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STRUCTURAL DATA FROM THE JOYITA UPLIFT: IMPLICATIONS FOR ANCESTRAL ROCKY MOUNTAIN DEFORMATION WITHIN CENTRAL AND SOUTHERN NEW MEXICO

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Abstract—Structural analysis of the modern-day Joyita Hills defines two brittle-fault trends that were active during ancestral Rocky Mountain (late Paleozoic) deformation. North-striking, west-dipping normal faults and northwest-striking, southwest-dipping normal faults bound the late Paleozoic Joyita uplift to the west and south, respectively, and define the uplift as a north-trending structural high. Kinematic indicators define brittle-fault displacement as dominantly dip slip, with north-striking normal faults showing a significant component of left slip. The Proterozoic core of the Joyita Hills contains three preferred orientations of gneissic to mylonitic foliations, two of which are comparably oriented to the late Paleozoic brittle faults. Direct field observation shows that north-striking mylonites and foliations have been reactivated by the younger, north-striking brittle faults. Northwest-striking brittle faults are also thought to represent reactivation of northwest-striking foliations, although this correlation has not yet been verified. Drill-core data indicate that the San Mateo and Lucero basins were one continuous, north-trending basin. The modified basin connects with the Orogrande basin via a southeast-trending channel. Geometrical and kinematic analyses, when combined with basin trends and available paleocurrent data, suggest that a north-trending, divergent, left-lateral wrench zone was active within central and southern New Mexico during the late Paleozoic.

INTRODUCTION

Regional relationships of ancestral Rocky Mountain deformation, including the location, trend, relative timing and magnitude of individual uplifts and depositional basins, were summarized by Kluth (1986) and Kluth and Coney (1981). Within New Mexico, late Paleozoic tectonism resulted in a series of north- and northwest-trending uplifts and basins. Although the general trends and locations of these structures have been well defined upon the basis of stratigraphic studies (Kottlowski, 1960), specific folds and faults have seldom been recognized, and little is known about the structural style associated with basin and uplift development.

On the basis of stratigraphic relationships, several investigators (Read and Wood, 1947; Kottlowski, 1960; Kottlowski and Stewart, 1970; Baars, 1982; Siemers, 1983) have interpreted the modern Joyita Hills area (Fig. 1) as the location of a late Paleozoic, north-trending positive feature (the Joyita uplift). In addition, geologic mapping and biostratigraphic (fusulinid) analysis (Kottlowski and Stewart, 1970) documented an angular unconformity between Pennsylvanian and Permian strata and defined the Joyita uplift as an early Wolfcampian tectonic element (Fig. 2).

The purpose of this paper is to present new structural data from the Joyita Hills and interpret its relationship to the adjacent Lucero and San Mateo basins. Observations indicate that ancestral Rocky Mountain faults within the Joyita Hills are the result of reactivation of Proterozoic mylonite zones, and are comparable, in both orientation and sense of offset, to those identified as late Paleozoic faults in the Albuquerque Basin to the north (Baars, 1982) and the Sacramento Mountains to the southeast (Otte, 1959; Pray, 1961). These similarities indicate that each area was subjected to the same style of deformation during ancestral Rocky Mountain tectonism. Fault orientations and kinematic indicators, when combined with existing isopach maps (Kottlowski, 1960; Baars, 1982) and available paleocurrent data (Altares, 1990), define a north-trending, divergent, left-lateral wrench fault system extending from the Sierra Nacimiento area southward through the Joyita Hills as a result of late Paleozoic tectonism. Similar structural features in the Sacramento Mountains are related to the same stress system.

STRUCTURAL ANALYSIS

In addition to ancestral Rocky Mountain deformation, the Joyita Hills area has also been subjected to tectonism during the Laramide orogeny and Rio Grande rift extension. A fundamental aspect of these events appears to be reactivation of existing structures. As a result, faults associated with the younger Phanerozoic tectonic events (dominantly normal and strike-slip faults) have been superimposed on structures of Early Wolfcampian (Bursum Formation) and Pennsylvanian age, which makes recognition of ancestral Rocky Mountains structures difficult.

Fortunately, stratigraphic sequences that represent most of the known section within central New Mexico are well exposed within the Joyita Hills and adjacent areas to the east and south (El Valle de La Joya). Middle Permian (Leonardian and Guadalupian) and Mesozoic sedimentary strata postdate ancestral Rocky Mountain deformation, yet predate Laramide tectonism; Cenozoic volcanic units predate Rio Grande rift tectonic events. These exposures provide an opportunity to define and document Laramide and Rio Grande rift-fault orientations and structural styles, which in turn provide the means by which ancestral Rocky Mountain structures may be properly reoriented and evaluated. In addition, exposures of Proterozoic rocks within the core of the Joyita Hills provide the opportunity to evaluate the influence of existing basement structures on each of the younger tectonic events.

A brief note concerning the method of analysis is required before proceeding. Field observation of brittle structures, including joint, fault, fault striae and dike orientations, indicates that each structural feature maintains consistent angular relationships with respect to bedding. The brittle structures (which are preferentially aligned with respect to the applied stress field), therefore, were superimposed on bedding prior to any appreciable reorientation of strata that were horizontal at the beginning of a given deformational event. As such, in areas where rotation has occurred, proper analysis of brittle structures (and ultimately the orientation of the applied stress field) requires the restoration of strata to horizontal and a corresponding rotation of fracture patterns. In repeatedly deformed rocks, sequential rotations are required. Brittle structures are therefore treated as early-formed features within a given deformational event. This process resolves data that are initially a meaningless array of dispersed data and produces joint, striation, dike and fault patterns that define realistic orientations for principal stress axes according to Anderson's (1951) theories on near-surface brittle failure. In this paper, fault orientations associated with Laramide and Rio Grande rift deformation are presented in this manner. The combined effects of mid-Tertiary and Laramide rotation are removed in order to restore late Paleozoic and Proterozoic structures to their post-ancestral Rocky Mountain orientations.

