Geology and Ground-Water Resources of The Los Alamos Area New Mexico

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With a section on QUALITY OF WATER

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the same sequence to the late Miocene, but later he (Osborn, 1918, p. 34) decided that the lower part of the sequence was transitional into the Pliocene and that the upper part was early Pliocene in age. Frick (1933, p. 549) stated that,

> * * * recent investigation indicates that the accumulations of this portion [Espanola-Santa Fe area] of the Rio Grande basin ranges from the Mid-Miocene to Pleistocene. The Pleistocene occurs in remnants of eolian origin that here and there cap the irregular Pliocene-Miocene surface.

More recent investigations by Frick and others apparently indicate that the undifferentiated unit of the Santa Fe Group of the immediate region ranges in age from about middle Miocene to middle or upper Pliocene (Frick, 1937; Wood and others, 1941, p. 31).

PUYE CONGLOMERATE

Definition

The name Puye (pronounced poo-yay) Gravel was used by Smith (1938, p. 937) as a formation name in the explanation of his map of the Abiquiu quadrangle, an area a few miles north of the Los Alamos area. Smith stated (1938, p. 949) that the new formation would be described in a forthcoming publication, but this description has not appeared, and no type locality was specified for the formation. A thick unit of conglomerate, cropping out in Guaje Canyon and along the Puye Escarpment in the Los Alamos area was traced northward into the Abiquiu quadrangle and is equivalent to the Puye Gravel as mapped by Smith. The name Puye Conglomerate is used for these rocks in this report because the formation is sufficiently consolidated to stand in vertical cliffs.

The Puye Conglomerate, as mapped in the Los Alamos area, is best exposed in Guaje Canyon and near the southern end of the Puye Escarpment where it has been eroded to form steep slopes and cliffs. The type locality is herein designated as the belt of exposures along Guaje Canyon between Guaje Mountain and the Puye Escarpment. J. E. Weir, Jr., and W. D. Purtymun measured a stratigraphic section of the formation in the NW¼NE¼SW¼ sec. 11, T. 19 N., R. 7 E., near the outer edge of the unit. A detailed description of this section is given on page 33, and a graphic section is shown on plate 1. At the site of this section the Puye Conglomerate is 232 feet thick, but it thickens westward, toward the Sierra de los Valles. The thickest known section is in a test hole in Pueblo Canyon (19.6.14.221). Here the unit is 726 feet thick.

The lower part of the formation consists of gravel composed of well-rounded pebbles, cobbles, and small boulders of quartzite, quartz, granite, and some volcanic debris in a matrix of fine- to coarse-grained arkosic sand. This unit, ranging from 0 to about 80 feet thick, is

here named the Totavi Lentil of the Puye Conglomerate. This lentil rests with angular unconformity on the undifferentiated unit of the Santa Fe Group. The upper part of the Puye, above the Totavi Lentil, is here informally called the fanglomerate member of the Puye Conglomerate. Fragments of volcanic rocks of latitic composition form most of the detritus of this thick fanglomerate member. Beds of latitic pumice also are present, and there is some included basalt.

Distribution and Thickness

The Puye Conglomerate is of local extent. It is present only on the east side of the Sierra de los Valles where it lies adjacent to the latitic rocks of the Tschicoma Formation. The strip occupied by the formation as known at the surface and in the subsurface is about 10 miles wide, and exposures extend about 15 miles in a north-south direction, from the latitude of Espanola southward into the Los Alamos area. The Puye probably is present in the subsurface for several miles south of the area of exposures, although here its east-west extent probably is fairly narrow. South of Los Alamos Canyon the deposition of the Puye Conglomerate was restricted at the east because of the synchronous outpouring of lava flows of the lower units of the basaltic rocks of Chino Mesa from centers in the Cerros del Rio. The Totavi Lentil in the southern part of the area in White Rock Canyon interfingers with basalt flows and is not a distinct unit south of the mouth of Ancho Canyon. The Puye Conglomerate at the north end of White Rock Canyon is only 60–80 feet thick. The formation thickens northward and westward on the Pajarito Plateau. The maximum known thickness is at well 19.6.14.221 in Pueblo Canyon, where the unit, including both members, is about 725 feet thick. It is 220–270 feet thick along the east edge of the Puye Escarpment. The thickness near the mouth of Guaje Canyon is 232 feet. In roadcuts along State Highway 4 in sec. 15, T. 19 N., R. 7 E., near Totavi it is about 155 feet thick.

