The Rio Grande depression from Taos to Santa Fe

Vincent C. Kelley

1956, pp. 109-114. https://doi.org/10.56577/FFC-7.109

in:

Southeastern Sangre de Cristo Mountains, Rosenweig, A.; [ed.], New Mexico Geological Society 7th Annual Fall Field Conference Guidebook, 151 p. https://doi.org/10.56577/FFC-7

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

THE RIO GRANDE DEPRESSION FROM TAOS TO SANTA FE

By
Vincent C. Kelley
University of New Mexico

INTRODUCTION

The Rio Grande depression extends for about 450 miles from the head of the San Luis Valley in Colorado through the length of New Mexico to near El Paso, Texas. The width is very irregular and ranges from about 10 to 40 miles. In a broad regional sense the Rio Grande depression is part of a much longer series of intermontane depressions which follow the full length of the Eastern Rockies of Colorado and New Mexico, and in effect divides the orogenic belt into a western chain extending from the Park Range on the north to the Black Range on the south and an eastern chain extending from the Front Range on the north to the Franklin Range on the south. The chains of uplifts as well as the intermontane depressions are interrupted and commonly staggered or en echelon in arrangement. The intermontane depressions extend from the Laramie basin on the north, southward through the "parks" of Colorado and the series of lesser basins or grabens which constitute the Rio Grande depression. The individual north-trending grabens or fault troughs of New Mexico are arranged en echelon north-northeasterly along the Rio Grande and are separated from each other at the "offsets" by structural constrictions or narrow salients from adjoining uplifts. The form and internal faults and folds of the several depressions are by no means uniform or simple. Likewise the geologic histories of the individual basins or grabens appear to have been variable in both space and time. Their formation may have begun during Laramide time and may be continuing at present. The deformations throughout the length of the intermontane depressions do not appear to have been synchronous.

During this field conference the principal part of the depression that is seen is along the eastern side of the San Luis and Espanola basins. These are separated at the Embudo structural constriction that is formed by the Picuris salient, the Cerro Azule bedrock "island", and the Ojo Caliente structural prong which extends southward from the San Juan Mountains of Colorado.

