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Zane E. Spiegel

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Zane Spiegel
New Mexico Institute of Mining and Technology

INTRODUCTION

Mapping of several important areas of late Cenozoic sediments in the Rio Grande trough has been accomplished by recent workers. However, four units (see correlation chart, Figure 2) mapped by Bryan and McCann (1937) along the Rio Puerco had apparently not been restudied in sufficient detail to assure definite correlations with the sections observed elsewhere. Therefore, this work was undertaken by the writer in August, 1960[1], as part of a quantitative investigation of the relationships of aquifer systems in this area to streamflow in the Rio Grande drainage basin. A geologic map was made of the lower Jemez River basin proper (Fig. 1) but the "Lower Jemez River Region" as described herein extends from White Rock Canyon to Alameda.

Field work consisted primarily of reconnaissance traverses in a four-wheel-drive truck up each of the major arroyos that drain northward into the Jemez River or eastward into the Rio Grande in the reach from the vicinity of Zia Pueblo to Alameda. Many of the faults and contacts observed in the truck traverses were traced on foot across the narrow badland ridges separating the numerous arroyos, and all data were recorded directly on 7½-minute series topographic maps (scale 1:24,000). In part of the area north of Jemez River (see Fig. 1), a map by Soister (1952, scale 1 inch per mile) was adapted. This area had previously (1958) been reconnoitered by the writer and Bruce Maxwell, and the eastern edge of Santa Ana Mesa was mapped at that time. Conclusions concerning the geologic history of the region are based in great part on reconnaissance traverses made by the writer in the course of previous investigations of ground-water resources at various localities.

REGIONAL GEOLOGIC EVENTS IN EARLY TERTIARY TIME

During Cretaceous time, the lower Jemez River region had a relatively uniform environment that produced fine-grained clastic marine sediments. Much of New Mexico became tectonically very active in latest Cretaceous time, and by early Tertiary time some areas were uplifted greatly; intervening basinal areas were gradually filled with thick sections of fine-grained red fluviatile sediments. The rocks deposited in these basins, called the El Rito, Galisteo, and Baca formations, appear to reflect a common set of conditions in the respective areas of erosion and deposition. Known outcrops of these rocks are of such limited extent that details of the original shape, topography, and geology of the basins and source areas cannot presently be reconstructed with certainty.

However, the great thickness, good sorting, and fine-grained character of the westernmost outcrops of the Galisteo formation (near La Cienega, La Bajada, and Placitas) suggest that its depositional basin was common with that of the El Rito formation, which crops out less than 40 miles to the northwest. No evidence is known that suggests the alternative hypothesis—that a drainage divide (hence a common source area) existed between the outcrop regions of these two formations. The principal source areas for the Galisteo-El Rito basin were the southern Sangre de Cristo Mountains and eastern Rio Arriba County. On the other hand, the Baca formation in central and western Socorro County appears to have been derived from uplifts in the region of the Ladron and Los Pinos Mountains in northern Socorro County; thus an east-west drainage divide probably separated the Baca and Galisteo-El Rito depositional basins. The only outcrops of the Galisteo formation in the map area (Fig. 1) are red clays near Placitas (sec. 36, T. 13 N., R. 4 E., and in T. 13 N., R. 5 E.). These fine-grained deposits do not give any direct evidence of the location and nature of the source areas, but suggest that the southern edge of the basin was far to the south of Placitas.

The character of sedimentation changed markedly in both the Galisteo-El Rito and Baca basins, because shallow intrusives broke through to the surface at several local centers (for example, Cerrillos, Cienega, Hagan, and numerous localities in Socorro County). Lava flows, breccias, pyroclastics, and volcanic-derived sediments spread out over the fluviatile sediments, filled the basins, and were in turn intruded and locally domed up by later igneous masses. The extensive disruption of pre-existing drainage by these tectonic, volcanic, and intrusive events formed several large lake and playa basins and filled them with ash and fine-grained weathering products. The entire complex of post-Galisteo volcanics and associated sediments in and near the Hagan basin has been called the Espinaso volcanics, and a similar post-Baca igneous facies in Socorro County has been called the Datil formation. The Potosi volcanic series of the San Juan region, some volcanics and intrusives in the Sangre de Cristo Mountains near Questa and Costilla, and some of the older volcanics and intrusives of the Jemez region are also possible equivalents of the post-Galisteo igneous facies.