Totavi Lentil

The Totavi (pronounced To-tah-vee) Lentil of the Puye Conglomerate is here named for the community of Totavi in the eastern part of the area. The gravel of the lentil is excavated from a quarry near Totavi and used for concrete aggregate. The quarry designated as the type locality of the lentil is just north of State Highway 4 and about a quarter of a mile west of Totavi in the NW¼SE¼SE¼ sec. 15, T. 19 N., R. 7 E. The base of the lentil is not exposed at the quarry, but it is well exposed north of Totavi where the lentil rests with erosional unconformity on the undifferentiated unit of the Santa Fe Group. The Totavi Lentil at the quarry is about 58 feet thick and is overlain conformably by the fanglomerate member of the Puye.

The Totavi Lentil is a poorly consolidated conglomerate composed of material ranging from fine-grained sand to boulders more than 1 foot in diameter. The sand, composed mainly of quartz and microcline, occurs as lenses and as an interstitial filling between the larger particles. The gravel and boulders are composed chiefly of quartzite, granite, and pegmatitic rocks derived from a Precambrian terrane. Some fragments are volcanic rocks that are foreign to the area, and a few boulders are composed of rocks from the Tschicoma Formation.

The following section of the Totavi Lentil was measured in the gravel quarry north of State Highway 4 on the north side of Los Alamos Canyon. The quarry is in the NW¼SE¼SE¼ sec. 15, T. 19 N., R. 7 E., about a quarter of a mile west of Totavi. The section was measured by J. E. Weir, Jr., and W. D. Purtymun, April 28, 1960, and is shown graphically (section A) on plate 1.

	Thickness (feet)
Top of section.	
Puye Conglomerate	
Fanglomerate member (in part):	
4. Conglomerate	20+
3. Siltstone, light-gray to light-brown; probably formed of tuffaceous material, forms ledge in upper part of quarry. Bed is well consolidated and may be calcareous where it forms a hard ledge. Near the west side of quarry the bed is almost as friable as the underlying Totavi Lentil. Bed was deposited on an irregular surface and appears to interfinger with the upper gravels of the Totavi Lentil	3+
Totavi Lentil:	
2. Conglomerate, containing interbedded interfingering sand lenses and thin siltstone beds; friable but stands as a cliff in the quarry wall. Individual lenses truncate other lenses. Upper 30–40 ft contains black stringers of carbonaceous(?) material. Sands are composed predominantly of granitic detritus. In Bayo Canyon, a short distance to the north, the Totavi Lentil is only 20 ft thick. Base of unit is very poorly exposed and covered at places	53±
Undifferentiated unit (in part):	
1. Clay, tan to brown, silty and sandy. Upper surface of clay is slightly irregular but may be a westward-sloping bench of old streambed	5+
Base of section.	

Exposures of the Totavi Lentil extend from several miles north of the Los Alamos area southward to the junction of White Rock and Ancho Canyons in the southeastern part of the area. Good exposures are nearly continuous along the Puye Escarpment and in Los Alamos and Guaje Canyons, where the lentil crops out along a topographic break between the relatively steep slopes formed on the underlying undifferentiated Santa Fe and vertical cliffs formed by the overlying fanglomerate member of the Puye Conglomerate.

The lentil in the west wall of White Rock Canyon is poorly but continuously exposed to immediately south of Ancho Canyon, where it interfingers with beds of basalt and poorly consolidated sediments of the lowest unit of the basaltic rocks of Chino Mesa. Beyond this point it could not be differentiated from enclosing basalt flows. Thin wedges of the lentil pinch out eastward on the east side of the Rio Grande.

