Uplift, erosion, and burial of Laramide fault blocks, Salado Mountains, Sierra County, New Mexico

William R. Seager and Anton B. Mayer

New Mexico Geology, v. 10, n. 3 pp. 49-53, 60, Print ISSN: 0196-948X, Online ISSN: 2837-6420.
https://doi.org/10.58799/NMG-v10n3.49

This page is intentionally left blank to maintain order of facing pages.

New Mexico GEOLOGY
• Science and Service
Volume 10, No. 3, August 1988

Uplift, erosion, and burial of Laramide fault blocks, Salado Mountains, Sierra County, New Mexico

by *William R. Seager*, New Mexico State University, Las Cruces, NM 88003, and *Anton B. Mayer*, Leggette, Brashears, and Graham, Inc., 423 Sixth St., NW, Albuquerque, NM 87102

Introduction

In recent years Laramide deformation in south-central New Mexico has been compared to that of the central Rockies of Wyoming (Seager and Mack, 1986; Seager and others, 1986). The structural style in both areas is distinguished by basement-cored block uplifts separated by broad basins filled with synorogenic to post-orogenic sedimentary rocks. Thrust or reverse faults border uplift–basin margins, at least on one side, and these, as well as associated tight, overturned folds, indicate substantial crustal shortening.

In south-central New Mexico, uplifts and basins trend north–northwest to nearly east–west, highly oblique to the northerly trend of late Tertiary fault blocks of the Rio Grande rift. Thus, the Laramide uplifts are truncated and segmented by the younger faults so that fragments of the Laramide structures are often revealed in cross section in the modern ranges. Such fragments, exposed near the Rio Grande from the Caballo Mountains south to the East Potrillo Mountains, constrain the location, trend, and geometry of the Laramide Rio Grande uplift (Fig. 1) and its two complementary basins, the Love Ranch and Potrillo Basins (Seager and others, 1986).

Major boundary faults and folds of the Rio Grande uplift strike northwesterly toward the Black Range and toward its outlying foothills, the Animas and Salado Mountains (Fig. 1). Although the Rio Grande uplift is buried beneath the broad, deep, late Tertiary Palomas Basin, structures or unconformities that probably indicate an extension of the uplift appear at various places in the Black Range area. For example, near Lake Valley (Fig. 1) Laramide uplift was sufficient to cause erosion into lower Paleozoic rocks, and in the headwater region of North Percha Creek Laramide erosion exposed Precambrian granite. The most instructive outcrops, however, are in the Salado Mountains, located ☞

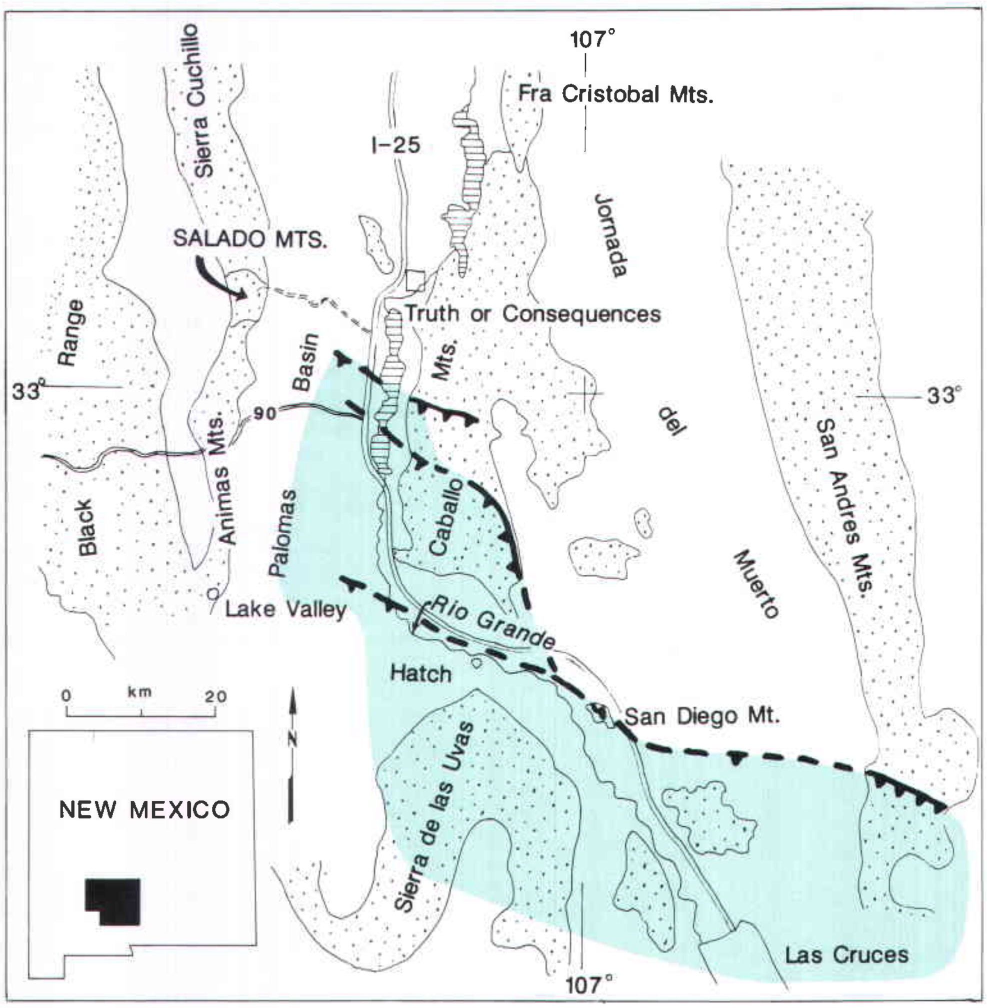

FIGURE 1—Location map. Shaded area shows extent of Laramide Rio Grande uplift as interpreted by Seager et al. (1986).