Mid-Tertiary normal fault systems

Faults associated with the development of the Rio Grande rift define three distinct sets of conjugate normal faults (Fig. 3) in Proterozoic metamorphic rocks through Tertiary volcanic sequences. The two dom-

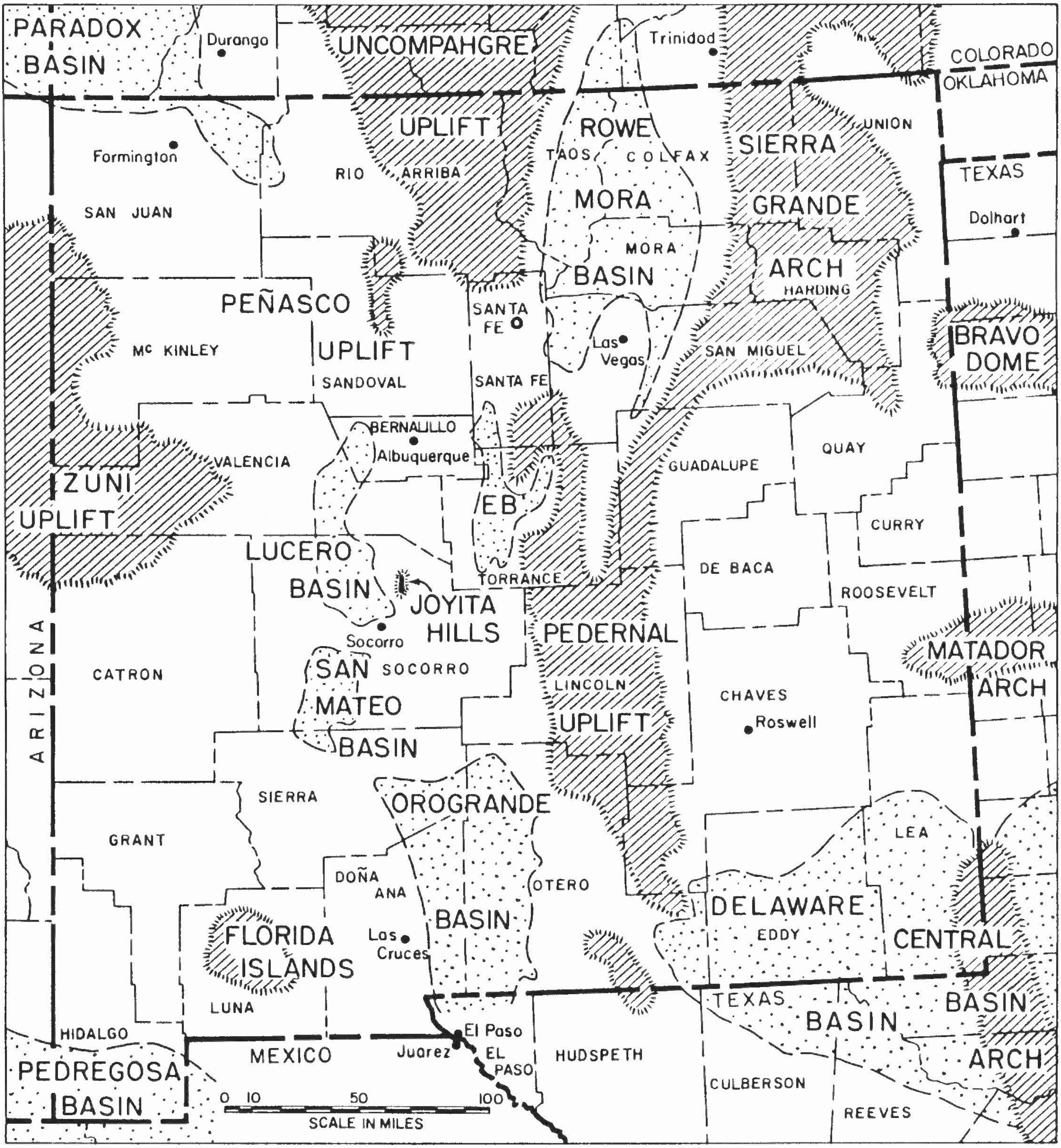


FIGURE 1. Pennsylvanian paleogeographic index map showing the location of major uplifts and depositional basins, and the location of the modern-day Joyita Hills (late Paleozoic Joyita uplift) in north-central Socorro County. From Kottlowski and Stewart (1970).

inant sets strike to the north-northeast and northwest, respectively. Associated slickenside striations define fault displacements as dip slip. A third conjugate fault pattern, numerically less significant than the other two, strikes east-northeast. Each conjugate set defines a distinct orientation of principal stress axes, in which σ_1 ($\sigma_1 > \sigma_2 \sim \sigma_3$) was vertical (Anderson, 1951), and σ_2 was parallel to fault strike. Tertiary volcanic units within the Joyita Hills strike to the north-northeast and dip 25°–30° to the west-northwest, indicating that the down-to-the-west rotation developed while the north-northeast-striking fault system was active. In that all three conjugate sets of normal faults are restored to realistic orientations by removing the effects of down-to-the-west rotation, each fault system must have been superimposed on bedding prior to rotation.