Drill cuttings from the Totavi Lentil were obtained from several wells and test holes west of the outcrop areas. The lentil was penetrated by four wells in Guaje Canyon, but it pinches out between wells 19.7.5.231 (G4) and 5.112 (G5) in this canyon. It was penetrated also by well 22.114 (L4) in Los Alamos Canyon and by test holes 19.6.13.344, 14.221, and 19.7.20.221 farther west in Los Alamos and Pueblo Canyons. As indicated by cuttings from test hole 19.6.17.234 in Los Alamos Canyon, it is interbedded between two quartz latite flows of the Tschicoma Formation. The Totavi Lentil thickens northwestward from its area of wedgeout in White Rock Canyon and is about 88 feet thick at test hole 19.6.14.221 in Pueblo Canyon.

The Totavi Lentil is nonconformable with the underlying undifferentiated unit of the Santa Fe Group at some places and disconformable at other places. The lentil in the northeastern part of the area is overlain conformably by the fanglomerate member of the Puye Conglomerate. At the northwest tip of Sagebrush Flats, it is overlain conformably by arkosic sedimentary rocks of the upper tongue of the undifferentiated unit of the Santa Fe. It is overlain by and interfingers with basaltic rocks of Chino Mesa in White Rock Canyon. For the most part it is overlain conformably by unit 1 of these basaltic rocks; but south of Ancho Canyon it interfingers with this unit, and, in places, the lentil is overlain conformably by unit 2 of the basaltic rocks of Chino Mesa. To the west, the lentil interfingers in the subsurface with quartz latite flows of the Tschicoma Formation, as shown by the log of test hole 19.6.17.234 in Los Alamos Canyon.

Fanglomerate Member

The main body of the Puye—the fanglomerate member—is composed of debris that has been washed eastward from rocks of the Tschicoma Formation. Exposures along Guaje Canyon are apparently typical of the fanglomerate member (fig. 12) although test holes show large amounts of water-washed pumice locally. Exposures of the fanglomerate member in the Los Alamos area extend northwestward from a point just southwest of Otowi bridge along canyons incised in the Pajarito Plateau and northward along the Puye Escarpment. It is exposed in grayish-buff cliffs which have been intricately fluted by erosion. The upper surface of the Puye is