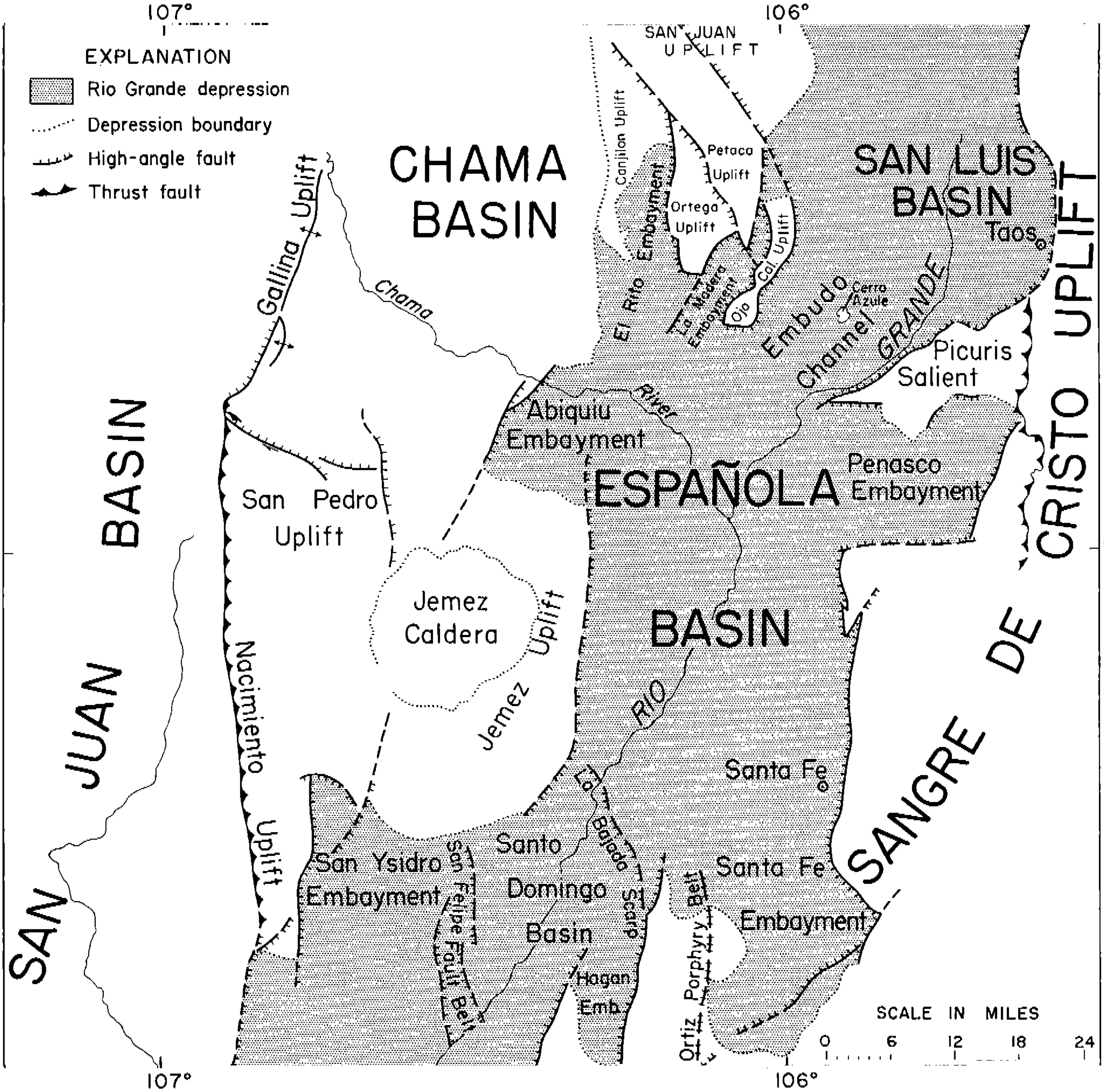
Only a small part of the southern end of the San Luis basin is seen during the field excursion. In this area the eastern side is bounded boldly by the Taos uplift consisting of Precambrian and Pennsylvanian rocks. To the west, the San Luis basin is bounded by low structural uplifts consisting of Precambrian rocks overlain by volcanic rocks and their alluvial products of Miocene and Pliocene age. No Paleozoic rocks are present and this area was a part of the Ancestral Rockies of the Uncompahgre-San Juan Highland of Permo-Pennsylvanian time which supplied the thick series of the same ages that are present in the great Sangre de Cristo Range to the east of the Rio Grande depression.

The southern end of the San Luis basin in the vicinity of Taos is filled with several thousand feet of sand and gravel of the Santa Fe group. Below these late Tertiary sediments there may be hundreds or thousands of feet of sand and gravel of middle and early Tertiary age. These beds are equivalent to the El Rito, Abiquiu, and Picuris formations.

ESPANOLA BASIN

The Espanola basin, which lies northwest of Santa Fe, is an irregular part of the Rio Grande depression 40 to 50 miles long and 18 to 40 miles wide as shown on the accompanying map. However, it is a generally north-trending basin which is bounded on the east by the Sangre de Cristo uplift, on the west by the Jemez uplift, on the north by the Embudo constriction, and the south by the La Bajada constriction.

The northern boundary is taken arbitrarily along the irregular Embudo constriction where Precambrian fault blocks or buried hills rise above the Tertiary sediments of the Cerro Azule structural channel between the Espanola and San Luis basins. The principal structural channel and linkage of the Espanola and San Luis basin lies between the Ojo Caliente and Picuris prongs. At the north end of the Espanola basin, just south of the Embudo constriction, the depression widens greatly, and the Abiquiu and Penasco embayments are recognized as sub-basins. These embayments attest to the irregular nature of the bounding faults between the uplifts and the basin, although in part they are the result of overlap of Tertiary sediments in sectors of former great erosion and deposition. The La Bajada constriction, which bounds the basin on the south, is formed by the La Bajada fault zone which bounds the Santo Domingo basin on the north. The Cerrillos uplift to the northeast of the La Bajada fault zone consists of Mesozoic and early Tertiary sediment and middle Tertiary volcanic rocks intruded by several porphyry masses. The connecting structure between the Espanola and the Santo Domingo basins is the White Rock channel. This linkage between the two basins lies



TECTONIC MAP OF THE RIO GRANDE DEPRESSION AND ADJACENT REGIONS BETWEEN SANTA FE AND TAOS, N.M.

between the buried northern end of the Cerrillos uplift and a small salient at the southeastern edge of the Jemez uplift.