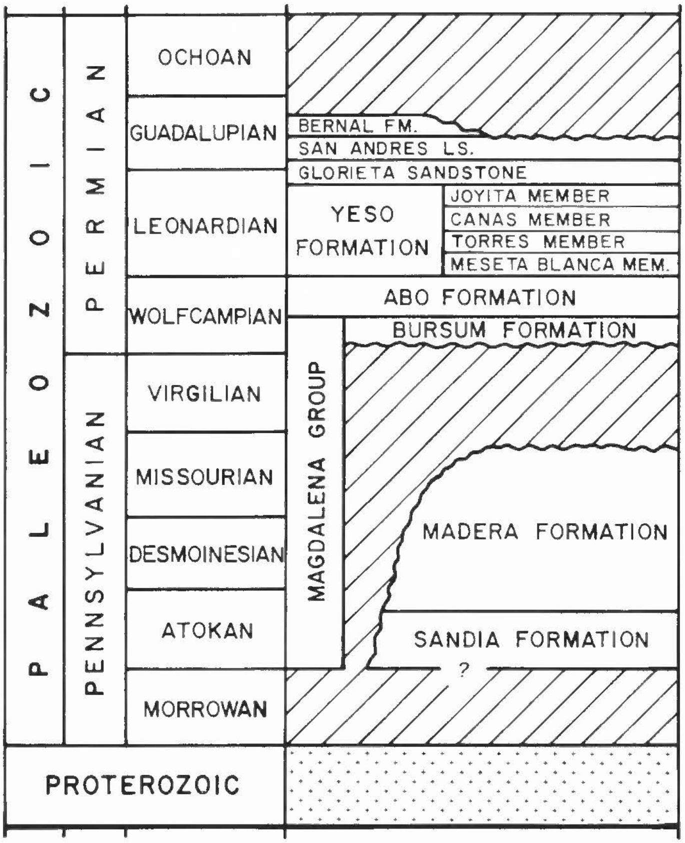


FIGURE 2. Generalized Paleozoic stratigraphic section within the Joyita Hills. Mesozoic and Cenozoic stratigraphic units (not shown) are also exposed within the Joyita Hills and within adjacent areas (El Valle de La Joya) to the east and south. Modified from Osburn and Lochman-Balk (1983).

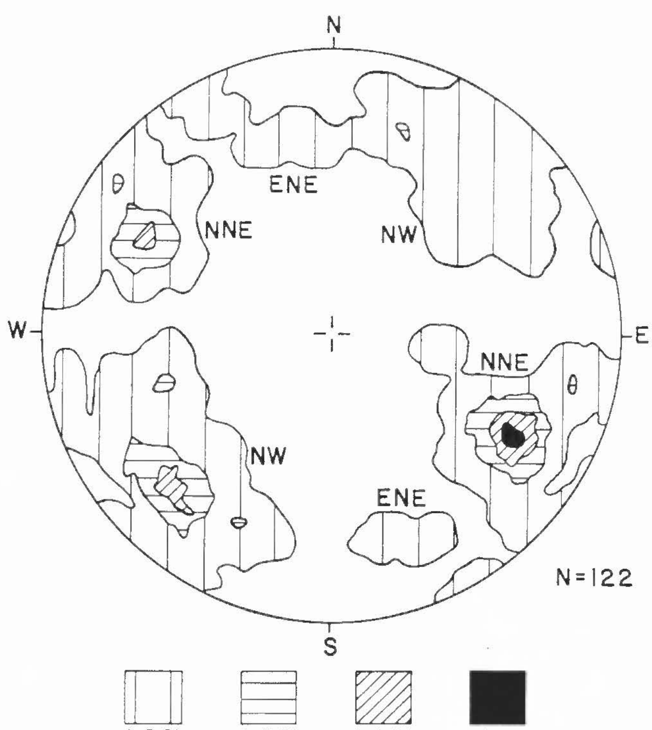


FIGURE 3. Mid-Tertiary normal-fault systems. Fault orientations define conjugate pairs striking to the north-northeast (NNE), northwest (NW) and east-northeast (ENE). Lower-hemisphere, equal-area projection of poles to fault planes. Contoured at 0, 4, 8 and 12% intervals per 1% area.

Therefore, the northwest-striking and east-northeast-striking normal fault systems must predate the north-northeast-striking normal fault system.

Laramide strike-slip fault systems

Near vertical strike-slip faults cut Proterozoic through Cretaceous rocks (Fig. 4) and are marked by nearly horizontal fault striae. These faults define two separate conjugate sets of strike-slip faults (σ_2 vertical). North-striking synthetic shears, interpreted as both synthetic (NNE) and secondary synthetic (NNW) shears, and east-northeast-striking antithetic shears developed in a north-trending, right-lateral wrench zone (Christie-Blick and Biddle, 1985, fig. 5a; Chapin, 1983). Brown (1987) documented right-lateral, strike-slip displacement along the northeast-striking Montosa fault zone, which lies 13 mi (21 km) to the east of the Joyita Hills. A conjugate set of right-lateral, northeast-striking (synthetic) shears and less well-defined northwest-striking (antithetic) shears within the Joyita Hills are thought to be related to movement along the Montosa fault zone.

Ancestral Rocky Mountain fault systems

Two sets of normal faults which offset early Wolfcampian (Bursum Formation) strata, Pennsylvanian strata and Proterozoic rocks (Fig. 5) are interpreted to be ancestral Rocky Mountain faults because: (1) they can neither be traced into, nor found within, middle to late Wolfcampian (Abo Formation) or younger strata; or (2) they display differences in fault character between Bursum and older rocks versus Abo and younger strata. The two fault sets consist of north-striking, west-dipping normal faults and northwest-striking, southwest-dipping normal faults, respectively. Both sets were reactivated during Tertiary rifting.

North-striking normal faults

A series of near vertical, north-striking faults has only been observed within Proterozoic, Pennsylvanian and early Wolfcampian rocks. These faults are all marked with fault striae that plunge 50°–60° south and

