permian	Hueco Limestone	410	Limestone; dark gray, medium to massive bedded, fossiliferous.
	disconformity		
Mississippian	Rancheria Formation	220	Limestone, chert, shale; bedded chert well developed at top.
	disconformity		
Devonian	Percha Shale	250	Shale; olive gray. One-ft limestone bed at base.
	disconformity		
Silurian	Fusselman Dolomite	1,480	Dolomite; six alternating dark and light units, thin to thick bedded. Bedded chert at top. Silicified corals.
	disconformity		
Ordovician	Montoya Formation: Cutter Member	180	Limestone/dolomite; limy and fossil-rich at base, dolomite increases upward, chert lenses near top.
	Montoya Formation: Aleman Member	150	Dolomite/limestone/chert; buff gray carbonate with abundant nodular and bedded chert. Fossiliferous.
	disconformity		
	Montoya Formation: Upham Member	60	Dolomite; dark gray, massive. Five-ft Cable Canyon sandy zone at base.
	disconformity		
	El Paso Formation: upper	190	Limestone and chert; medium to dark gray. Similar to middle unit but with abundant chert. Fossiliferous.
	El Paso Formation: middle	900	Limestone; light to medium gray, thin to medium bedded, many textural variations, very fossiliferous.
	El Paso Formation: lower	160	Dolomite; dark gray, thin to medium bedded, coarse crystalline, silty at base, abundant oncolites.
Cambrian	Bliss Sandstone	110	Arkosic to quartzose sandstone. Grades upward to calcareous sandstone and silty limestone/dolomite.
	nonconformity		
Precambrian	syenite, granite diorite	—	Alkali-feldspar syenite and granite; interlayered diorite south of reverse fault.

FIGURE 2—Stratigraphic summary of southern Florida Mountains.

Throughout the Paleozoic the Florida Mountains area was located south of the transcontinental arch (Turner, 1962), and shallow-shelf marine deposition prevailed. At least four epeirogenic upwarpings resulted in stratigraphic breaks (Middle Ordovician, Early Silurian, Late Silurian–Devonian, and Early Pennsylvanian(?)–Early Permian) evidenced by unconformities and gaps in the fossil record. Kottlowski (1958) explained the absence of Pennsylvanian strata in the Florida Mountains as a result of a Pennsylvanian "Florida Island" which bordered the Orogrande and Pedregosa Basins to the east and west, respectively. Turner (1962), expanding this concept, described the Deming axis (trending from southeast Arizona to trans-Pecos, Texas) as a series of positive elements produced by epeirogenic upwarping events active from Mississippian through Tertiary time. Elston (1958) suggested that the Florida Mountains were a southeast extension of the Burro uplift in Early Cretaceous time. The west-northwest trending Texas lineament, which encompasses the Florida Mountains, was proposed by Moody and Hill (1956) as a regional wrench fault system, but this concept has failed to gain acceptance by later workers (Turner, 1962; King, 1969; Thompson and Potter, 1981). Corbitt and Woodward (1970, 1973) and Corbitt (1974) interpreted thrust faulting in the Florida Mountains as a salient of the Cordilleran fold belt of western North America that marks the northern erosional limit of thrusting associated with Laramide deformation of the Mexican Cordilleran geosyncline to the south. Drewes (1978) extended the Cordilleran orogenic belt from Nevada through southern Arizona and southwest New Mexico to Chihuahua, Mexico. Woodward and DuChene (1981) compared southern New Mexico to the overthrust belt in Wyoming–Utah. The present mountain range is a northeast-tilted (25 degrees) uplift formed by extensional tectonism of the Basin and Range–Rio Grande rift systems. This tilting must be removed to evaluate original attitudes of older Laramide structures.

Structural features

Structural relations in the Florida Mountains suggest complex Laramide compressional deformation characterized by: 1) high-angle reverse faulting, 2) localized low-angle thrusting, 3) localized fold developments, 4) localized extensive tectonic brecciation, and 5) examples of stratigraphic elimination along thrust faults. Evidence for pre-Laramide deformation is generally absent but may be obscured by later Laramide structures. A possible exception is a southeast-tilted homocline beneath Gym Peak that strikes into and is crosscut by the south Florida Mountains reverse fault (to be discussed). This tilting may have occurred earlier in the Mesozoic associated with the Burro uplift-Deming axis system of epeirogenic upwarpings.