Also in this issue

Oil and gas discovery wells drilled in New Mexico in 1987 p. 54
Charges for natural resources on State Lands as of 1988 p. 60
Ore-testing capabilities at the New Mexico Bureau of Mines and Mineral Resources p. 61
Chicosa Lake State Park p. 62
Abstracts from NMGS 1988 spring meeting p. 64
Upcoming meetings and field trips p. 69
Service/News p. 70
Staff notes p. 72

Coming soon

Type and reference sections of Lower Cretaceous strata
Kit Carson State Park
Geomorphic development of City of rocks, Grant County

15 km nearly due west of Truth or Consequences (Fig. 1; Lamarre, 1974; Mayer, 1987). In this area not only is the Laramide fault-block structure revealed, but also the manner in which the fault blocks were eroded and eventually buried by younger volcanic rocks.

General features and stratigraphy of the Salado Mountains

The Salado Mountains are a relatively small (approximately 20 km^2) group of hills and peaks located near the center of the easternmost, outlying fault block of the Black Range. To the north, the fault block is known as Sierra Cuchillo, to the south it goes by the name Animas Mountains. Bordered on the west by a late Tertiary normal fault, downthrown to the west, the whole fault block is tilted eastward (Fig. 2). In the Salado Mountains the easterly dip ranges from approximately 15 to 25 degrees, and strata dip eastward beneath gravels of the Palomas Basin.

Rocks ranging in age from Precambrian to Quaternary crop out in the Salado Mountains (Fig. 3). Precambrian rocks include granite, muscovite phyllite and schist, and metadiorite, all exposed in the core of a Laramide fault-block uplift. Paleozoic strata nonconformably overlie the Precambrian and range in age from Cambrian–Ordovician to Permian. Largely marine limestone, dolomite, shale, and sandstone, these rocks form the highest hills and peaks in the mountain group. Because of erosion during or following the Laramide or faulting during the late Tertiary, parts of the El Paso, Montoya, and Abo sections either are not exposed or are missing altogether. In spite of this, a thickness of approximately 600 m of Paleozoic rock crops out (Mayer, 1987).

Middle Tertiary volcanic and clastic rocks overlie Paleozoic strata, the contact being an angular unconformity of modest (10 to 15 degrees) discordance. Middle Tertiary strata have an uneven thickness because lower parts of the section are inset against or onlap Laramide topography whereas somewhat younger rocks overlap completely and bury the older terrane. Among the oldest of the Tertiary rocks are post-orogenic boulder conglomerate and breccia beds, only a few meters thick, derived from an adjacent Laramide uplift. Clasts are as much as several meters in diameter and include Paleozoic strata as old as the Bliss Formation. Conglomerates probably are correlative with the Love Ranch Formation of the Caballo–San Andres Mountains area (Kottlowski et al., 1956). The Love Ranch strata grade upward into or are interbedded with intermediate-composition flows and volcaniclastic strata of the Rubio Peak Formation (Palm Park, Spears, or Datil Group equivalent; Elston 1957; Kelley and Silver, 1952; Seager and Hawley, 1973; Cather et al., 1987). Much of the formation is laharic in origin. As much as 1,075 m thick, the formation thins dramatically both because its lower beds pinch out by onlap onto Lar-