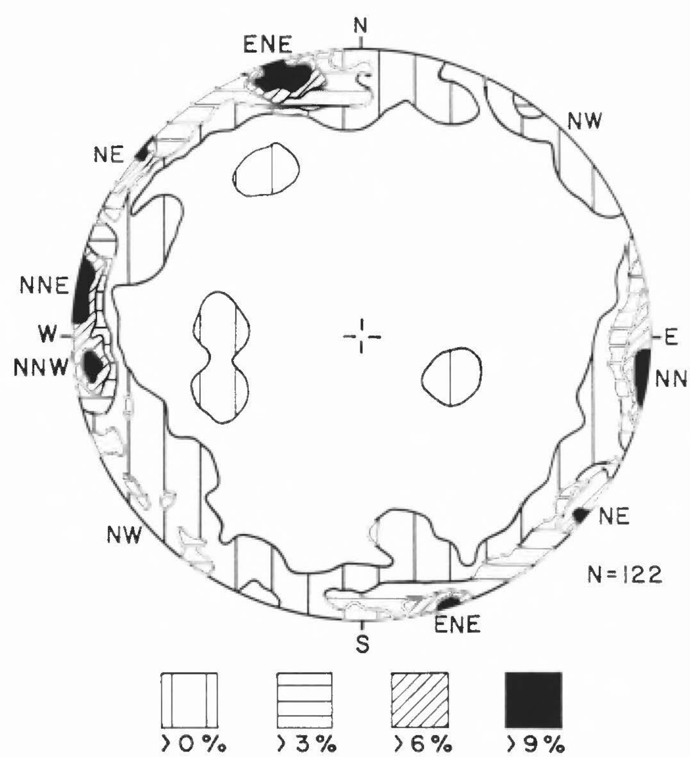


FIGURE 4. Laramide strike-slip fault systems. Near-vertical strike-slip faults striking to the north-northeast (NNE), north-northwest (NNW) and east-northeast (ENE) define a north-trending, right-lateral wrench fault system. Additional strike-slip faults strike northeast (NE) and northwest (NW). Lower-hemisphere, equal-area projection of poles to fault planes. Contoured at 0, 3, 6 and 9% intervals per 1% area.

FIGURE 5. Generalized geologic map of the Joyita Hills. Star denotes westernmost north-striking fault described in text and illustrated in Fig. 6. Other north-striking faults are designated with asterisk pattern along fault trace. Sandia and Madera Formations are successively truncated southward by the Bursum Formation. The Abo Formation (stipple pattern) truncates the Bursum Formation and is in depositional contact with Proterozoic rocks in the southern Joyita Hills. Modified from Kottlowski and Stewart (1970).

display both down-to-the-west and down-to-the-east displacements. The westernmost fault of this series can be traced from Proterozoic rocks into the overlying Sandia, Madera and Bursum Formations, but is overlain by unfaulted strata of the Abo Formation, and is therefore interpreted as an ancestral Rocky Mountain fault (Fig. 6). Down-to-the-west fault displacement juxtaposes middle Madera Formation limestones in the hanging wall against the Sandia Formation/Proterozoic contact in the footwall. Stratigraphic separation is approximately 300 ft (100 m). Associated folding deformed the Sandia, Madera and Bursum units into an anticlinal (footwall, east block) and synclinal (hanging wall, west block) fold pair. Erosionally thinned strata of the Madera Formation in the footwall are overlain by depositionally thinned Bursum/Abo Formation sequences, which thicken to both east and west. This westernmost fault, although complicated by younger, crosscutting faults and poor exposure along the Bursum/Abo Formation contact, is interpreted to be a buried ancestral Rocky Mountain fault that has not been reactivated.

Fault and striation orientations observed along the more eastward of the north-striking faults are the same as those observed along the westernmost fault. Therefore, each of the north-striking faults was active as a down-to-the-west fault during late Paleozoic tectonism. Yet the observed displacement on the more eastward of these faults is down-to-the-east. In one outcrop, south-plunging striations have been overprinted by dip-slip (near vertical) striations, indicating that these eastward faults have been reactivated by younger tectonism. The easternmost faults are found in proximity to the East Joyita fault, and the down-to-the-east displacement is the result of reactivation of this ancestral Rocky Mountain fault trend during Tertiary, down-to-the-east, dip-slip displacement along the East Joyita fault.

Rotation of regional bedding within Abo and younger strata to horizontal restores these near-vertical, north-striking faults to their post-ancestral Rocky Mountain orientation, which was north-striking and west-dipping at 65°–70°, with a normal sense of displacement (Fig. 7; Baars, 1982, figs. 3 and 4). The fold hinge then plunges 10°–15° north.

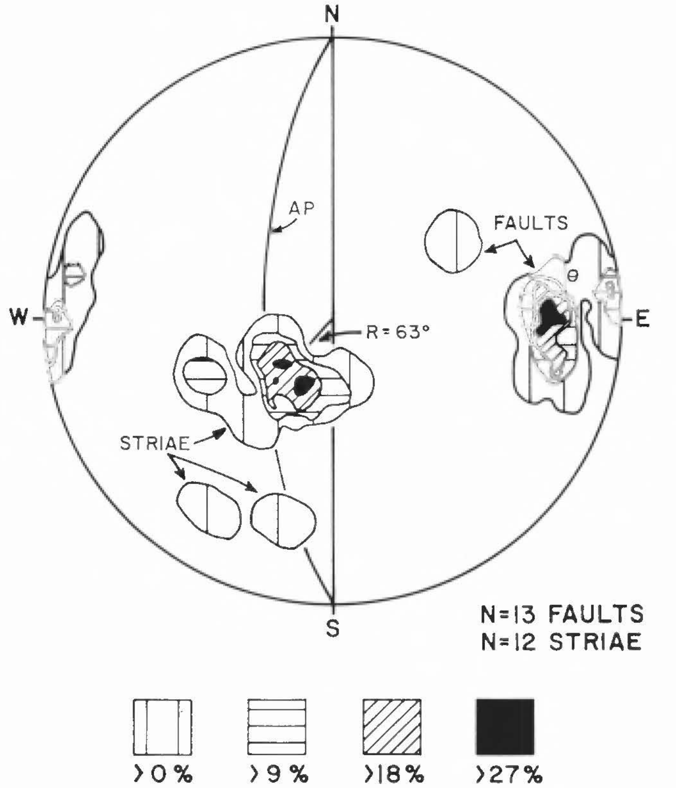


FIGURE 7. North-striking ancestral Rocky Mountain normal faults. Composite, lower-hemisphere, equal-area projection of poles to fault planes and fault striae. Contoured at 0, 9, 18 and 27% intervals per 1% area. AP defines average fault plane orientation; R defines approximate angle of rake of fault striae.