The eastern margin of the Espanola basin is well marked by the resistant Sangre de Cristo escarpment which rises abruptly from the softer Tertiary strata of the basin. The Sangre de Cristo uplift is the largest and longest in New Mexico. It is about 190 miles long and borders the Rio Grande depression on the east from near Santa Fe on the south to the northern termination of both structures at the Sawatch uplift some 90 miles north of the New Mexico-Colorado line. The rocks of the uplift are almost entirely either Precambrian or Pennsylvanian. These have been complexly folded, overthrust eastward, and offset along large tear faults during intense Laramide deformation (C. B. Read, oral communication). The present western fault scarp is, however, caused by late Tertiary high-angle faults, that are en echelon or saw-toothed in their arrangement (Cabot, 1938, pp. 97-104). Unfaulted tilted erosional contacts appear to exist in many places along the eastern boundary of the basin and in the Picuris embayment (op. cit.).

The west escarpment is less well marked, and the faults between the basin and the Jemez uplift are not immediately obvious owing to the thick blanket of Pleistocene Bandelier rhyolite tuff along the western flanks of the Jemez Mountains. The fault zone responsible for the prominent Los Alamos fault scarp has brought early and middle Tertiary rocks of the uplift into juxtaposition with late Tertiary Santa Fe rocks at many places along the eastern base of the Jemez uplift.

The rocks of the Espanola basin are predominantly those of the Santa Fe group, and the exposures in this area are typical of the deposits which appear to be very characteristic of the entire Rio Grande depression. All along the eastern half of the Espanola basin the Santa Fe is tilted westward 5 to 10 degrees along the Sangre de Cristo fault scarp, and it appears that the entire western tilt of the Santa Fe on the east side of the Espanola basin is due to late and post-Santa Fe movement on the fault. Several large patches of Santa Fe sand and gravel occur on benches along the Sangre de Cristo escarpment several hundred feet above the general surface of the basin.

Near the course of the Rio Grande, which roughly coincides with the axis of the basin, the Santa Fe beds become nearly horizontal. The most westerly exposures of the Santa Fe are found in the bottoms of youthful canyons cut into the Pajarito Plateau along the west base of the Jemez uplift, and there the Santa Fe generally has a low easterly dip. Thus, the Santa Fe has a broad synclinal structure across the basin. Some of this structure is depositional but some of it, especially on the east side, is tectonic. Cabot (1938, p. 93) and Denny (1940, p. 689) have stated that Santa Fe materials were derived from the Sangre de Cristo uplift, and Smith (1938, p. 956) has concluded that the Jemez uplift was not in existence or active during Santa Fe time. In this they were mistaken, for the Santa Fe around the Jemez uplift contains an abundance of rock fragments of Jemez provenance and little material from the Sangre de Cristo and northern areas. It is apparent that the central drainage line of the basin, which shifted intermittently during Santa Fe time in accordance with variations in the influx of materials and tilting of the subsiding floor, determined the separation as well as intertonguing of the east and west facies of the formation.

Some pyroclastic, as well as sedimentary volcanic materials, occur in the western facies of the Santa Fe, and these indicate volcanic activity in the Jemez uplift during Santa Fe time. Furthermore, the general coarseness of the western Santa Fe materials indicates the presence of an uplift in the Jemez area during much of Santa Fe time. Furthermore, the Santa Fe group intertongues with volcanic flows and breccias which were derived from the Chicoma volcanic centers in the Jemez area. In consequence, it appears that the Espanola basin recurrently subsided with reference to the adjoining uplifts throughout Santa Fe time, instead of being downthrown entirely by a single short tectonic event which came at the end of Santa Fe time. The end of Santa Fe time appears to be marked by a long period of quiescence, which allowed widespread bevelling of the deformed strata, especially along the eastern side.