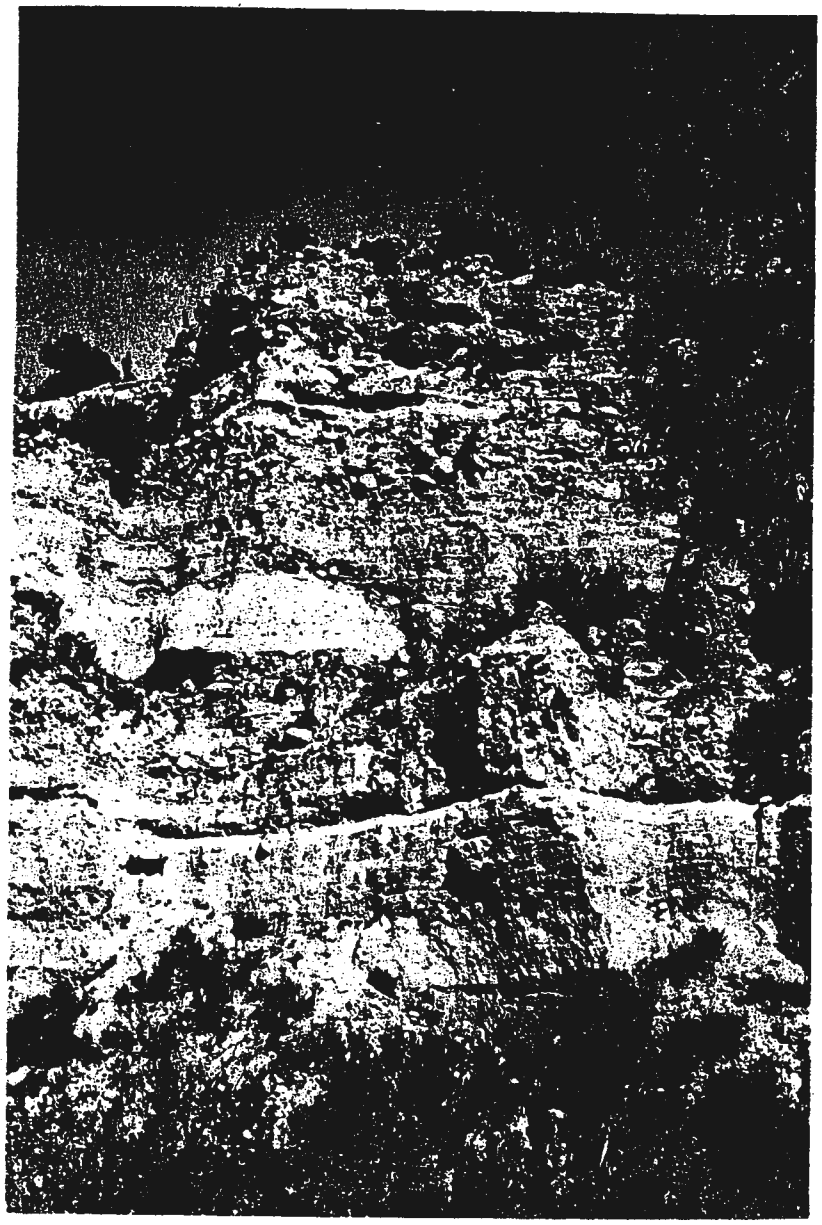

FIGURE 12.—Exposure of the fanglomerate member of the Puye Conglomerate in Guaje Canyon. The white bed that pinches out abruptly is water-washed pumice.

eroded; hence, the original thickness of the fanglomerate member cannot be determined. The thickest known section of the fanglomerate member is 637 feet at test hole 19.6.14.221 in Pueblo Canyon. The member is 209 feet thick at the measured section of the Puye Conglomerate. It thins southward and wedges out just southwest of Otowi bridge, where it abuts against unit 2 of the basaltic rocks of Chino Mesa.

Most of the fanglomerate member apparently is composed of silty sandy conglomerate in which beds of two types commonly can be recognized. These beds differ only by the relative abundance of fine- and coarse-grained material. They intertongue in places. Silt and sand are relatively minor constituents in one type, occurring chiefly in interstices between larger fragments. The amount of silt and sand generally is greater than the amount of gravel and boulders in the other type. Sorting is poor in both types. Near the western margin of the member, where it contains the coarsest material, boulders and angular blocks as large as 5 feet or more in diameter are contained in a matrix whose individual particles range downward in size to silt. In places such boulders are isolated in the finer matrix. Ten miles to the east where the member contains the finest material, beds of silt, sand, and gravel are associated intimately. Bedding is indistinct throughout the member, but layering that dips at least 1° or 2° to the east can be seen at most localities. Locally the dips are more than 10° to the east.

The following section of the fanglomerate member, Santa Fe Group, was measured on the north wall of Guaje Canyon about three-fourths of a mile west of the confluence of Guaje and Los Alamos Canyons. The Puye forms most of the steep slopes and cliffs of the canyon wall here, and the benches and gentle slopes at the top of the canyon are underlain by some old alluvium. The Bandelier Tuff caps the highest part of the north wall of the canyon. The base of the section is in the NW¼NE¼SW¼ sec. 11, T. 19 N., R. 7 E., in a small wash on the south side of a topographic promontory. The altitude of the top of the Puye is about 6,190 feet. The section is shown graphically (section *B*) on plate 1 and was measured by J. E. Weir, Jr., and W. D. Purtymum, April 28, 1960.

Old alluvium (resting unconformably on the Puye).