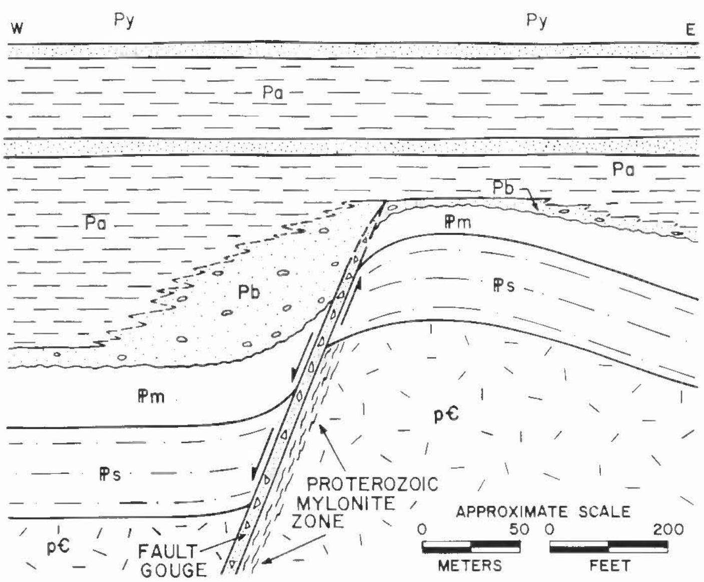


FIGURE 6. Generalized cross section along westernmost north-striking normal fault. Cross section has been restored to its post-ancestral Rocky Mountain orientation by removing 30° of down-to-the-west rotation about a N35°E, horizontal axis. Py = Yeso; Pa = Abo; Pb = Bursum; IPm = Madera; IPs = Sandia; pЄ = Proterozoic basement. Fault and contacts dashed where obscured.

South-plunging striations and mullion observed along these faults, when similarly rotated, rake 63° southward, and define fault displacement as normal, left-oblique slip.

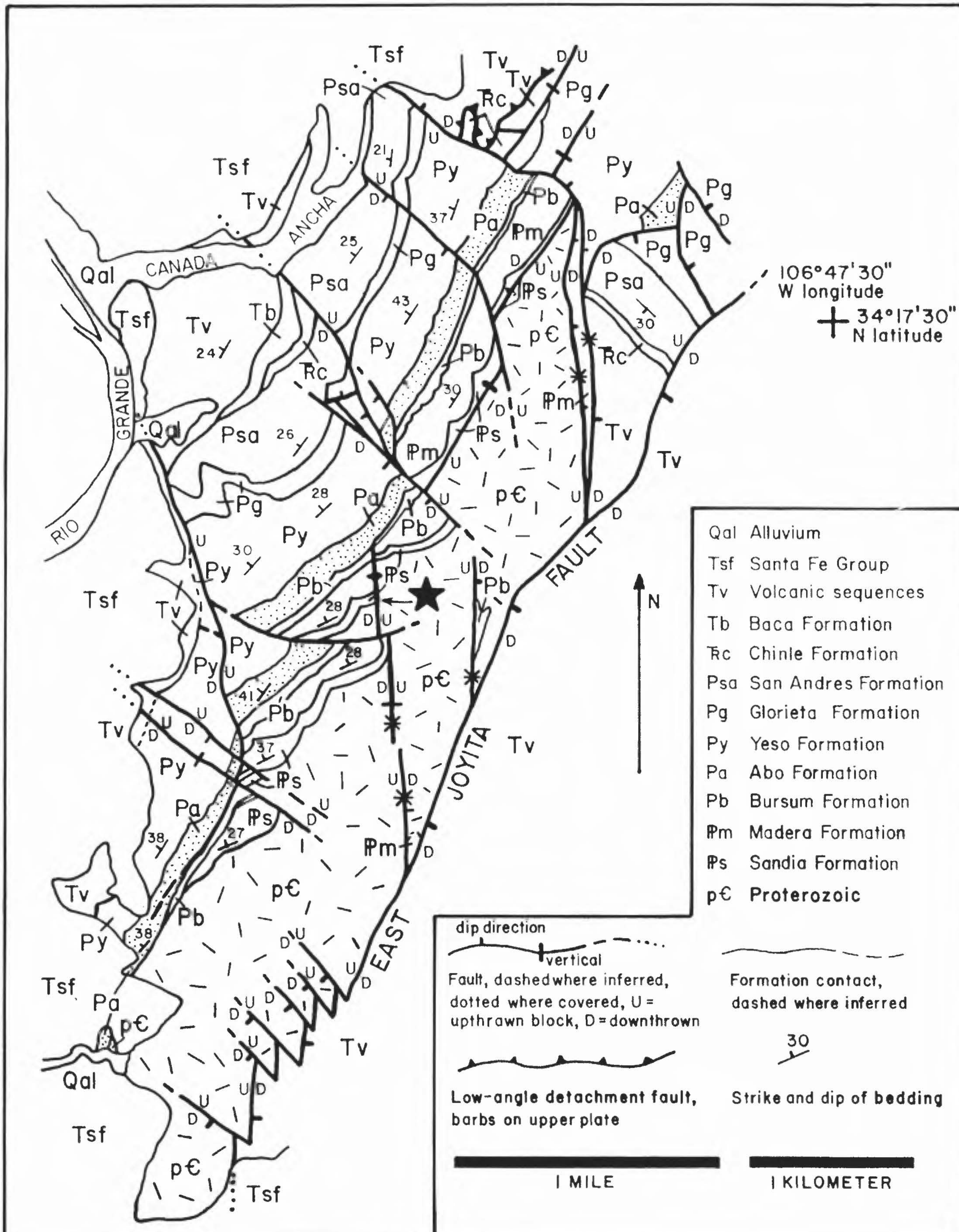
Northwest-striking normal faults

Field relationships indicate that northwest-striking normal faults were active during both Tertiary rifting and ancestral Rocky Mountain deformation. Where they cut Abo Formation and younger strata, northwest-striking normal faults occur along discrete fault planes with limited brecciation, and display conjugate dip directions to the southwest and northeast (Fig. 3). In contrast, northwest-striking normal faults cutting only Bursum and older rock sequences occur as 10-to-20-ft (3 to 7 m)-wide zones of highly brecciated rock, and dip consistently to the southwest.

Restored orientations of northwest-striking normal faults cutting only Bursum Formation and older rock sequences strike northwestward and dip steeply (75°–80°) to the southwest (Fig. 8). Striations on these faults, when comparably restored, indicate nearly pure dip-slip displacement.