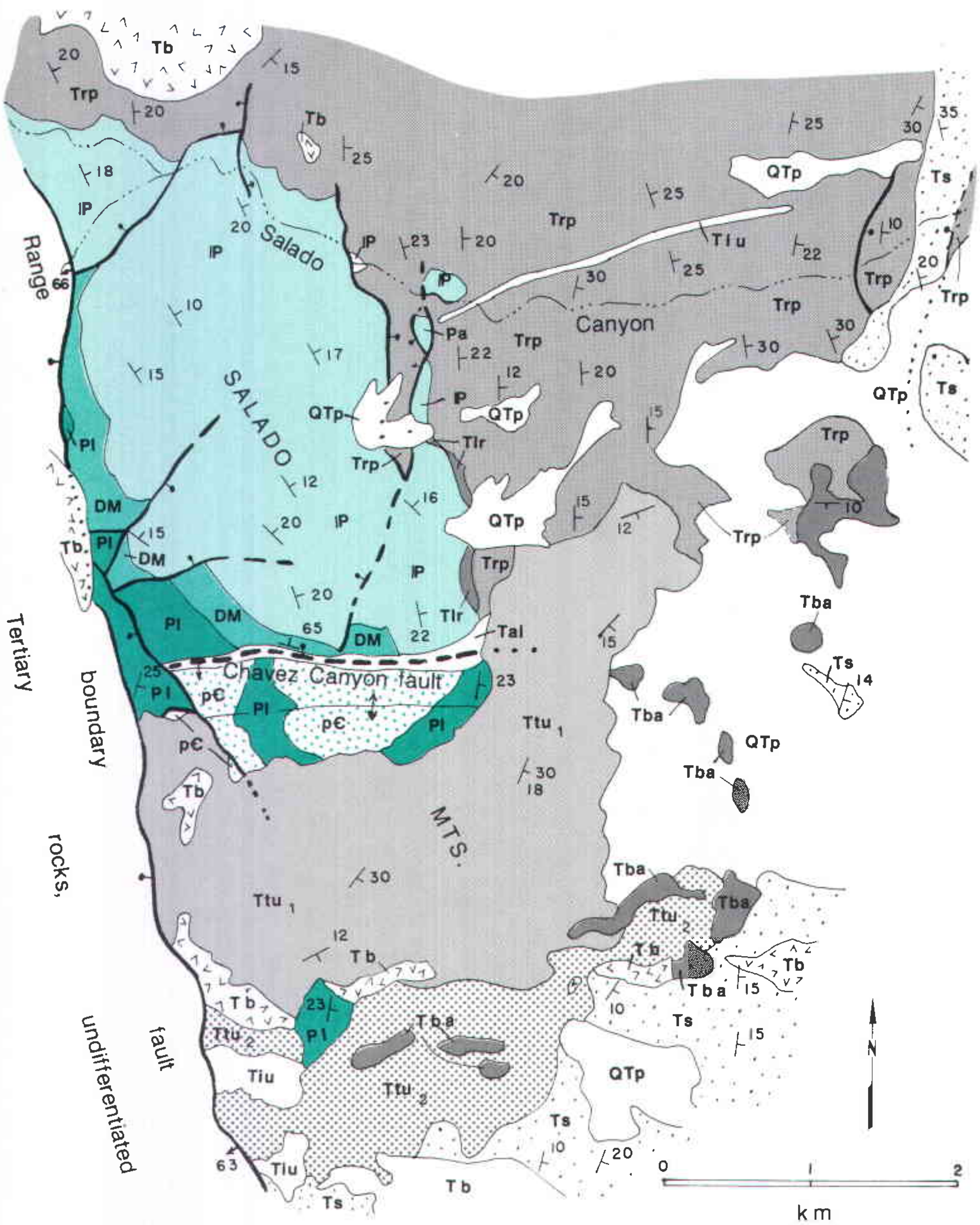

FIGURE 2—Generalized geologic map of the Salado Mountains, modified after Mayer (1987). **p€**, Precambrian rocks; **Pl**, lower Paleozoic rocks; **DM**, Devonian and Mississippian rocks; **IP**, Pennsylvanian rocks; **Pa**, Permian Abo Formation; **Tlr**, Love Ranch Formation; **Trp**, Rubio Peak Formation; **Ttu$_1$**, unnamed lithic ash-flow tuff; **Ttu$_2$**, unnamed crystal ash-flow tuff; **Tba**, basaltic andesite flows; **Ts**, lower Santa Fe Group; **Tb**, basalt flows; **QTp**, Palomas Formation; **Tai**, biotite andesite dike; **Tiu**, igneous intrusions, undifferentiated.

New Mexico GEOLOGY

• Science and Service

Volume 10, No. 3, August 1988

Editor: Carol A. Hjellming
Drafting assistance: Rebecca Titus
Published quarterly by
New Mexico Bureau of Mines and Mineral Resources
a division of New Mexico Institute of Mining & Technology

Subscriptions: Issued quarterly, February, May, August, November; subscription price $6.00/calendar year.

Editorial matter: Articles submitted for publication should be in the editor's hands a minimum of five (5) months before date of publication (February, May, August, or November) and should be no longer than 20 typewritten, double-spaced pages. All scientific papers will be reviewed by at least two people in the appropriate field of study. Address inquiries to Carol A. Hjellming, Editor of *New Mexico Geology*, New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801

Circulation: 1,600

Printer: University of New Mexico Printing Plant

amide topography and because its upper beds are truncated by an unconformity. Radiometric dates from elsewhere in the Black Range and south-central New Mexico region indicate the Rubio Peak Formation is late Eocene to earliest Oligocene in age (e.g. Kottlowski et al., 1969; Marvin and Cole, 1978; Clemons, 1982; Loring and Loring, 1980). Unconformably above the Rubio Peak Formation, two ash-flow tuffs of probable middle Oligocene age crop out along the eastern and southern flanks of the mountains. The lower tuff, lithic rich and 100 to 200 m thick, has not been correlated with other tuffs of the region. The upper tuff, 30 to 60 m thick, is crystal rich and also has not been correlated with other tuffs. Scattered remnants of basaltic andesite flows, inferred to be correlative with Bear Springs basalt (Elston, 1957) or basaltic andesite of Poverty Creek (Elston et al., 1973), unconformably overlie the tuffs or Rubio Peak Formation. Recent K–Ar dating indicates these units are approximately 28 Ma old (Seager et al., 1984).

Unconformably overlying various parts of the middle Tertiary volcanic section is a sequence of "early rift" fanglomerate, sandstone, and siltstone assigned to the lower Santa Fe Group. A thousand meters or more thick in outcrops along Salado Creek, the formation was derived primarily from middle Tertiary volcanic rocks. It may be correlative with all or part of the Miocene Hayner Ranch and Rincon Valley Formations of the Caballo Mountains–Hatch Valley area (Seager and Hawley, 1973) and with the Popotosa Formation of the Socorro area (Denny, 1940; Bruning, 1973; Chapin and Seager, 1975). The unit dips eastward 15 to 25 degrees and was clearly rotated along with older strata as the Salado Mountains block was uplifted and tilted eastward in late Tertiary time.

Essentially undeformed basalt flows and piedmont-slope gravels unconformably overlie older rock units. The basalt issued from vents to the west of the Salado Mountains, then flowed eastward down ancestral drainage ways such as Salado Creek. Locally, the flows may be offset a few meters by movement on range-boundary faults. The flows now cap geomorphically high-level mesas or ridge tops. Judging from dated flows in similar geomorphic positions near Hillsboro, the flows may be approximately 4 to 4.5 Ma (Seager et al., 1984). Piedmont-slope gravels assigned to the Palomas Formation (Lozinski and Hawley, 1986) of latest Pliocene and Pleistocene age bury the basalt flows and overlap older rock units. Late Quaternary and Holocene alluvium in arroyos or shallow drainageways are the youngest deposits in the area.

Laramide structure

Erosion of the late Tertiary Salado Mountains fault block has revealed a fragment of an older fault-block uplift of probable Laramide age. Because the Laramide uplift and its boundary fault trend nearly east–west, they are truncated on the west by the north-trending boundary fault of the Salado Mountains and buried on the east by post-Laramide volcanic and sedimentary rocks. In between, the Laramide geology is well exposed, particularly in the Chavez Canyon area (Fig. 2).