	Thickness (feet)
Puye Conglomerate:	
Fanglomerate member:	
12. Conglomerate, pinkish-gray. Contains lenses of gravel ranging in grain size from granules to boulders. Unit contains a 5-ft layer of light-tan conglomeratic siltstone (puddingstone) about 30 ft from base. Boulders 2–3 ft across occur in layers near the top of the unit. Many boulders are composed of porphyritic red and light-green latite	50

	Thickness (feet)
Puye Conglomerate—Continued	
Fanglomerate member—Continued	
11. Siltstone, gray, conglomeratic (puddingstone). Similar to unit 8 below. Unit probably is of laharic origin	17
10. Boulder conglomerate, with silty or Kosic matrix. Boulders are composed of latite and porphyritic quartz latite	4
9. Siltstone, conglomeratic (puddingstone). Unit contains widely dispersed pebbles and a few thin layers of granule gravel. Gravel is composed of volcanic detritus. Unit probably is of laharic origin	56
8. Conglomerate, brownish- to bluish-gray. Gravel ranges in grain size from granules to boulders as much as 3–5 ft across. Matrix is moderately rounded sand and silt and a few lenses of tan siltstone. Gravel is composed of dark-gray and red to purple volcanic ditritus. Porphyritic latite noted	22
7. Siltstone, tan to light- and medium-gray; very pumiceous in lower 8 ft and conglomeratic and pumiceous in upper 5 ft. Gravel bed at top is highly crossbedded. Pumiceous beds contain a small amount of granules composed of latitic volcanic detritus. Pumice and other volcanic debris are rounded and stream worn, or worn in mudflow	13
6. Siltstone, conglomeratic; contains alternate layers and interlenses of volcanic gravel. The gravel ranges in grain size from granules to pebbles and is composed almost exclusively of volcanic detritus. Gravel occurs in crossbedded lenslike layers	36
5. Siltstone, light-tan, medium-bedded; blocky in places. Contains a few gravel lenses composed of volcanic detritus and some arkosic detritus	11
Totavi Lentil:	
4. Gravel, pinkish-gray; very well rounded from stream action. Gravel composed mainly of quartzite, white massive quartz and granite and other felsic rock detritus with some intermixed volcanic detritus. Gravel ranges in size from granules to boulders. Arkosic sand of varied grain size fills interstices in gravel beds. Unit is very friable. Angular unconformity at base of unit	23
Undifferentiated unit (in part):	
3. Sandstone, creamy-gray, silty; contains some lenses that are conglomeratic. Gravel is mostly volcanic detritus	13
2. Conglomerate, bluish- to light-gray, very sandy and friable. Gravel ranges in size from granules to pebbles and a few cobbles. Layer of cream-gray sand, 2 ft thick, is about 5 ft above the base. Gravel is mostly volcanic detritus with some quartzite and arkosic detritus	12
1. Siltstone, pink, sandy, very friable. Bed is exposed extensively in lower Guaje Canyon and is the uppermost pink bed in this vicinity. Apparent dip is 1° in a S. 11° W. direction	10
Base of section.	

Nearly all the detrital fragments are latitic. These fragments are pebbles, cobbles, and boulders and are gray and purplish-gray to red

quartz latite and latite. All the fragments are conspicuously porphyritic. Phenocrysts of plagioclase, some of which are more than half an inch long, form about 25 percent of the rocks. Other less common phenocrysts are composed of augite, biotite, and hornblende. The quartz latite fragments also contain small phenocrysts of quartz. The sand is composed of fragments of these rocks and their phenocrysts. The silt is latitic debris that commonly is partly glassy to glassy.