The late Cenozoic structural and geomorphic history of the Espanola basin in unusually well revealed along the La Bajada constriction. Much of the physiographic expression of the Espanola basin is due to the numerous volcanic eruptions which began in late Santa Fe time in the Cerros del Rio just east of the Rio Grande. The tilting and bevelling of the Santa Fe beds along the margins of the basin began and were largely developed before these eruptions. Along the Rio Grande, where many of these eruptions occurred, channels in tilted Santa Fe strata are filled by basalt flows. Elsewhere, away from the main channel, the flows are interbedded with sediments of Santa Fe type. North of the lava flows lake clays, termed the Culebra lake clay (Kelley, 1948, p. 6), accumulated in the impounded waters, and some of the lavas which poured into the lake form, with the clay, subaqueous puddingstone and pillow structure. In addition, at about the end of Santa Fe time and generally prior to the basaltic eruptions, renewed uplift of the Jemez block caused the spreading of alluvial fans (Puye gravel) over the slightly deformed earlier Santa Fe beds as far east as the Rio Grande. Volcanic activity also occurred in the Jemez uplift during Puye time, as is indicated by the lenses and thin beds of pyroclastic pumice within the Puye gravel.

Following the spreading of the Puye gravel and most of the basaltic eruptions of the Cerros del Rio, the La Bajada fault zone, which may have been initiated in Pliocene or earlier time, again became active and gave rise to the present La Bajada escarpment. In some places, late basalt dikes were also injected along the fault. The Rio Grande flowed out of the lake west of its present channel, and around the lobes of basalt, and over the rising La Bajada escarpment. After some dissection by the river of the elevated escarpment had occurred, great eruptions of rhyolite tuff from the Jemez uplift engulfed the river and filled its channels completely. The area of the great rhyolitic eruption then collapsed to form the Jemez caldera. Some slight rise of the escarpment appears to have continued after the eruptions of the Bandelier rhyolite tuff, as this formation is broadly downwarped over the western end of the escarpment near the Jemez uplift. The Rio Grande, forced eastward again to near its channel of late Santa Fe time, cut down during late Pleistocene and Recent time, and developed the present gorge of White Rock Canyon. The La Bajada escarpment is the most prominent structural feature that crosses the Rio Grande depression along its length. Its development had a profound effect upon the earlier formed geomorphic features in the area.

Bryan (1938), in accounts of the erosional surfaces of the Espanola and Santo Domingo area, described a high surface which he termed the Ortiz surface from its development around the Ortiz Mountains. This surface is widely developed around Santa Fe and northward in the Espanola basin. In the Santa Fe area and in the Cerros del Rio of the La Bajada constriction the Ortiz surface has cut across tilted Santa Fe beds and has been covered by later sand and gravel (Ancha formation) as well as lava flows of the Cerros del Rio centers. West of the Rio Grande along the Pajarito Plateau the Ortiz horizon lies beneath the Puye gravel, which is in places several hundred feet thick.

SUMMARY

In the analysis of the tectonics of the Rio Grande depression stratigraphy, structure, and physiography become so interrelated as to be nearly inseparable. The stratigraphic sequence and lithology reflect the contemporaneous structure and physiography. In the geomorphology of the region the recognition and understanding of deformational features that are both younger and older than the physiographic features are of utmost importance. Also many of the largest and most significant structural elements are inferred from the geomorphology. Above all else, the geologic history is important, and the securing of a correct sequence of structural and geomorphic events, as well as the stratigraphic sequence, requires careful and often painstaking detailed work. The salient regional aspects of the stratigraphy, structure, and geomorphology are summarized below.

In late Cretaceous time the last great seaways to invade the continental interior gradually gave way to expanding floodplains. Toward the end of Cretaceous time the great floodplains began to be disturbed by linear upwarps, which often developed a pronounced asymmetry that culminated in overturned folds and great overthrusts. These early, Laramide tectonic features were developed along the entire length of the New Mexico Rocky Mountains, and although most of the thrusts dip westward, some dip eastward. The uplifts resultant from these compressional structures appear to have been paralleled by flanking downwarps which became filled with the products of erosion from the uplifts. The Laramide sediments, represented by such formations as the Raton, El Rito, and Galisteo, formed in basins of much greater expanse than the later trough-filling deposits of the Rio Grande depression. Although the early Laramide suite of sediments was largely non volcanic in lithology, in certain areas, especially toward the south and in the San Juan Mountain sector to the northwest, earlier and contemporaneous volcanic sources are evident.