The low-angle faults of the Mahoney mine–Gym Peak area are controversial in that most have younger over older stratigraphic displacements but also are noted to locally carry older strata over younger in the more traditional fashion of thrust faulting. The thrusted recumbent fold in the steep northern cliffs of Gym Peak is an example of older rocks displaced over younger rocks (fig. 3). Considerable evidence was presented by Brown (1982) to document these low angle faults as thrust faults which are best explained by the effects of two deformation-controlling factors: 1) thrusting over homoclinally tilted strata resulted in younger downdip rocks being displaced over older, updip rocks; and 2) relief variations in the Precambrian basement, due to faulting, contributed to complex thrust relations. Additionally, extreme cases of tectonic elimination (in excess of 1,370 ft in one locale) resulted from thrusting and contributed to apparent hanging-wall-down relations.

The most prominent structural feature in the Florida Mountains is the south Florida Mountains reverse fault that displaces Precambrian igneous rock against various Paleozoic formations (fig. 3). After removal of basin-and-range tilting, the average original fault attitude strikes N. 50° W. and dips 85° southwest. The thickness of the Paleozoic section (4,100 ft) represents a minimum stratigraphic separation on the fault. Movement on the south Florida Mountains reverse fault is interpreted to have generated three levels of imbricate thrusting within the Paleozoic rocks; the Victorio, Gym Peak, and Mahoney thrusts are named for the lower, middle, and upper levels, respectively.

The Victorio thrust sheet is an intensely deformed, locally brecciated, complex sheet which displaced younger Paleozoic rocks over older autochthonous Paleozoic rocks and Precambrian basement along a highly variable fault surface (relief on fault surface primarily due to normal fault displacements in rocks below). Tectonic elimination is pervasive along the thrust surface with strata ranging from middle El Paso (Ordovician) beds to Fusselman Dolomite (Silurian) resting on Precambrian syenite basement as well as similar eliminations between the autochthonous and allochthonous Paleozoic rocks. The present location of this thrust sheet, north ☞