Light-gray pumice beds ranging in thickness from a thin film to a few feet have been observed on the surface in several places, and such beds are quite thick in places in the fanglomerate member in the subsurface. Test hole 19.6.13.344 in Los Alamos Canyon penetrated 90 feet of water-washed pumice in the lower part of the fanglomerate member, and test hole 14.221 in Pueblo Canyon penetrated 320 feet of similar pumice that lies directly on the Totavi Lentil. These pumice beds are composed of angular to subangular fragments as much as 2 inches in diameter. Locally they contain abundant fragments of porphyritic latite. Ash commonly fills the interstices. The pumice is latitic and tiny phenocrysts of biotite and plagioclase are common. The pumice also contains tiny phenocrysts of hornblende and pyroxene. For the most part these beds seem to be water-lain, but horizontal bedding is well developed in other beds that possibly may have been deposited as ash fall. The fanglomerate member along the Puye Escarpment contains a few thin beds of very fine grained white tuff. These beds, ranging in thickness from about 1–3 feet, rest directly on the Totavi Lentil and are water-laid ash. Abundant diatoms were noted in one specimen collected from this ashy material. Large isolated boulders in a matrix of sandy silt or silty sand occur in places (fig. 13). These beds were deposited as volcanic mudflows or lahars.

The fanglomerate in the subsurface contains flows of basalt. The flows between depths of 176 and 255 feet penetrated by test hole 19.7.20.221 in Pueblo Canyon, and those between depths of 266 and 388 feet penetrated by test hole 19.6.13.344 in Los Alamos Canyon are medium to dark gray. The rock is composed of small phenocrysts of plagioclase and tiny phenocrysts of olivine and clinopyroxene in a fine- to medium-grained groundmass of semifelted plagioclase, clinopyroxene, olivine(?), and magnetite, as determined by study of thin sections. These flows are identical in composition with some of those in unit 2 of the basaltic rocks of Chino Mesa and are correlated with these rocks. The basalt between depths of 410 and 510 feet penetrated by test hole 19.7.20.221 is similar to and also is correlated tentatively with unit 2 of the basaltic rocks of Chino Mesa.

The fanglomerate member rests conformably on the Totavi Lentil and interfingers with parts of the Tschicoma Formation and basaltic