The central Laramide structure is the Chavez Canyon fault (Fig. 2), movement on which raised a Laramide fault block of modest relief. The fault trends N85°W and is upthrown on the south side. Precambrian and lowest Paleozoic rocks in the uplifted block are juxtaposed against Ordovician to Pennsylvanian strata in the down-faulted block to the north. Stratigraphic separation is as much as 400 m. Unfortunately, the dip of the fault is not known precisely because the fault is intruded throughout its length by a 50-m-thick biotite andesite dike. The trace of the ☞

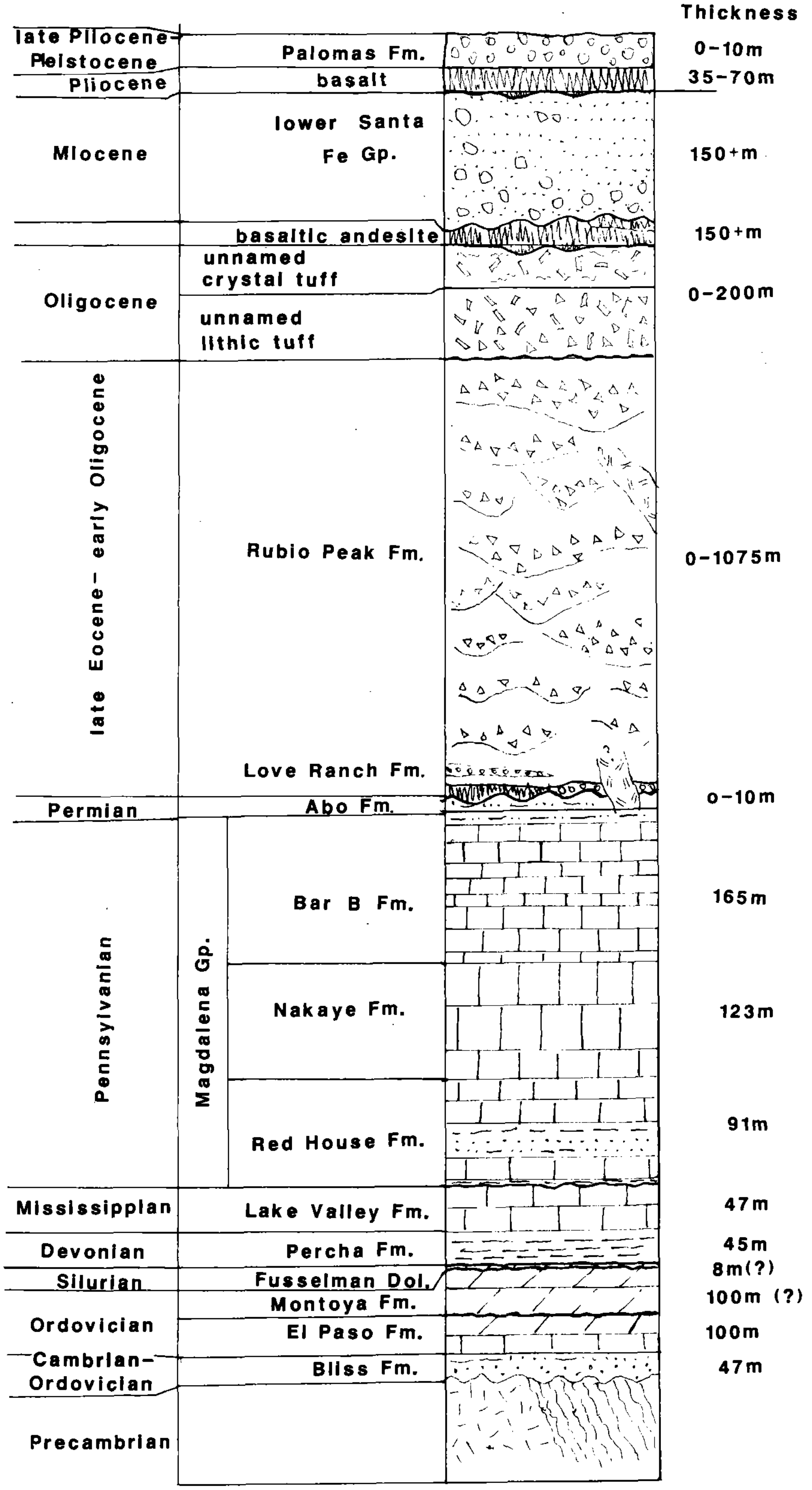

FIGURE 3—Columnar section of sedimentary and volcanic rocks exposed in Salado Mountains.

dike across topography suggests a steep southerly dip for both dike and fault. If so, the fault is reverse. Bedding attitudes in beds of the downthrown block adjacent to the dike are steep but not overturned, suggesting predominantly vertical movement rather than low- or even moderate-angle thrusting.

If 15 to 25 degrees of late Tertiary tilting are removed, Paleozoic rocks are restored to their Laramide attitude. The operation shows that, except for the steep drag near the Chavez Canyon fault, footwall rocks generally had a northeast strike and 10-degree-northwest dip prior to emplacement of the Tertiary volcanic section. Uplifted hanging-wall rocks appear to be broadly domed along an east–west axis, although so few Paleozoic strata remain that this is not entirely clear. The Chavez Canyon fault remains a steep, probably south-dipping fault after late Tertiary tilting is removed.

Age of Laramide deformation

The age of Laramide deformation in the Salado Mountains is poorly constrained. The only direct evidence we have for the age of the Chavez Canyon fault is a K–Ar date from the andesite dike that intrudes the fault. Lamarre (1974) dated biotite from this dike at 43.7 ± 1.7 Ma. The fault is therefore older.