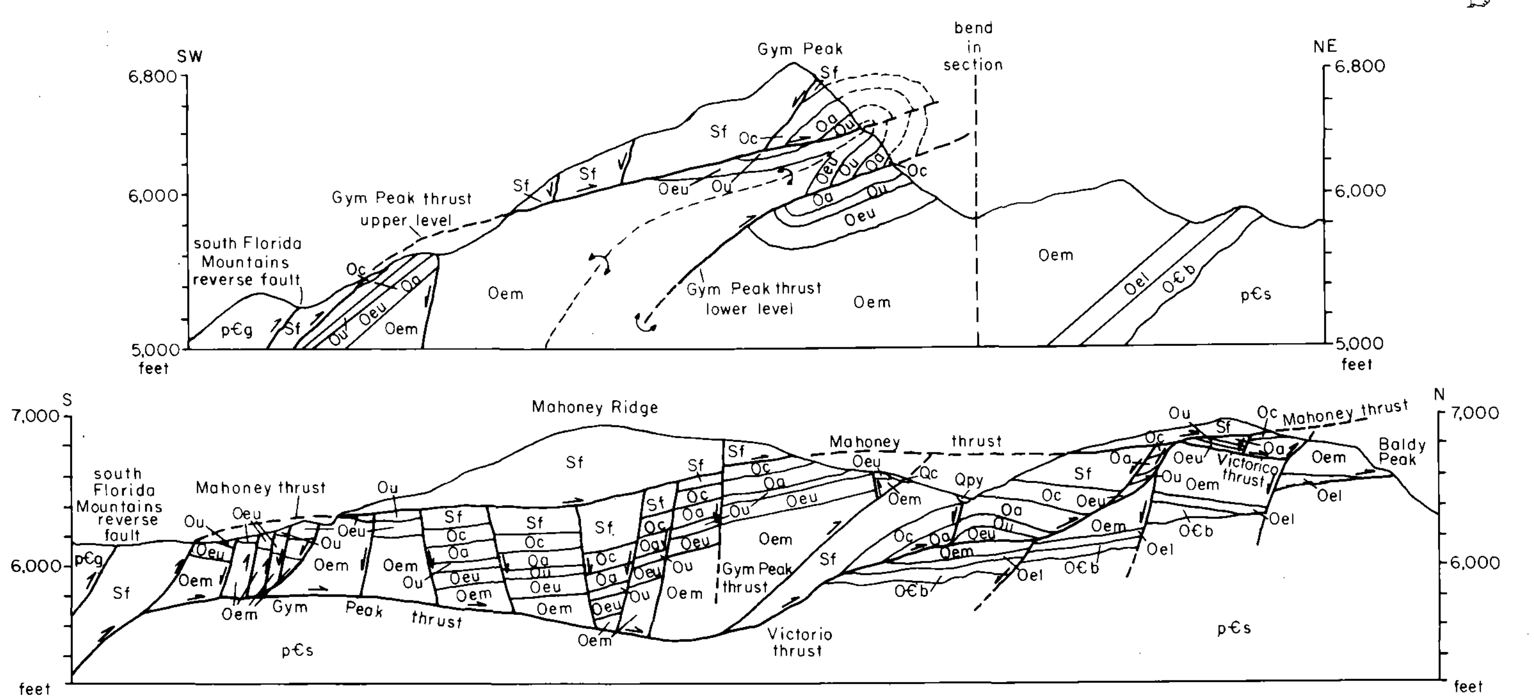

FIGURE 3—TRUE-SCALE CROSS SECTIONS THROUGH GYM PEAK AND MAHONEY RIDGE. **p€g,** Precambrian granite; **p€s,** Precambrian syenites; **O€b,** Bliss Sandstone; **Oel,** lower El Paso Formation; **Oem,** middle El Paso; **Oeu,** upper El Paso; **Ou,** Upham member of Montoya Formation; **Oa,** Aleman member of Montoya; **Oc,** Cutter member of Montoya; **Sf,** Fusselman Dolomite; **Qc,** undifferentiated colluvium, **Qpy,** younger piedmont-slope arroyo alluvium.

of and below the Gym Peak thrust, suggests that rocks of this sheet may have had their source in the present location of the Gym Peak thrust and were simply pushed northeast to make room for the incoming Gym Peak thrust.

The Gym Peak thrust in general displaced younger over older strata except in the northern cliffs of Gym Peak where a large recumbent drag fold developed with upper and lower limbs thrusted; the Montoya Formation members here are clearly repeated three times with the middle section overturned (fig. 3). The fold attitude and closure is consistent with generation by a northeast-yielding Gym Peak thrust with an estimated 2,000 ft of horizontal displacement. Within the Gym Peak thrust are a number of normal faults which trend northeasterly and are truncated at the top by the Mahoney thrust and at the base by the Gym Peak thrust. These faults are interpreted as syntectonic with Laramide compression forming parallel to the maximum principal stress and the result of tensional stresses localized in the allochthonous sheet because of extreme relief changes from faulting in the autochthonous rocks below. This relationship is analogous to extension across the crests of domes or folds.

The Mahoney thrust is the highest level of thrusting and displaced younger over older strata. The thrust typically truncates underlying structures suggesting that latest movement postdated movement of the lower thrust levels. This situation is analogous to an experimental study by Sanford (1959) which showed that vertical uplift caused successive imbricate thrust slices to develop with higher levels having the most recent movements.

Regional interpretation

The proposed involvement of the Florida Mountains in regional Cordilleran overthrusting is not supported by field evidence presented in this study. A basement-cored block uplift model, characteristic of Rocky Mountain foreland provinces (Osterwald, 1961; Berg, 1962; Prucha and others, 1965; Woodward, 1969), best explains observed field relations. The classic cases of large-scale overthrusting (King, 1969; Osterwald, 1961) involve thin-skinned (does not involve crystalline basement) deformation of extremely thick (25,000 to 50,000 ft) miogeosynclinal sequences. In contrast, basement-cored uplifts involve crystalline basement and typically, a rather thin, cratonic sedimentary sequence. The latter case certainly seems appropriate in the Florida Mountains where Precambrian basement is obviously involved and stratigraphic sequences are thin (Paleozoic measured section is 4,108 ft). An overthrust model requires large-scale horizontal movements versus the dominantly vertical movements of the block-uplift model. The dominant structure feature in the Florida Mountains is the south Florida Mountains reverse fault, and we conclude in this study that horizontal movements on the genetically related thrusts are proportionately smaller than the vertical displacement of the reverse fault; certainly the horizontal movements are much less than the common range of 2–3 mi for foreland block uplifts (Woodward, 1969). Prucha and others (1965) note that thrust faults formed during overthrusting should be geometrically concave upward, and faults produced by vertical basement uplift should be concave downward. In general, the latter configuration is true in the Florida Mountains (figs. 3, 4) except where relief on the autochthonous basement causes local fluctuations. Woodward (1969) noted that foreland block uplift areas typically have shown a long history of structurally positive tendencies evidenced by thinning of units and unconformities over positive areas. This seems true in the case of the Florida Mountains where epeirogenic upwarpings have been documented dating back to early Paleozoic (Elston, 1958; Kottlowski, 1958; Turner, 1962). Regional overthrusting should produce telescoping of facies and stratigraphic anomalies yet to be reported in the literature for southwest New Mexico. In fact, isopach contours by Kottlowski (1963) pass indiscriminately into the proposed Cordilleran overthrusted region.