Most of the deformation during early Tertiary time seems to have been by broad folding and basin formation, although strong folding and thrusting occurred locally. Many of the intrusive masses caused severe local deformation, metamorphism, and alteration.

REGIONAL GEOLOGIC EVENTS IN MIDDLE AND LATE TERTIARY TIME

Volcanism apparently continued sporadically in many large areas of New Mexico, contemporaneously with renewed broad uplift and erosion of old positive areas such as the San Juan-Conejos, Nacimiento-San Pedro and Zuni Mountains on the west, and the Sangre de Cristo Mountains and Pedernal Hills on the east, during late Miocene(?) and Pliocene time.

As volcanism waned, the lava and pyroclastic piles were deeply weathered and eroded and the sediments derived from them and underlying rocks were deposited in a large, broad basin or complex of basins that was warped down slowly (locally on normal faults) between these eastern and western lines of uplifts. The succession of

[1]Geologic and hydrologic reconnaissance of the area shown in Figure 1 had recently been completed by Bruce Maxwell, Geologist, U. S. Geological Survey. Mr. Maxwell accompanied the writer in the field during most of this investigation.

basin deposits, as one would expect, generally has the inverse order of superposition of the older rocks present in a particular source area; that is, volcanic facies at the bottom, then reworked Galisteo-El Rito rocks, Cretaceous rocks, and so on through the section present at the inception of this depositional period. Locally, intense volcanism contributed lava beds and pyroclastic deposits, temporarily blocked streams, and created new sediment source areas. This entire sequence of clastic deposits and interbedded lava flows in the broad Rio Grande depression has been included in the Santa Fe group by Baldwin (1961). It should be noted that the Santa Fe group is arbitrarily limited geographically, by past usage and by Baldwin's redefinition, to deposits in the Rio Grande valley. Similar sediments in many parts of New Mexico and other western states bear various local names, but have essentially the same geologic age and mode of origin.

THE SANTA FE GROUP IN THE LOWER JEMEZ RIVER VALLEY

The Santa Fe group in the map area was divided into three formations (Fig. 1), which were further subdivided into members.

Lower Unnamed Formation

The oldest unit, called herein the lower unnamed formation, consists of two main members and a minor facies mappable only locally. The lower member (Tl on Fig. 1) consists of a thick light tan to gray sandstone that appears to be derived from sandstones of Cretaceous or lowermost Tertiary age. The sandstone is generally poorly cemented except where faulted. It is poorly exposed except where the upper red member is present above it, or where local cementation along faults is abundant (e.g., southwest part of T. 14 N., R. 3 E.). The upper part of the lower gray sandstone commonly contains interbedded pumice ash and granule beds south of Jemez River, but observed exposures were too few to map separately. A local volcanic-derived facies, apparently equivalent to these beds, was mapped by Soister (1952) as the Bodega Butte member on the west side of Santa Ana Mesa (T. 14 N., R. 3 E.).

The writer believes that sediments under the eastern and northeastern rim of Santa Ana Mesa (also mapped by Soister as Bodega Butte member) are much higher in the section than the sediments on the west side, and they are mapped separately herein. Further work should be done in the area north of Santa Ana Mesa in order to fully resolve this problem, as well as to trace the volcanic facies back to the source area.

The upper member of the lower unnamed formation consists of red mudstone, reddish brown sandstone, and red silty conglomerate that appears to be derived largely from the Abo-Cutler formation and other red beds to the north. It is on the order of 500 feet thick under and southwest of Santa Ana Mesa, and in the Rincones de Zia, but apparently thins to several thick red clay beds aggregating about 100 feet in thickness near sec. 26, T. 14 N., R. 2 E. The red beds clearly interfinger extensively with the underlying gray sandstone beds and are therefore included in the lower formation.