In about middle Tertiary time volcanic activity that extruded rhyolitic to andesitic rocks developed on an enormous scale. These eruptions, together with their great outwash of alluvial material, accumulated to thicknesses of several thousand feet. The volcanic suites occur mostly in the western half of the Rocky Mountain belt and in the adjacent Colorado Plateau; but locally, as in the Raton and Cerrillos-South Mountain areas, the eruptions developed along the Great Plains border. Nevertheless, the uplifts bordering the east side of the depression are notably lacking in this suite of rocks. Little or no sharp folding or overthrusting accompanied the volcanic episode. High-angle faulting, however, appears to have accompanied and followed the great igneous activity. In several places there appear to have been two or three distinct volcanic stages separated by intervals of tectonic disturbance and erosion. Although local basins of accumulation appear to have developed during this epoch of Tertiary deposition and deformation, the areas of accumulation were rather wide, and the trough-like aspects of the later Rio Grande depression were not yet developed. In wide areas, the middle Tertiary flows and pyroclastic and volcanic alluvial beds lie with only slight unconformity or discordance upon the earlier non volcanic sediments. The intense fracture belt and prominent tilted blocks which are so characteristic of the Rio Grande depression and adjoining uplifts are later features.

The development of the Rio Grande structural belt probably began in late Miocene time and culminated in what may be termed the Cascadian orogeny toward the end of Pliocene time. With the development of the linked en echelon basins, the Santa Fe sediments, which are the characterizing feature of the Rio Grande depression, began to form. The Santa Fe has been assigned to ages that range from late Miocene to Pleistocene. In its typical development it is an alluvial-fan deposit of a characteristic pinkish or light-tan color. Although it is locally grayish it generally stands in fairly marked contrast to the somber brown, purplish-brown, or grayish-white of the middle Tertiary sediments upon which it often rests. The Santa Fe is typically a relatively non-volcanic sediment, but in many places, especially along the west side of the depression, its coarse fragments may be almost exclusively volcanic, but even in these places the characteristic pinkish color is evident in the clay and sand beds. The Santa Fe in large part reflects the rocks which were at the surface in the adjoining uplifts, and the superposition of its local members often roughly reflects, in reverse order, the stratigraphic superposition of the adjoining areas. In many places where the adjoining uplift consisted of carbonate rocks such as the Magdalena, San Andres, or lower Paleozoic formations, the adjacent Santa Fe is largely a calcirudite fanglomerate. Elsewhere playa and lake deposits form a large part of the Santa Fe. Pyroclastic breccia and tuff may be abundant in the Santa Fe, and this is especially true around the Jemez uplift. Basaltic flows are almost a characteristic of the Santa Fe, and are intercalated sparingly throughout the section.

Beds of well rounded gravel are common in the upper part of the Santa Fe, and these have been taken to indicate the presence of a through-flowing river. Although these beds indicate a considerable distance of transportation, they do not prove that a river such as the Rio Grande flowed to the ocean. Even the late Santa Fe gravel cannot be continuously traced along the depression.

The birth of the present Rio Grande still remains a problem. It appears to be at least as old as the late stages of development of the Ortiz pediment surface. Whether the Rio Grande existed during all or part of Pliocene time or during the bulk of Santa Fe deposition cannot be demonstrated. A factor often overlooked in connection with the possible existence of the ancient Rio Grande is the conclusion by Atwood and Mather (1932, p. 21) that the San Juan Mountain area, the principal source for most of the present river, was a peneplain at the end of Pliocene time.

The Ortiz surface along the Rio Grande is roughly assigned a Pleistocene age, but parts of it may be late Pliocene in age. It has also been noted that the Ortiz surface may be correlated through a series of outlying remnants with the general level of the High Plains, which is an extensive cut-surface overlain by the Pliocene Ogallala formation. Thus, the Ortiz surface, which is probably the most expansive in the Rio Grande area at Present, and its many correlatives may be of widely varying ages. There are places where the Ortiz surface is being extended by pedimentation into the mountain fronts at the present time.

Viewed broadly, the Ortiz surface, its overlying deposits, and all later surfaces and deposits may be assigned to Santa Fe time. Santa Fe time is a time characterized by filling of the basins flanked by the uplifts. The filling process is going on today. The cutting of the pediments and the inner canyons during Pleistocene and Recent times is a process which has been repeated many times. Unconformities, old erosion surfaces, and caliche (marl) beds are found in many places within the Santa Fe especially along the margins of the depression. There are also beds younger than Santa Fe obscurely laid against and in the Santa Fe beds along the inner canyon, indicating that the Rio Grande has cut and filled at earlier times. Finally, along the center of the depression there are places where little or no break in deposition occurred until the Recent canyon cutting cycle. The bajadas from the mountainward pediments are in continuous unbroken sequence with the underlying Santa Fe deposits along many parts of the depression.