Regional relationships suggest Laramide deformation in the Truth or Consequences region may have occurred in two pulses (Chapin and Cather, 1981): an earlier one in latest Cretaceous to Paleocene time related to deposition of the McRae Formation (Hunter, 1986), and a later one in early to middle Eocene time related to emplacement of the Love Ranch Formation (Seager, 1983; Seager and Mack, 1986). Little is known about the earlier phase. The Salado Mountains deformation may be a product of the younger event because Love Ranch-type clastic strata derived from the hanging wall of the Chavez Canyon fault are present in the basal parts of the Rubio Peak Formation.

Erosion and burial of the Laramide uplifts

Before Laramide deformation began, Paleozoic and Mesozoic strata approximately 2,000 m thick covered the Salado Mountains area (Kottlowski, 1963). This approximation includes estimates of the thickness of Permian and Upper Cretaceous rocks that are missing in the Salado Mountains but are preserved in the Sierra Cuchillo (Jahns, 1955) and Truth or Consequences area. Almost the entire Phanerozoic section was eroded from the hanging wall of the Chavez Canyon fault during or following Laramide deformation, and all but 700 m were removed from the footwall. Both blocks were structurally high relative to some unknown adjacent basin, and presumably that basin contains the detritus derived from the uplifts. No thick accumulations of Laramide synorogenic or postorogenic deposits are known in the Black Range or Sierra Cuchillo so it seems likely that the Laramide Basin is hidden beneath parts of the Palomas Basin. Perhaps the Laramide Love Ranch Basin, well exposed in western parts of the Jornada del Muerto, extends northwestward beneath the Palomas Basin and contains erosional debris from the Chavez Canyon fault blocks (Fig. 4). Preservation of Cretaceous rocks in the Palomas Basin in the Summmit 1 Mims and Gartland 1 Brister wells supports this (Foster, 1978).

By middle Tertiary time Laramide fault blocks in the Salado Mountains were buried by volcanic rocks. If one views the geologic map (Fig. 2) from the west looking eastward down dip, the map takes on the aspects of a cross section, and the manner in which the uplift was buried becomes clear.

Figure 5, a diagrammatic cross section derived from the "down plunge" view of the geologic map, shows the important relationships. A pediment cut on the downthrown block of the Chavez Canyon fault is covered discontinuously by bouldery debris of the Love Ranch Formation derived from the upthrown block. These beds also interfinger with basal beds of the Rubio Peak Formation. Andesite lava flows of the Rubio Peak fill some of the deepest drainageways incised into lowest parts of the paleopiedmont slope. Younger Rubio Peak laharic strata progressively onlap the piedmont slope, eventually burying the dike in the Chavez Canyon fault. Perhaps the Rubio Peak Formation also buried the hanging-wall block of the Chavez Canyon fault; this is not entirely clear because erosion locally removed part of the upper beds of the Rubio Peak Formation before emplacement of the overlying tuffs. At any rate, the Rubio Peak Formation thins by deposition as it onlaps the Laramide fault blocks and thickens to the north. Clearly, the Rubio Peak strata leveled the former topography. Succeeding sheets of ash-flow tuff overlapped the eroded Rubio Peak strata as well as the structurally highest parts of the Laramide uplift south of Chavez Canyon fault; finally the ash-flow tuffs buried the uplift completely. Emplacement of basaltic andesite flows and deposition of Santa Fe fanglomerate further concealed the Laramide fault block.

Regional relationships

Figure 4 illustrates that the Laramide fault blocks in the Salado Mountains may be in-