These two areas of greater thickness of the red member may represent two distinct basins of sedimentation. The source area of the eastern basin apparently was north of Santa Ana Mesa. In the region between these basins contributions of debris from the erosion of the volcanic rocks of the Jemez Mountains may have accompanied sediments derived from erosion of the pre-volcanic red-bed terrane. The source area of the western basin was in the early Santa Fe-age Nacimiento-San Pedro Mountain uplift, prior to the eruption of the basalts on San Pedro Mountain.

Inasmuch as the regional dip of the lower and upper unnamed formations of the Santa Fe group is eastward in the eastern part of the map area, and southward in the southern part, the lower formation crops out only in the northwestern part. There is no evidence that a single through-flowing stream was present during the deposition of the lower unnamed formation; instead, there is evidence (Wright, 1946) that these alluvial deposits ("Lower Gray and Middle Red members" of Wright's "Santa Fe formation") at that time were graded to a large playa in and near T. 6 N., R. 2 W. The fine-grained sediments reported in the lower part of the Norins Well in sec. 19, T. 11 N., R. 4 E. (see Stearns, 1953, p. 475) may represent an eastern area of playa deposits distinct from, but equivalent to, those described by Wright in the lower Rio Puerco area. These fine-grained deposits, together with those of the red member along the Rio Grande near Bernalillo and Sandia Pueblo, suggest that the Sandia Mountains were not uplifted very high in early Santa Fe time. The Abiquiu (?) formation of Stearns (1953) is interpreted herein as a sedimentary facies of the lower part of the Santa Fe group, derived principally from erosion of deeply weathered volcanic rocks (Stearn's Espinaso formation) in and around the Galisteo Creek valley and the foothills near Santa Fe. The lakes inferred by Stearns (1953) at La Bajada may have been part of a large playa area which was eventually filled and later covered by coarse-grained sediments of the upper unnamed formation of the Santa Fe group.

Upper Unnamed Formation

The upper unnamed formation consists of (a) a western facies (Tub) of alluvial fan sand and gravel containing many pebbles of red granite and boulders of basalt derived from the Nacimiento-San Pedro uplift; (b) an eastern facies (Tuc) derived from Paleozoic and Mesozoic rocks east of the Rio Grande; and (c) an axial gravel facies (Tug, Tugc) that represents the deposits of a very large river that flowed generally southward. Although the streams that deposited the coalescing alluvial fans of the western and eastern facies were tributaries of the axial river, the pebbles in the river channel deposits are principally quartzite resembling Precambrian rocks in north-central New Mexico. In as much as pebbles of andesite and rhyolite similar to flows resting on the Precambrian rocks are the second most common type in these river deposits, it is inferred that the principal headwater region of the ancient river was in the Conejos-San Juan and Questa regions. Occasional gray quartzite pebbles were observed that have a hard red ferruginous cement filling fractures and external pits, and these pebbles may be reworked from former outcrops of the El Rito formation north of El Rito. It is possible that most of the quartzite and volcanic pebbles were reworked from uplifted outcrops of alluvial fan deposits and interbedded lavas of early Santa Fe age in the Tusas-Tres Piedras region (see Butler, 1946).