The dominant structures of the Rio Grande depression are of the so-called Basin and Range type. However, these features are so far removed from the Great Basin and so different from the Arizona Basin and Range structures that it is better to consider the Rio Grande structural belt as a separate and distinct type included with the Rocky Mountain structural belt. The depression is a great rift belt, and there is much evidence of horizontal shifting which may total many miles. The vertical displacements may be only incidental to the horizontal shifting across the entire rift belt. The late Tertiary tectonic pattern is specialized and distinct enough to warrant the application of the term Rio Grande Rift Belt of the Rocky Mountains. The pattern is dominated by faults of northerly to northeasterly trends. Faults of westerly or northwesterly trend are uncommon and usually not large. Most of the faults were initiated in late Tertiary time. The fracture pattern is markedly en echelon, and so-called bounding faults of the major uplifts are often curved or saw-toothed in plan.

The forces which have given rise to the present system of fractures are difficult to conceive from the pattern alone. The geologic history indicates repeated deformation from Laramide to Recent time. Many earthquakes in the depression suggest that the deformation is presently in progress. It may be observed that in the total deformation, fracturing prevailed over folding. The controlling external or deep-seated forces have undoubtedly changed throughout the Cenozoic, and with each shift of major forces there was set up a complicated set of secondary and tertiary forces among highly diverse blocks, prisms, and irregular rock masses of the region. Although the belt has probably always been subjected to compression of one sort or another, there were at times local areas of tension.

It does not appear, however, that the grabens or basins were formed by an east-west release of compression that would allow the simple depression of blocks by gravity alone. Rather it appears that the basins were forced down under compression just as the uplifts were forced up. A deep-seated shear zone acted upon by tangentially directed forces of a couple would cause lateral shift, and this in turn would set up in the outer crust the observed en echelon structures.

The faults which bound the uplifts are mostly covered by pediment and alluvial fan deposits, but where observed, generally appear steep to vertical. The steep faults generally dip toward the depression, but whether these faults are dominantly and over-all, high-angle thrusts or ramps or high-angle gravity faults is not known. Under the hypothesis of rifting both types are compatible.

In conclusion it should be emphasized that the early Cenozoic structural elements and sedimentary prisms exerted an influence upon the resolution of the later secondary and teritary forces and the consequent structures. The structural pattern is complicated and cannot be interpreted by a single simple set of regional forces. Deep-seated rifting in late Tertiary time probably is the underlying cause of the en echelon basins and uplifts which constitute the Rio Grande depression.

REFERENCES

American Association of Petroleum Geologists, 1944, Tectonic map of the United States, scale 1:2,500,000.

Atwood, W. W. and Mather, K. F., 1932, Physiography and Quaternary geology of the San Juan Mountains, Colorado: U. S. Geol. Survey Prof. Paper 166, 176 pp.

Bryan, Kirk, 1938, Geology and ground-water conditions of the Rio Grande depression in Colorado and New Mexico; Regional Planning, pt. VI — The Rio Grande joint investigation in the upper Rio Grande Basin in Colo., N. M., and Texas 1936-1937, Washington, D. C., Nat'l. Res. Comm., vol. 1, pt. 2, sec. 1, pp. 197-225.

Cabot, C. C., 1938, Fault border of the Sangre de Cristo Mountains north of Santa Fe, New Mexico: Jour. Geology, vol. 46, pp. 88-105.

Denny, C. S., 1940, Santa Fe formation in the Espanola Valley, New Mexico: Geol. Soc. America Bull., vol. 51, pp. 677-694.

Kelley, V. C., 1948, Geology and pumice deposits of the Pajarito Plateau, Sandoval, Santa Fe, and Rio Arriba Counties, New Mexico: University of New Mexico Pumice Project Report, 16 pp.

1952, Tectonics of the Rio Grande Depression of Central New Mexico, *in* Guidebook of the Rio Grande Country, Central New Mexico, Third Field Conference, New Mex. Geol. Soc., pp. 93-103.

Smith, H. T. U., 1938, Tertiary geology of the Abiquiu quadrangle, New Mexico: Jour. Geology, vol. 46, pp. 933-965.