Proterozoic mylonites and foliations

Proterozoic rocks within the core of the Joyita Hills are gneissic to mylonitic. Foliations (Fig. 9) define three distinct trends: east-northeast, north and northwest. Comparison of north- and northwest-striking foliations with ancestral Rocky Mountain brittle fault orientations (Figs.


106°47'30" W longitude
34°17'30" N latitude
RIO GRANDE
CANADA ANCHA
EAST JOYITA FAULT
N
Qal Alluvium
Tsf Santa Fe Group
Tv Volcanic sequences
Tb Baca Formation
Ꞧc Chinle Formation
Psa San Andres Formation
Pg Glorieta Formation
Py Yeso Formation
Pa Abo Formation
Pb Bursum Formation
ℙm Madera Formation
ℙs Sandia Formation
p€ Proterozoic
dip direction
vertical
Fault, dashed where inferred, dotted where covered, U = upthrown block, D = downthrown
Formation contact, dashed where inferred
Low-angle detachment fault, barbs on upper plate
30
Strike and dip of bedding
I MILE
I KILOMETER

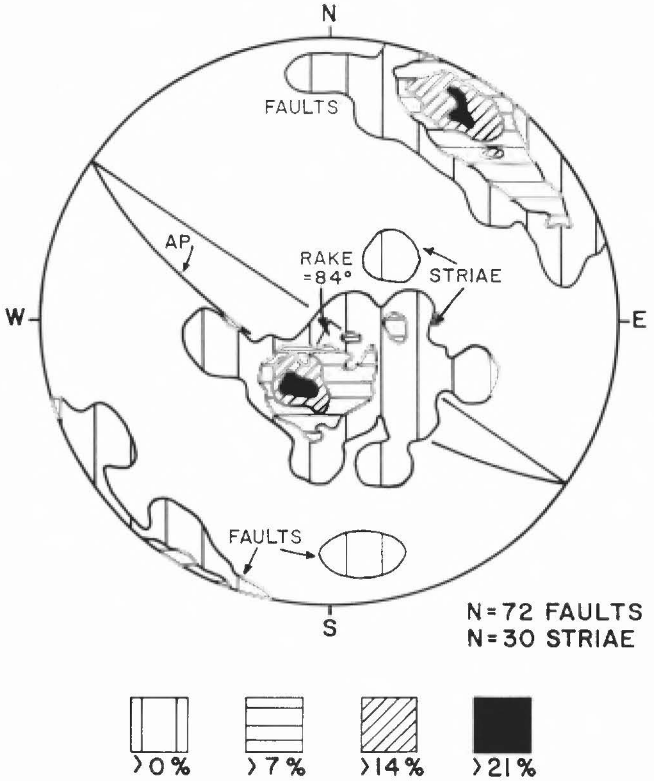


FIGURE 8. Northwest-striking ancestral Rocky Mountain normal faults. Composite, lower-hemisphere, equal-area projection of poles to fault planes and fault striae. Contoured at 0, 7, 14 and 21% intervals per 1% area. AP defines average fault plane orientation; R defines approximate angle of rake of fault striae.

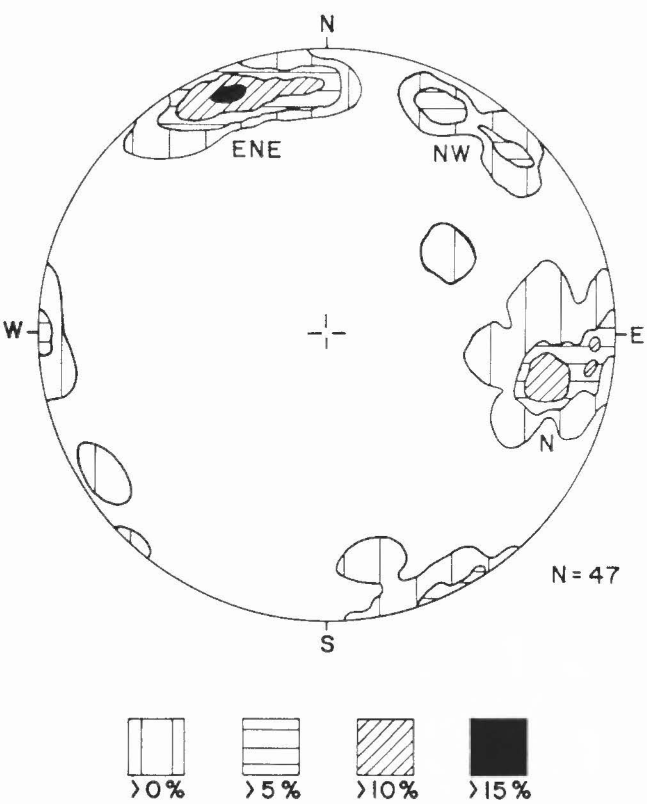


FIGURE 9. Preferred orientations of Proterozoic gneissic to mylonitic foliations define three common trends: north (N), northwest (NW) and east-northeast (ENE). Lower-hemisphere, equal-area projection of poles to foliations, contoured at 0, 5, 10 and 15% intervals per 1% area.

7 and 8) indicates that orientations are similar. Through direct field observation, the westernmost north-striking brittle fault that offsets only Proterozoic units, and Sandia, Madera and Bursum Formations is known to have overprinted and reactivated a north-striking mylonite zone. Northwest-striking brittle faults display comparable orientations to northwest-striking foliations; however, direct observation of reactivation has not yet been demonstrated in the field.

Comparison of gneissic and mylonitic foliations with Laramide (Fig. 4) and Rio Grande rift (Fig. 3) structures further illustrates the influence of Proterozoic foliations on the development of younger Phanerozoic structures. In short, the Phanerozoic structural evolution of the modern Joyita Hills was strongly influenced by basement control and the repeated reactivation of existing Proterozoic foliations and mylonite zones during each major Phanerozoic tectonic event.