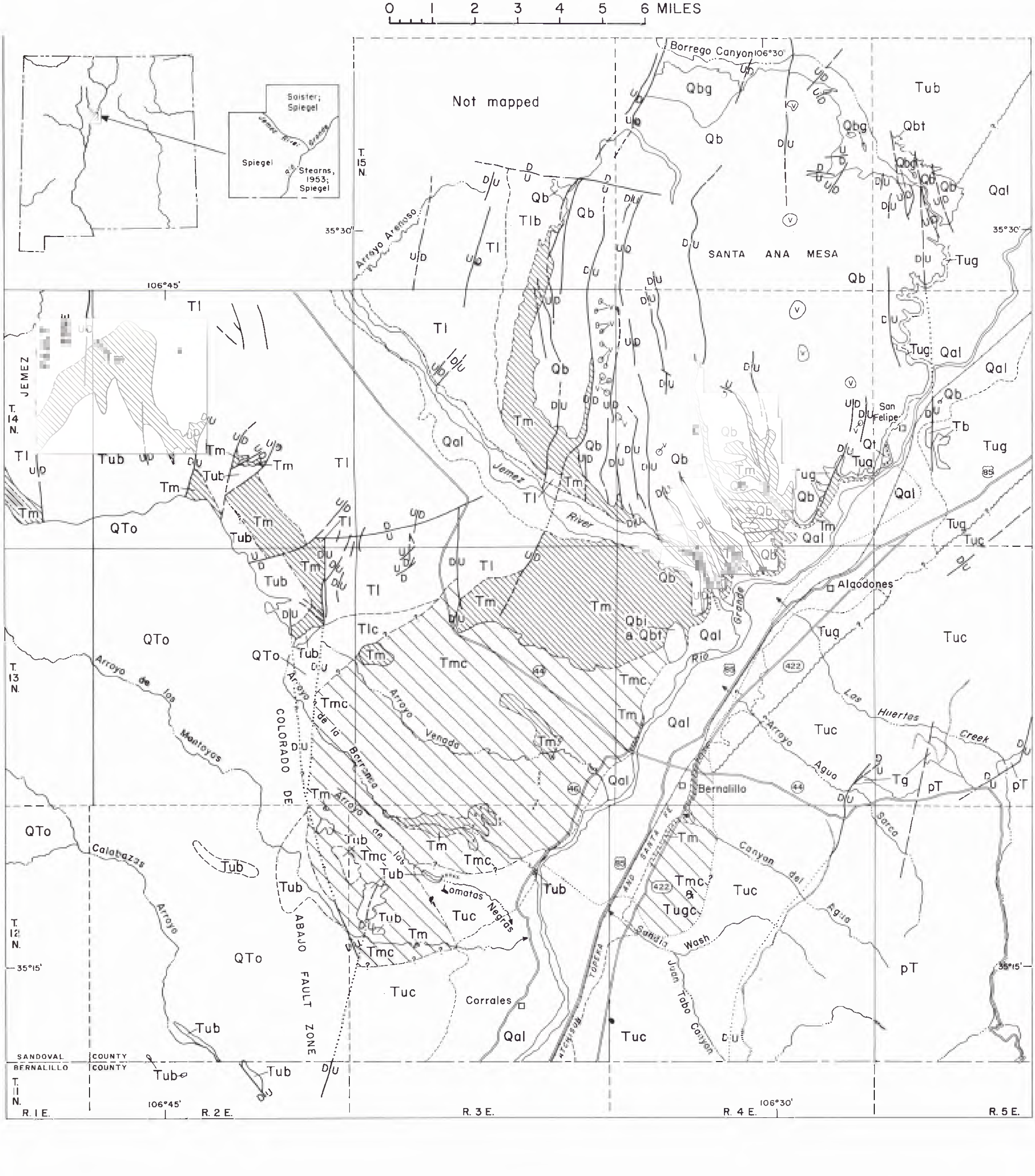
West of the longitude of Zia Pueblo, the sequence of sediments from the lower to the upper formations of the Santa Fe group clearly represents the cycle of erosion of the section of older rocks from the Nacimiento-San Pedro and western Jemez Mountains. The presence of numerous basalt pebbles in the western facies of the upper formation indicates that extensive basalt flows were poured out

FIGURE I.