The south Florida Mountains fault may have a significant strike-slip component. Juxtaposition of Precambrian granite in the hanging wall south of the fault and Precambrian syenite north of the fault is difficult to explain by simple uplifting of the granite. Attitudes of Paleozoic strata south of Gym Peak and in Mahoney Park indicate possible drag folding associated with right lateral movement along the south Florida Mountains fault (W. R. Seager, personal communication, 1982). This fault was near vertical before basin-and-range tilting and considerable tectonic brecciation occurred along the fault (typical of strikeslip faults).

In conclusion, Laramide deformation in the Florida Mountains closely resembles the basement-cored block uplifts of the Rocky Mountain foreland. Similar deformation is documented elsewhere in southern New Mexico (Seager, 1981). We stress that the scope of this study is limited to the Florida Mountains and no attempt is made to evaluate the proposed Cordilleran overthrust belt elsewhere. However, we suggest that in light of the present study other parts of southwest New Mexico and perhaps southeast Arizona may need to be objectively reexamined.

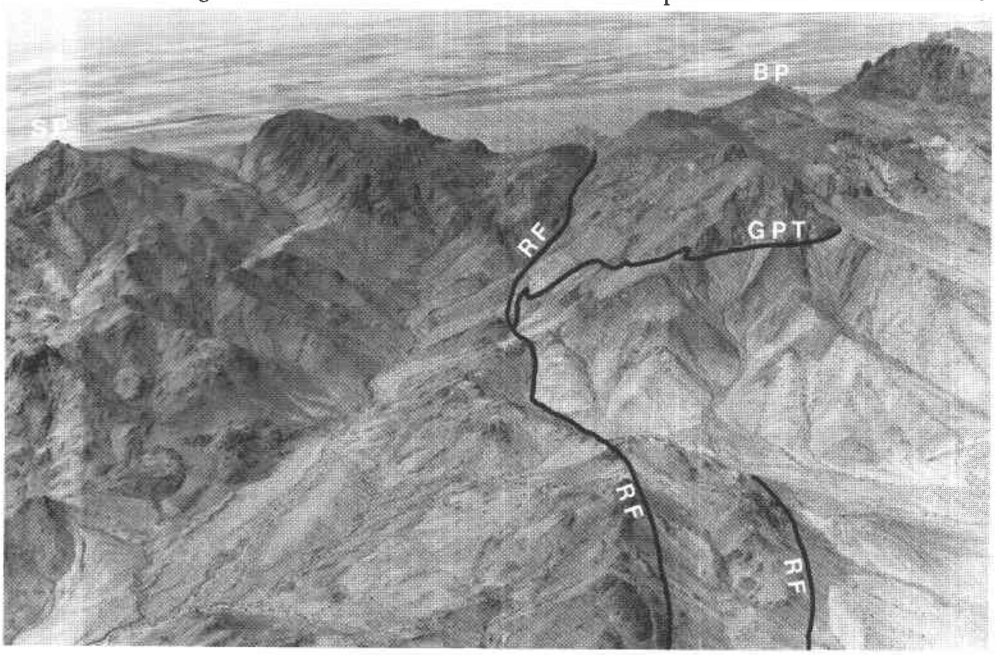

FIGURE 4—AERIAL VIEW (LOOKING NORTHWEST) OF SOUTH FLORIDA MOUNTAINS REVERSE FAULT **(RF)**. Gym Peak in upper right part of photo where southwest-dipping Gym Peak thrust **(GPT)** is well exposed displaying concave-downward geometry. **BP,** Baldy Peak; **SP,** South Peak.