Depositional basin trends

A mineral exploration hole on the west flank of the Magdalena Mountains, south of Kelly, cored 2009 ft (612 m) of Pennsylvanian strata (Krewedl, 1974; Chapin, unpublished core log). This indicates that the San Mateo and Lucero basins are one continuous, north-trending basin (Fig. 10) which bounds the Joyita uplift to the west. The Lucero portion of this basin is mislabeled as the Acoma sag by Baars (1982, fig. 2). Also, the thickness of the Pennsylvanian System in the Ladron Mountains used by Baars for the isopachs of figure 2 is much less than that reported by either Kottlowski (1960) or Siemers (1983). A prong extending southeastward from the San Mateo/Lucero basin bounds the Joyita uplift to the south and southwest. Isopach trends (Fig. 10; Kottlowski, 1960) between the modified San Mateo/Lucero basin and the Joyita uplift parallel the fault trends defined as ancestral Rocky Mountain normal faults and delineate the uplift margins.

When paleocurrent data from early Wolfcampian Bursum strata (Altares, 1990) are superimposed on the Pennsylvanian isopach map (Fig. 10), it appears that the southeast-trending prong of the San Mateo/

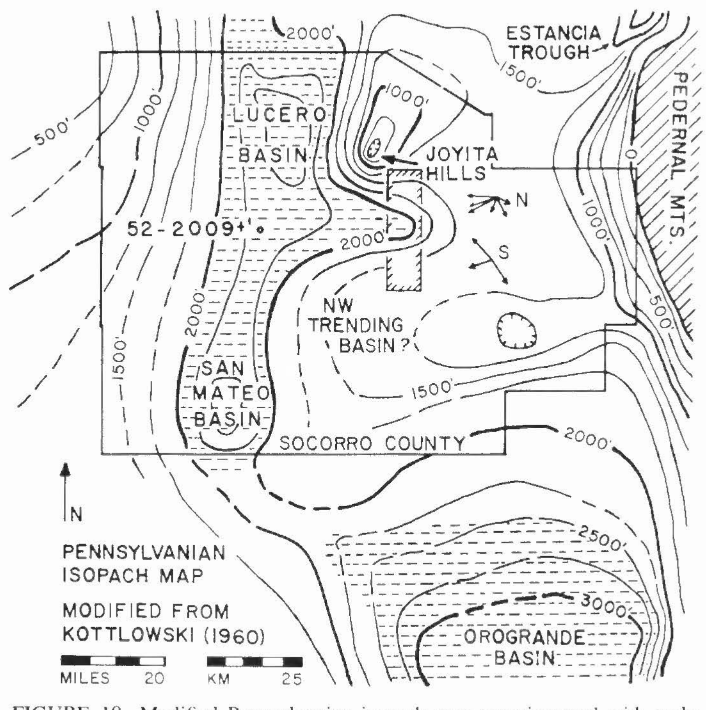


FIGURE 10. Modified Pennsylvanian isopach map superimposed with early Wolfcampian paleocurrent directions from Altares (1990). Hachured box outlines location of Altares (1990) field area. Paleocurrent directions (vector means) labeled N and S are from the north and south of Altares' field area; length of each vector is proportional to vector strength. Drill-core data (Chapin, unpublished core log; control point number 52, Kottlowski, 1960) documents stratigraphic thickness of Pennsylvanian rocks to be in excess of 2000 ft (610 m), and redefines the Lucero and San Mateo basins as one continuous, north-trending basin.

Lucero basin may have been more extensive than originally defined by Kottlowski (1960). Altares' (1990) field area spans the north-south dimension of the prong. Paleocurrent data north of the prong indicate paleoflow directions to the west, southwest and south; that is, basinward with respect to the prong. Paleocurrent data south of the prong, however, do not show north- and northeast-directed paleoflow directions as would be expected from isopach trends along the southern margin of the prong. Thus, the axis of the prong lay farther to the southwest. Isopachs between the San Mateo/Lucero basin and the Orogrande basin to the southeast are poorly defined, due to a paucity of control points. However, the combination of the southeast-trending prong of the San Mateo/Lucero basin, paleoflow directions to the west, southwest and south, and a southeast-trending trough between the southern end of the San Mateo/Lucero basin and the northern end of the Orogrande basin suggests that the two basins were connected by a (perhaps complex) southeast-trending channel during the late Paleozoic. Alternatively, the San Mateo/Lucero basin may be a fragment of another basin displaced northward by Laramide, right-lateral wrench faults (Chapin and Cather, 1981; Chapin, 1983).

DISCUSSION AND INTERPRETATION

Two normal fault systems have been identified as ancestral Rocky Mountain in age. Although each fault trend has been reactivated to some extent during subsequent tectonism, existing isopach maps confirm both fault trend and sense of displacement. Brittle kinematic indicators (striations and mullion structures) define fault displacements as dominantly dip slip, with north-striking faults showing a component of left slip. Furthermore, fault orientations are either known to represent (north-striking faults) or can be reasonably concluded to represent (northwest-striking faults) reactivation of Proterozoic shear zones. The fault orientations associated with the Joyita uplift, and basin trends within Socorro County, are comparable to structures identified as ancestral Rocky Mountain structures to both the north and south.

To the north, as originally proposed by Read and Wood (1947) and confirmed by Baars (1982), anomalously thin Pennsylvanian sequences define a north-trending, structurally positive element extending from the Nacimiento–San Pedro area (Peñasco uplift of Kottlowski and Stewart, 1970; Fig. 1) southward to the Joyita Hills. Fault orientations (Figs. 6 and 7) are comparable to those of Baars (1982, figs. 3 and 4) for the western margin of the uplift. The redefined San Mateo/Lucero basin (Fig. 10) borders the uplift on the west.

In the Sacramento Mountains to the south, faults with similar styles have been interpreted as late Paleozoic structures (Roswell Geological Society, 1956; Otte, 1959; Pray, 1961). Dip-slip displacement occurred along a series of north-striking, high-angle and vertical, normal faults (e.g., Fresnal, Arcente, Alamo and Bug Scuffle faults), some of which (Alamo and Bug Scuffle) show a scissors-like sense of displacement. The area between the eastern shelf sediments exposed in the Sacramento Mountains and the Orogrande basin has been interpreted by Pray (1961) to be a narrow, north-south transition zone. This transition zone was probably a west-dipping normal fault zone (Roswell Geological Society, 1956) comparable to west-dipping faults exposed within the Sacramento Mountains, and similar to basin boundaries in the San Mateo/Lucero basin to the north.