GEOLOGY OF THE LOWER JEMEZ RIVER AREA, NEW MEXICO.

by

Zane Spiegel



E X P L A N A T I O N

Recent

QUATERNARY

Qal

Alluvium
Channel deposits, low terraces, fans, and slopewash along Rio Grande and Jemez River

UNCONFORMITY

Qt
xx x xx

Terrace deposits
Gravel deposited by the late Pleistocene Rio Grande; X, selected outcrops only

Pleistocene

Qbg

Basalt gravels
Basalt boulders, gravel, and sand north of Santa Ana Mesa

Qb, Qbi
Qbt

Basalt
Qb, flows from Santa Ana Mesa; Qbi, dikes and neck;
Qbt, cinders and vent-wall debris (also present nearly everywhere under the basalt on the east and northeast rims)

QTo

Uppermost gravel
Coarse sand and gravel capping high plain west of the Rio Grande

Santa Fe Group

Pliocene

ANGULAR UNCONFORMITY

Tub	Tug / Tugc / Tb	Tuc

Upper formation
Tub, western facies, sand and gravel fan deposits, locally pumiceous; Tug, axial river gravels (Tugc where covered);
Tb, basalt flow interbedded in Tug; Tuc, eastern facies, undifferentiated, generally poorly exposed or covered

TERTIARY

Miocene (?) to Pliocene

Tm	Tmc
Tl	Tlb

Lower formation
Tm, red member, mudstone, sandstone, and silty conglomerate; Tmc, covered area; Tl, lower member, light tan to gray sandstone;
Tlb, pumiceous upper part of lower member

ANGULAR UNCONFORMITY

Eocene

Tg

Galisteo formation
Red mudstone

ANGULAR UNCONFORMITY

pT

Pre-Tertiary rocks

Formation contact
Dashed where uncertain; dotted where covered

U
D
Fault
Dashed where uncertain; dotted where covered

Contact of alluvium on older rocks

(v)
Basalt cone

Zone of interfingering

at this time, and in fact, basalt flows are interbedded in the western facies northwest of Santa Ana Mesa, and also rest on an erosion surface that bevels the Precambrian rocks of San Pedro Mountain.

The interfingering of the axial river gravels and the western facies is either missing by erosion or not clearly exposed in the map area. The interfingering with the eastern facies is exposd about 2 miles east of Algodones and the general easterly dip of the upper unnamed member reverses there so that a thick section of the eastern facies, consisting of alluvial fan deposits derived from uplifted Paleozoic rocks, is exposed locally. Coarse conglomerate beds that may be equivalent in age to the lower unnamed formation in the northwest part of the map area, and to the Tesuque formation of the Santa Fe area, are exposed locally on the upthrown side of northeast-trending faults near Placitas, but have not been differentiated on the geologic map (Fig. 1).

The axial river gravels in the upper unnamed formation of the Santa Fe group crop out, with eastward dip and thickness greater than 500 feet, almost continuously from San Felipe to the mouth of White Rock Canyon. White ash beds and pumice lenses derived from the Jemez region are interbedded with the river deposits and superjacent sediments at numerous localities, especially near Pena Blanca.

North of the latitude of Santo Domingo, and east of the Rio Grande, the axial gravels interfinger with, and are overlain by, fine-grained red sediments possibly derived from the Galisteo formation. The principal thalweg of the ancient river probably trended southwest from Otowi to near Cochiti, and trended southward from a point about 6 miles west of Cochiti to Algodones, thence just east of the present inner valley of the Rio Grande to San Acacia, and through Socorro valley just west of the present river. The band of coarse channel sediments deposited by the ancestral Rio Grande is 3 to 6 miles wide from Cochiti to Socorro, but may be very narrow in the White Rock Canyon reach.

A thick bed of tilted and faulted vent-wall debris and basalt cinders underlies, or possibly is interbedded with, the axial river gravels at Cochiti diversion dam, and this "pyroclastic" unit was probably a precursor of the thick basalt flow extruded from a vent exposed near the mouth of Bland Canyon, about 4 miles north of Cochiti. Boulder beds interbedded with younger basalt flows in lower White Rock Canyon (T. 17 N., R. 6 E.) probably represent channels of the ancestral Rio Grande after it overtopped the temporary dam caused by the underlying basalt flows.

Although the boulder beds were not traced continuously through the canyon, they appear to be equivalent to the river channel deposits (Denny, 1940) in the Santa Fe group near Otowi. The latter interfinger eastward with the Ancha formation and westward with coarse arroyo deposits derived from erosion of an uplift of older volcanic rocks of the Jemez Mountains, and are underlain by the Tesuque formation (Fig. 2).