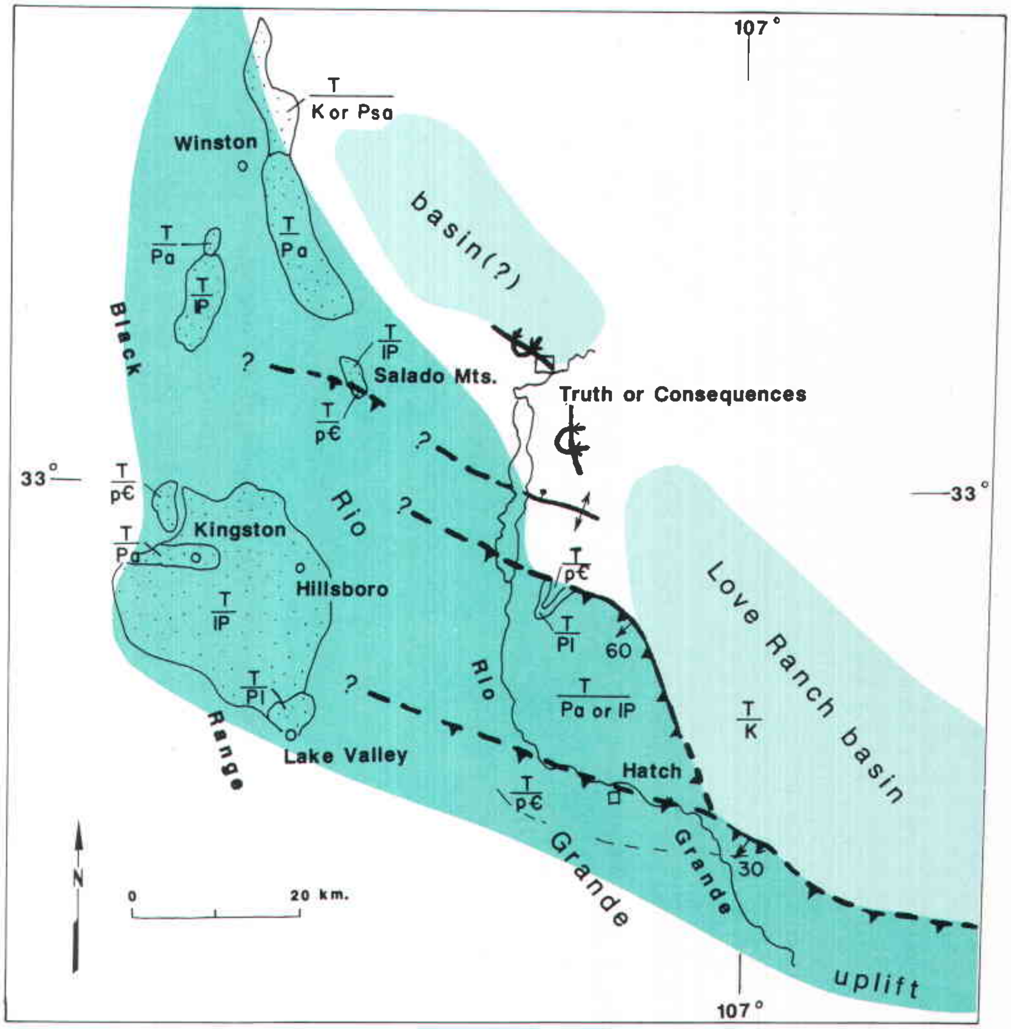

FIGURE 4—Interpreted extension of Laramide Rio Grande uplift and Love Ranch Basin into Black Range area. Dotted areas are parts of Black Range where pre-Laramide rocks are exposed. Symbols T/pꞒ, T/Pl, T/ℙ, T/Pa, T/Psa, T/K refer to areas where Tertiary volcanic or clastic rocks overlie Precambrian, lower Paleozoic, Pennsylvanian, Abo, San Andres Limestone, or Cretaceous rocks respectively.

terpreted as a westward extension of northern parts of the Rio Grande uplift of the Caballo Mountains area. The easterly trend of the Chavez Canyon fault blocks is nearly parallel to westernmost exposures of the Rio Grande uplift-margin structures in the central Caballo Mountains. Also, the northward downstepping of faults is consistent in both areas.

The Rio Grande uplift of the Caballo Mountains–southern Rio Grande area is a huge structure, consisting of at least two major blocks and several smaller ones (Seager et al., 1986). Consequently, it is unlikely that the relatively small fault blocks of the Salado Mountains represent the full extent of the Rio Grande uplift in the Black Range area. They probably are intra-uplift blocks or elements of a much broader uplift that probably extends southward to Lake Valley or beyond as well as westward and northward. Parts of this inferred broad uplift were raised sufficiently high so that erosion cut into broad areas of Precambrian or lower Paleozoic rocks prior to late Eocene time (Fig. 4). For example, in and adjacent to North Percha Creek in the east-central Black Range, the Rubio Peak Formation thins onto Laramide uplifts, and Precambrian granite is overlapped by sheets of younger ash-flow tuff (Ericksen et al., 1970; Seager et al., 1982). These are the same onlap and overlap relationships displayed so strikingly in the Salado Mountains. Only locally are rocks as young as Permian preserved beneath Tertiary volcanics in the central and southern Black Range area; these must represent local intra-uplift sags or synclines in the broader uplift.

Conclusions

The Laramide uplift in the Salado Mountains is probably only a small element of a much broader uplift of early Tertiary age—the Rio Grande uplift—that encompassed much of the central and southern Black Range as well as broad areas to the east and south. The Salado Mountains structure trends N85°W, in approximate conformity with Laramide trends in other parts of the Rio Grande uplift but at high angles to younger Rio Grande rift faults. Erosion of 1500 to nearly 2,000 m of Paleozoic and Mesozoic strata from the Salado Mountains area is an index of the magnitude of Laramide uplift in the region. Except for very thin post-orogenic pediment veneers, sedimentary deposits resulting from this erosion are missing, even on the structurally lowest blocks. They must have been transported across the uplift into adjacent basins that now lie hidden beneath the late Tertiary Palomas Basin. By late Eocene time considerable topographic relief still existed across Laramide fault blocks. Subsequent deposition of upper Eocene to lower Oligocene lavas and volcaniclastic rocks leveled the landscape, and lower Oligocene ash-flow tuffs finally buried the highest, most deeply eroded fault blocks. Such onlap and overlap relationships of middle Tertiary volcanics onto eroded Laramide uplifts can be seen in many parts of southern New Mexico, but are perhaps nowhere more clearly revealed than in the Salado Mountains.

ACKNOWLEDGMENTS—Mapping in the Salado Mountains was done by Seager in the early 1970s and in 1987. Mayer mapped the area as part of his M.S. geology degree in 1986 and 1987. We appreciate the helpful reviews of Steve Cather, Richard Harrison, Tim Lawton, and Greg Mack.

References

Bruning, J. W., 1973, Origin of the Popotosa Formation, north-central Socorro County, New Mexico: Ph.D. dissertation, New Mexico Institute of Mining and Technology, Socorro, New Mexico 132 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 38, 142 pp.
Cather, S. M., McIntosh, W. C., and Chapin, C. E., 1987, Stratigraphy, age, and rates of deposition of the Datil Group (Upper Eocene–Lower Oligocene), west-central New Mexico: New Mexico Geology, v. 9, pp. 50–54.
Chapin, C. E., and Cather, S. M., 1981, Eocene tectonics and sedimentation in the Colorado Plateau–Rocky Mountain area, *in* Dickinson, W. R., and Payne, W. B. (eds.), Relations of tectonics to ore deposits in the southern Cordillera: Arizona Geological Society, Digest, v. 14, 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., 1982, Geology of Massacre Peak quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 51, scale 1:24,000.
Denny, C. S., 1940, Tertiary geology of the San Acacia area, New Mexico: Journal of Geology, v. 48, pp. 73–106.
Elston, W. E., 1957, Geology and mineral deposits of Dwyer quadrangle, Grant, Luna and Sierra Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 38, 86 pp.
Elston, W. E., Damon, P. E., Coney, P. J., Rhodes, R. C., Smith, E. I., and Bikerman, M., 1973, Tertiary volcanic rocks, Mogollon–Datil province, New Mexico, and surrounding region—K–Ar dates, patterns of eruption, and periods of mineralization: Geological Society of America, Bulletin, v. 84, pp. 2259–2274.
Ericksen, G. E., Wedow, H., Jr., Eaton, G. P., and Leland, G. R., 1970, Mineral resources of the Black Range Primitive Area, Grant, Sierra, and Catron Counties, New Mexico: U.S. Geological Survey, Bulletin 1319–E, 162 pp.
Foster, R. W., 1978, Selected data for deep drill holes along Rio Grande rift in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 163, pp. 236–237.
Hunter, J. C., 1986, Laramide synorogenic sedimentation in south-central New Mexico—petrostratigraphic evolution of the McRae Basin: Unpublished M.S. thesis, Colorado School of Mines, Golden, Colorado.
Jahns, R. H., 1955, Geology of the Sierra Cuchillo, New Mexico: New Mexico Geological Society, Guidebook to 6th Field Conference, pp. 158–174.