The anticlinal/synclinal folds exposed within the Sacramento Mountains (Pray, 1961) are commonly associated with the dominantly down-to-the-west normal faults, and are comparable in both style and orientation to the fold exposed within the Joyita Hills along the westernmost, north-striking normal fault (Fig. 6). If analogy can be made with structures in the Joyita Hills, then the north-striking normal faults within the Sacramento Mountains may represent reactivation of basement structures. The north-trending folds commonly associated with north-striking normal faults probably represent a flexure of sedimentary strata above older basement flaws as these faults propagated upsection and cut into overlying strata.

Baars (1982) documented several episodes of displacement along the Nacimiento fault during ancestral Rocky Mountain deformation, the youngest in post-Madera, pre-Abo time. Within the Joyita Hills, Kottlowski and Stewart (1970) defined the timing of major uplift as early Wolfcampian, and Pray (1961) concluded that ancestral Rocky Mountain deformation within the Sacramento Mountains was late Pennsylvanian to early Wolfcampian. Therefore, the timing of the latest, and perhaps the major, phase of uplift within the three areas was approximately synchronous.

It cannot be stated with certainty that the southern end of the modified San Mateo/Lucero basin and the northern end of the Orogrande basin were connected by a southeast-trending trough. However, northwest-trending isopachs, as originally drawn by Kottlowski (1960), and early Wolfcampian paleocurrent data (Altares, 1990), support this interpretation. As defined, basin locations and trends suggest that a continuous, and perhaps quite complex, depositional channel extended from the San Mateo/Lucero basin to the Orogrande basin during the late Paleozoic (Fig. 10).

In central New Mexico, ancestral Rocky Mountain tectonism resulted in basins and uplifts of dominantly north trend and subordinate northwest trend. The San Mateo/Lucero and Orogrande basins are aligned in a north-trending, left-stepping en-echelon pattern. The two basins were probably connected by a southeast-trending channel. Bounding structures are high-angle to vertical normal faults, with north-striking faults showing a component of left slip. Restored fault geometries and kinematic indicators, when combined with spatial relationships of basin location and trend, define an overall system compatible with subsidiary left-lateral displacement along a north-striking, dominantly normal fault zone extending through central and southern New Mexico (Fig. 11). The inferred wrench fault system must have been largely divergent in order to accommodate fault displacements that were dominantly dip slip. The inferred southeast-trending basin between the San Mateo/Lucero and Orogrande basins is envisaged as either a releasing bend or a rhomb-graben between two left-stepping, north-striking wrench faults (Ramsay and Huber, 1987, figs. 23.37 and 23.38; Sylvester, 1988, fig. 20). The latter alternative is presented in Fig. 11. Although

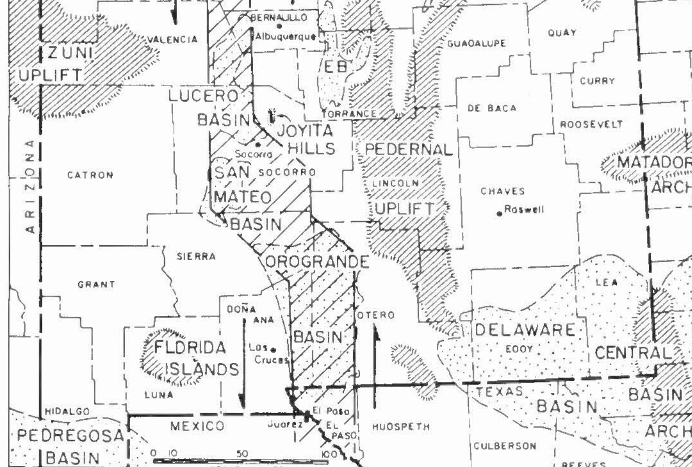


FIGURE 11. Hypothetical late Paleozoic, north-trending, left-lateral wrench zone within central and southern New Mexico. North-trending basins (San Mateo/Lucero basin and Orogrande basin) developed within principal zones of left-lateral shear. The inferred northwest-trending basin connecting the southern end of the San Mateo/Lucero basin and the northern end of the Orogrande basin is shown as a rhomb-graben between two left-stepping, left-lateral shear zones.

fault geometries and associated kinematics are compatible with this interpretation, the principal hindrance to demonstrating such a wrench zone is due to younger deformation. Laramide, right-lateral, north-trending wrench systems have been interpreted within New Mexico by Chapin and Cather (1981) and Chapin (1983), along the Nacimiento fault by Baltz (1967), and within the Joyita Hills (Fig. 4). Overprinting of strike-slip systems of comparable trend but opposite sense of displacement makes reconstruction difficult. However, it is important to note that restoration of approximately 60 mi (100 km) of Laramide right slip (Chapin and Cather, 1981; Chapin, 1983) would significantly diminish the northeast-southwest dimension of the rhomb-graben depicted in Fig. 11. Restoration would roughly align the southeast-trending prong at the southern end of the Lucero basin with the northwest-trending trough at the northwestern end of the Orogrande basin (Fig. 10).

CONCLUSIONS

This paper has presented new structural data from the Joyita uplift and drill-core data from the adjacent Lucero and San Mateo basins. The structural data define the Joyita uplift as a north-trending positive element, bound to the west and southwest by depositional basins. Drill-core data indicate that the San Mateo and Lucero basins are one continuous, north-trending basin. The basin probably extends southeastward into the Orogrande basin.

Although the area from which these data are obtained is relatively small with respect to the area to which they are applied, fault orientations and modified basin trends are compatible with interpretations of previous investigators in adjacent areas. The similar basin and uplift trends, fault orientations and sense of offset, and timing of deformation indicates that, during the ancestral Rocky Mountain orogeny, a large area of the crust in New Mexico experienced a comparable deformational history. The combination of basin and uplift geometries, brittle kinematic indicators and available paleocurrent data suggest a north-trending, divergent, left-lateral wrench system extended through central and southern New Mexico during the late Paleozoic.

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