Uppermost Gravels and Other Deposits

This classification tentatively includes all sediments and basalt flows capping high surfaces, except those that were obviously deposited on erosion surfaces cut by a stream system that had the form of the present drainage network. The high plain in the southwestern part of the map area is underlain by 10 to 30 feet of gravelly sand, herein called the uppermost gravels, in which pebbles of red granite and large basalt boulders are conspicuous. This unit is generally unconformable on the western facies of the upper formation (which it closelv resembles) and on the red member of the lower formation, and slopes southeastward. It was probably derived in part from the bedrock of the San Pedro-Nacimiento highland mass, and in part by reworking of other units of the Santa Fe group that lapped up on the margins of the older and broader highlands of early and middle Santa Fe time.

The uppermost gravels are equivalent to the "Ortiz gravels" and related erosion surfaces of Bryan (see discussion of this problem in Baldwin, 1961). The unit consists of the deposits of arroyos draining the uplands that were created or renewed by greatly increased normal faulting in late Santa Fe time.

There was a great change from sedimentation in deep slowly subsiding basins interspersed among broad uplifts (Pliocene and early Pleistocene (?) time), to the deposition of relatively thin blankets graded to a master drainage system which in Pleistocene time developed into the present stream network by cyclic downcutting.

The uppermost gravels reflect rapid uplift of narrow fault blocks, superimposed on epeirogenic uplift of the entire region. In contrast, late Miocene and Pliocene time was characterized by great depression of the basins in an absolute sense, and concurrent uplift of adjacent broad upland regions.[2]

Santa Ana Mesa is a complex of basalt flows (Qb) and related vent debris (Qbt) erupted from north-trending lines of cones. The flow complex was erupted onto an eastward-sloping erosion surface of low relief. As in all the other basaltic centers in the Rio Grande depression, the first fissure or vent intrusions into saturated sediments of the Santa Fe group produced violent eruptions of basalt cinders mixed with sand torn from the vent walls. This material was deposited as a thin sheet of olive, gray-brown, or tan pyroclastic material with characteristic thin bedding caused by aerial sorting. The basalt eventually covered the pyroclastic beds in most areas, except north of lower Borrego Canyon in secs. 17, 18, and 20, T. 13 N., R. 5 E. About two miles south of Jemez Dam the core of a minor eruption center has been bared by erosion, and the complex of dikes (Qbi) and pyroclastic vent-well debris (Qbt) is well exposed. Boulder beds (Qbg) derived from older basalt flows form terraces cut into the north margin of Santa Ana Mesa.