ACKNOWLEDGMENTS—We thank Frank Kottlowski, Director of the New Mexico Bureau of Mines and Mineral Resources, who arranged Bureau-funded field expenses for the study as well as offered encouragement to summarize our work for this publication. Robin Brewster aided in the preliminary summary draft. Thanks also go to Greg Mack for suggesting the block-uplift model and William Seager for invaluable discussions on structural relations. Additional funding and support was provided by Phillips Petroleum Company, New Mexico Geological Society, Dowell Division of Dow Chemical, and Gene Cook of Deming, New Mexico.

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Correction noted

NOTE: In the article "An historical vignette: Stephenson–Bennett mine" by Robert W. Eveleth in the February 1983 issue of *New Mexico Geology*, v. 5, no. 1, p. 9–13, 15, the superscript [3] in table 1 (p. 13) should appear only with the last two dollar values before the total.

4th Annual Minerals Symposium

CALL FOR PAPERS

The 4th annual New Mexico Mineral Symposium, sponsored by the New Mexico Bureau of Mines and Mineral Resources, the New Mexico Tech Mineralogical Society, the Albuquerque Gem and Mineral Club, and the New Mexico Museum of Natural History, will be held November 12 and 13, 1983, at the New Mexico Institute of Mining and Technology in Socorro, New Mexico. Two days of presented talks and a silent auction are planned. Participants may also take self-guided, informal field trips in the area.

General registration is $10.00; registration for students and senior citizens (over age 60) is $5.00. In addition, papers on mineral occurrences of New Mexico are solicited for presentation in 20 or 30 minute time blocks. Abstracts are due by August 15, 1983, and length of time (20 or 30 minutes) for talk should be indicated. Complete papers should be submitted within 6 months after presentation for publication in a symposium volume. To submit abstracts or for further information, contact Robert M. North, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801, (505) 835–5246.

New Mexico Geological Society Fall Field Conference

The 34th annual field conference of the New Mexico Geological Society will be held in the Socorro area October 13, 14, and 15, 1983. The field trip will be by 4-wheel-drive vehicles and will visit some spectacular canyon and mesa country that few people have seen. The first day will emphasize low-angle detachment faulting (Laramide and/or late Cenozoic) and Late Paleozoic and Cretaceous stratigraphy along the east side of the Socorro Valley. The evening banquet will feature Dr. Warren Hamilton of the U.S. Geological Survey speaking on "Mode of Extension of Continental Crust." The second day's route will cross the Lemitar Mountains, where severe extension (100% +), domino-style faulting, strong rotation (50–70 degrees) of both bedding and early rift faults, and the Oligocene volcanic section will be the focus. The itinerary will also include extensive travertine deposits along the Rio Salado, lacustrine delta deposits in the Eocene Baca Formation near Riley, and the Jeter detachment(?) fault along the east flank of the Ladron Mountains. An evening barbeque will be held in San Lorenzo Canyon where erosion has sculpted a scenic badlands from early rift fanglomerates and sandstones of the Popotosa Formation. The third day will focus on the Oligocene Socorro caldera with stops at the moat deposits, cauldron-facies tuff and intercalated breccias, resurgent dome, and very young manganese mineralization of the Luis Lopez district.

Total distance traveled during the 3-day conference will be only 150 miles, an NMGS record for least miles driven. Emphasis throughout the conference will be on "hands on" geology with walking traverses of stratigraphic sections and detailed examination of structural features. Well-illustrated road logs and more than 50 papers, maps, and stratigraphic charts will be published in a hardbound guidebook for the conference. The guidebook will contain significant new data on a wide variety of subjects including several papers bearing on exploration for minerals and energy fuels. An announcement and registration form will be mailed in August. The Registration Chairman, Dr. Richard M. Chamberlin, can be reached at the New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801 (505 835–5310).

Low-angle faults near Mesa del Yeso that separate steeply dipping Glorieta Sandstone (Pg) and San Andres Limestone (Ps) from nearly flat-lying beds of the Cañas Member of the Yeso Formation (Pye). Another low-angle fault (covered) juxtaposes the Cañas Member above Cretaceous beds that are exposed in an arroyo behind the hill. Stop 1, day 1, of field conference.