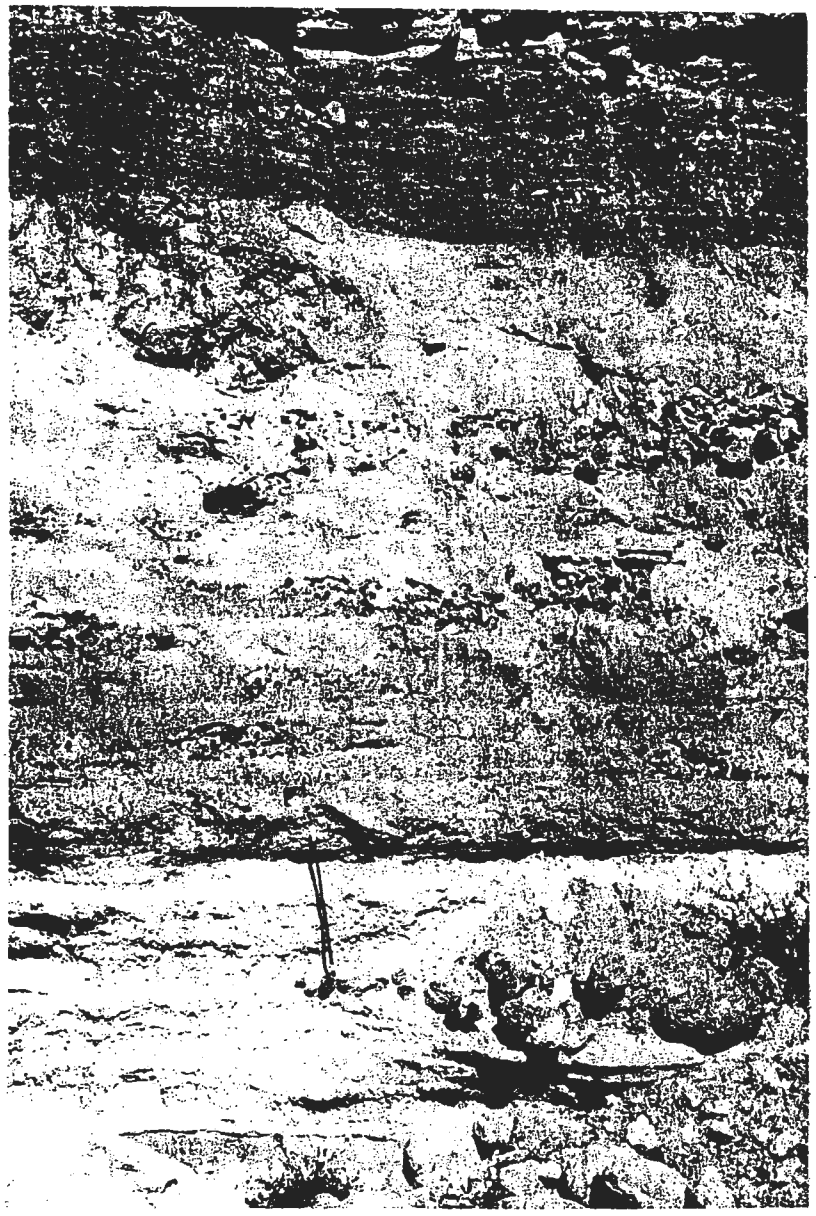

FIGURE 13.—Exposure of the fanglomerate member of the Puye Conglomerate in the upper part of Guaje Canyon near well G5. The white material is water-washed pumice; the overlying material which contains near the top an isolated boulder 2 feet across (in silt-size debris with irregular lenses of conglomerate and breccia), is a lahar about 6 feet thick; the material at the top is water-deposited conglomerate.

rocks of Chino Mesa along its eastern and western margins, respectively, indicating that the fanglomerate is contemporaneous in age with these rocks. C. S. Ross and R. L. Smith (oral communication) also observed that the fanglomerate member interfingers with the easternmost latitic flows of the Tschicoma Formation in Santa Clara Canyon, north of the Los Alamos area. The fanglomerate is overlain in the subsurface by flows of pyroxene andesite of the Tschicoma Formation at test hole 19.6.17.234 in Los Alamos Canyon. The lowest flows of Chino Mesa interfinger with the Totavi Lentil, and the basalt overlying the Totavi Lentil is surely equivalent in age to the lower part of the fanglomerate member. The occurrence within the fanglomerate of basalt that is identical in appearance and mineralogy with some of the flows of unit 2 of the basaltic rocks of Chino Mesa indicates that the basalt of unit 2 was erupted at the time of deposition of the higher parts of the fanglomerate. Rocks that overlie the Puye disconformably include: units 3 and 4 of the basaltic rocks of Chino Mesa, the old alluvium, and the Guaje Member of the Bandelier Tuff.

Age

The age of the Puye conglomerate is believed to be late Pliocene because of its stratigraphic position. However, diatoms found immediately above the Totavi Lentil may be either late Pliocene or early Pleistocene in age.

BASALTIC ROCKS OF CHINO MESA

Definition

The basaltic rocks of Chino Mesa consist of a thick sequence of basaltic to andesitic rocks and minor amounts of included poorly consolidated sediments that form Chino Mesa and adjacent parts of the Cerros del Rio and that cap some outlying mesas and buttes to the north. The sequence is thickest in the interior of the Rio Grande depression, and only its northern and western extensions occur in the Los Alamos area.

Distribution and Thickness

The basaltic rocks of Chino Mesa form the steep walls of White Rock Canyon and cap the high mesas to the east. West of the canyon, these rocks cap a large mesa mainly south of the settlement at White Rock. They are exposed in deep canyons cut in the overlying Bandelier Tuff on the east side of the Pajarito Plateau as far north as Los Alamos Canyon. Most of the basalt was erupted from centers in the Cerros del Rio and flowed northwestward into the Los Alamos area, where the older units interfinger with the Puye Conglomerate and an old alluvium unit. The basaltic sequence is more than 1,300 feet thick in the vicinity of Chino Mesa.