(continued on page 60)

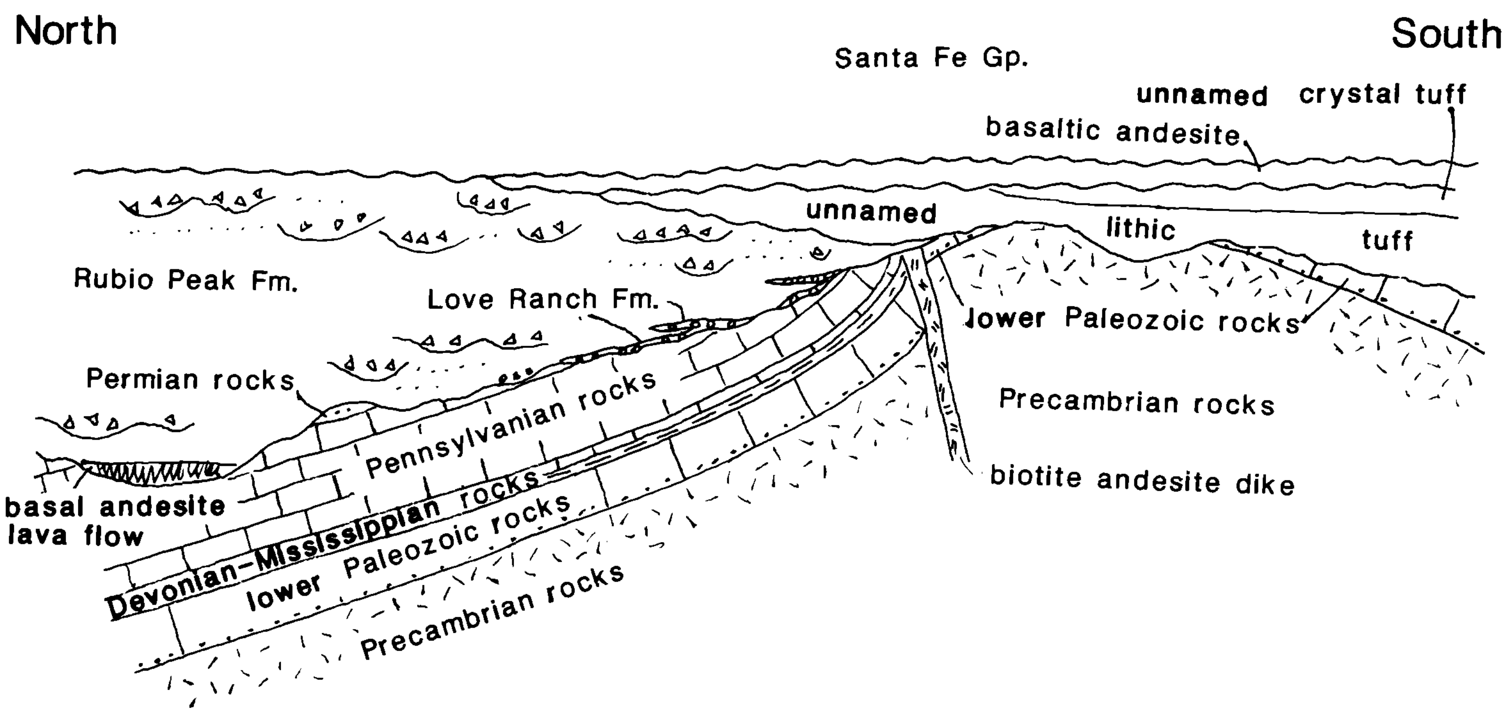

FIGURE 5—Diagrammatic section showing onlap and overlap relationship of Tertiary volcanic rocks to Laramide fault blocks.