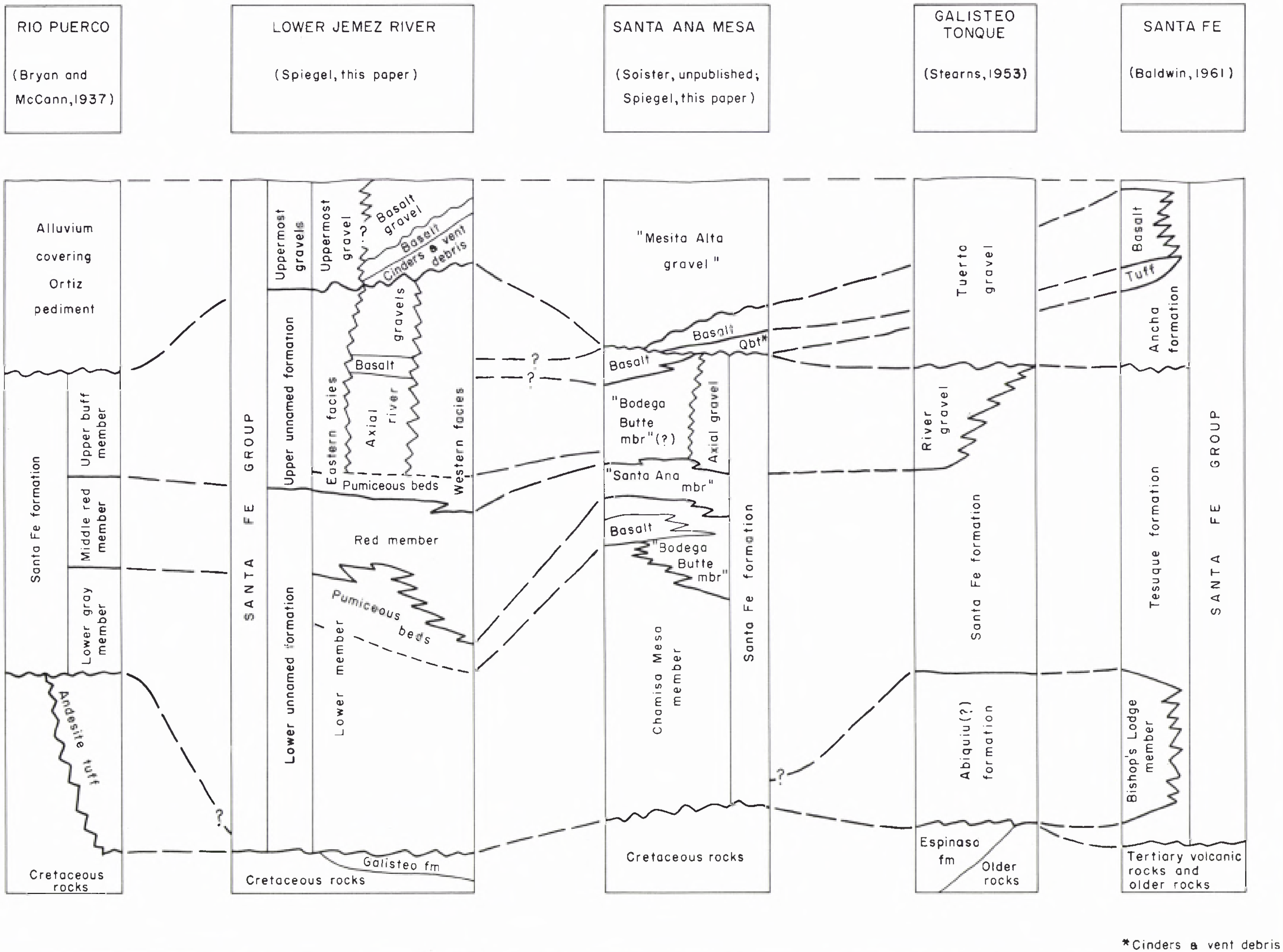
TERRACE AND CHANNEL GRAVELS

Terraces cut by the Rio Grande and tributaries are difficult to map in most areas because the soft sediments into which they are cut are easily masked by slopewash. However, some conspicuous outcrops of terrace gravels were mapped, especially those in which the contact with underlying rocks was exposed (usually the red member of the lower unnamed formation). The pebbles are well rounded, principally of gray quartzite and volcanic rocks, and were probably derived principally from the axial gravels of the ancestral Rio Grande.

The inner valleys of the Rio Grande and Jemez River are erosional channels partially refilled with boulders,

[2]The most convincing evidence of the absolute direction of movement in the basins is the contrast of the thick basin-filling sediments of the Santa Fe group with the thin blanket-like deposits of corresponding age (Ogallala formation and equivalents) on the plains to the east.

FIGURE 2.-- CORRELATION OF CENOZOIC ROCKS IN PART OF THE RIO GRANDE DEPRESSION.



gravel, and sand. The base of the channel fill is difficult to determine from well logs in most places, and the only reliable data obtained were the logs of test holes drilled at bridge or dam sites. The base of the channel fill is reported to be 56 feet below stream level (elev. 6278) at a bridge site 1½ miles above Jemez Springs and 65 feet deep at Jemez Dam. The base of the fill is about 70 feet below river level at the site of the proposed Cochiti Dam and 55 feet below the surface (elev. 5275) in the dry channel of Galisteo Creek at the site of the proposed Galisteo Dam (U. S. Army, 1958), in sec. 28, T. 15 N., R. 6 E.

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