(continued from page 53)
Kelley, V. C., and Silver, C., 1952, Geology of the Caballo Mountains with special reference to regional stratigraphy and structure and to mineral resources, including oil and gas: University of New Mexico Publications in Geology, no. 4, 286 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., Flower, R. H., Thompson, M. L., and Foster, R. W., 1956, Stratigraphic studies of the San Andres Mountains, New Mexico: New Mexico Bureau Mines and Mineral Resources, Memoir 1, 132 pp.
Kottlowski, F. E., Weber, R. H., and Willard, M. E., 1969, Tertiary intrusive-volcanic mineralization episodes in the New Mexico region (abs.): Geological Society of America, Abstracts with Programs, pt. 7, p. 278.
Lamarre, A. L., 1974, Fluorite in jasperoid of the Salado Mountains—significance to metallogeny of the western United States: Unpublished M.S. thesis, University of Western Ontario, London, 134 pp.
Loring, A. K., and Loring, R. B., 1980, K/Ar ages of middle Tertiary igneous rocks from southern New Mexico: Isochron/West, no. 28, pp. 17–19.
Lozinski, R. P., and Hawley, J. W., 1986, Upper Cenozoic Palomas Formation of south-central New Mexico: New Mexico Geological Society, Guidebook to 37th Field Conference, pp. 239–247.
Marvin, R. F., and Cole, J. C., 1978, Radiometric ages—compilation A, U.S. Geological Survey: Isochron/West, no. 22, pp. 3–14.
Mayer, A. B., 1987, Structural and volcanic geology of the Salado Mountains–Garcia Peak area, Sierra County, New Mexico: Unpublished M.S. thesis, New Mexico State University, Las Cruces, 61 p.
Seager, W. R., 1983, Laramide wrench faults, basement-cored uplifts, and complementary basins in southern New Mexico: New Mexico Geology, v. 5, pp. 69–76.
Seager, W. R., Clemons, R. E., Hawley, J. W., and Kelley, R. E., 1982, Geology of northwest part of Las Cruces 1° × 2° sheet: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 53, 3 sheets, scale 1:125,000.
Seager, W. R. and Hawley, J. W., 1973, Geology of Rincon quadrangle, New Mexico: New Mexico Bureau Mines and Mineral Resources, Bulletin 101, 42 pp.
Seager, W. R., and Mack, G. H., 1986, Laramide paleotectonics of southern New Mexico; *in* Peterson, J. A. (ed.), Paleotectonics and sedimentation in the Rocky Mountain region: American Association of Petroleum Geologists, Memoir 41, pp. 669–685.
Seager, W. R., Mack, G. H., Raimonde, M. S., and Ryan, R. G., 1986, Laramide basement-cored uplift and basins in south-central New Mexico: New Mexico Geological Society, Guidebook to 37th Field Conference, pp. 123–130.
Seager, W. R., Shafiqullah, M., Hawley, J. W., and Marvin, R., 1984, New K–Ar dates from basalts and the evolution of the southern Rio Grande rift: Geological Society of America, Bulletin, v. 95, pp. 87–99. □

Summary of charges for natural resources other than oil and gas on New Mexico State Lands as of January 1, 1988

compiled by

Louis B. Martinez, State Land Office, Mineral Division (505/827–5776), and *James M. Barker*, New Mexico Bureau of Mines and Mineral Resources (505/835–5114)

Type of lease	Length of lease	Filing fees	Annual rental	Royalty rate	Advance royalty	Acquisition method	Minimum bond
General mining	Primary—3 yr Secondary—2 yr Tertiary—5 yr Quaternary—5 yr Lease may be extended by production	$30.00	Primary (1–3 yr) @$0.25/acre Secondary (4–5 yr) @$2.50/acre Tertiary (6–10 yr) @$3.00/acre Quaternary (11–15 yr) @$10.00/acre Rental fixed at production	12.5% of gross sales price of materials; 5% on other minerals	0–10 yr—no advance royalty; Quaternary yrs.: 11th yr @ $10/acre 12th yr @ $20/acre 13th yr @ $30/acre 14th yr @ $40/acre 15th yr @ $50/acre Advance royalty of two years credited to production royalty	Competitive bid only, sealed or oral (Moratorium on over-the-counter leasing)	Performance bond—$2,000; at time mining commences—additional $5,000/lease
Potash	Primary—10 yr Five years in special cases Lease may be extended by production	$30.00	First yr @ $0.25/acre 2nd–5th yr @ $0.50/acre 6th–10th yr @ $1.00/acre Some older leases at lower rates	Sliding-scale royalty depends on ore grade, ranges from 2–5% of gross sales price	None	Application for lands shown to be open on the tract books	Performance bond for nonproducing—$5,000/lease Performance bond for producing—$10,000/lease (or $20,000 for multiple leases)
Salt	Primary—10 yr Lease may be extended by production	$30.00	$40 for each 40-acre legal subdivision	Not less than 10% of gross sales price at place of extraction	None	Application for lands shown to be open on the tract books	Performance bond—$500/lease (or $1,000 for multiple leases)
Coal	Primary—5 yr Preference right of renewal: Producing—5 yr Nonproducing—1 yr Absolute right to renew for four additional years	$30.00	$1.00/acre	12.5% of gross value at point of sale; 12.5% of market value in the area $0.86/ton at point of sale	1 yr @ $3.00/acre 2 yr @ $4.00/acre 3rd–5th yr @ $5.00/acre	Competitive bid only, sealed or oral	Performance bond for nonproducing—$500/lease (or $1,000 for multiple leases) Performance bond for producing—$20,000/lease (or $50,000 for multiple leases)
Geothermal	Primary—5 yr Secondary—5 yr Lease may be extended by production	$30.00	1st–5th yr @ $1.00/acre 5th–10th yr @ $5.00/acre	See statutes* 10% gross value Byproduct: 5% gross value Power plant: 8% net revenue Recreation: 2–10% gross value Space heating: 2–10% gross value Health: 2–10% gross value	None	Competitive bid only, sealed or oral	Performance bond for nonproducing—$2,000/lease Performance bond for producing—$5000/lease
Sand & gravel	Primary—1–5 yr	$30.00	$40 for each 40-acre legal subdivision or any fraction thereof	See schedule in Rule 5* Range: $0.55–$1.45/yd^3	None	Application for lands shown to be open on tract books; 40-acre restriction	Damage bond—$5,000 Performance bond—$2,000 (except on purchase contract or patent)
Caliche	15-day permit	$30.00	None	See schedule in Rule 5* Range: $0.55–$1.45/yd^3	None	Application for lands shown to be open on tract books; 40-acre restriction	Damage bond—$5,000 Performance bond—$2,000 (except on purchase contract or patent) May tender advance royalty in lieu of performance bond

Data source: State Land Office, Mineral Division. *For information, contact the State Land Office, Mineral Division.