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The Palomas Formation of south-central New Mexico—a formal definition

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Abstract

Upper Santa Fe Group deposits occurring in the Palomas, Engle, and San Marcial Basins of the southern Rio Grande rift are here named the Palomas Formation. The term "Palomas gravel" was first applied to Plio-Pleistocene basin fill in the region in 1907; however, the unit has never been defined formally. It consists of alluvial-fan and coalescent-fan deposits (piedmont facies) and ancestral Rio Grande fluvial deposits (axial-river facies). Maximum thicknesses range from 100 to more than 130 m locally. Formation deposition probably began before 5 Ma and continued until 400,000 to 500,000 years ago. The formation can be distinguished from other upper Santa Fe Group deposits by its extensive piedmont facies and relatively narrow belt of axial-river deposits. Older Santa Fe units (Miocene–latest Oligocene), which do not contain axial-river facies, occupy remnants of early rift basins that predate development of the present system of basins and uplifts.

Introduction

Upper Cenozoic basin fill in the Rio Grande rift is generally referred to as the Santa Fe Formation or Group, a term first proposed by Hayden (1873) for deposits in the Santa Fe area. The first definitive statement about the southern extension of the Santa Fe Formation was by Bryan (1938, p. 205):

> The main body of sedimentary deposits of the Rio Grande depression, from the north end of San Luis Valley to and beyond El Paso, is considered to be the same general age and to belong to the Santa Fe formation.

Baldwin (*in* Spiegel and Baldwin, 1963, pp. 38–39) formally proposed that the formation be raised to group status and considered:

> . . . [the group] to be a broad term including sedimentary and volcanic rocks related to the Rio Grande trough, with a range in age from middle(?) Miocene to Pleistocene(?).

Hawley et al. (1969) reviewed the status of research on the Santa Fe Group in south-central New Mexico and first described reference sections for upper and lower parts of the group.

Recent detailed mapping of basin fill in southern New Mexico has led to formal definition of a number of formations within the Santa Fe Group. The upper Santa Fe has been subdivided into: the Camp Rice and Fort Hancock Formations in the Mesilla and Hueco Bolson of New Mexico and Texas by Strain (1966, 1969), the Camp Rice Formation in the Rincon Valley–Jornada Basin area by Seager et al. (1971), and the Sierra Ladrones Formation in the Socorro and Albuquerque Basins by Machette (1978a, b). Recently, the gap in detailed mapping of the upper Santa Fe deposits in the Palomas and Engle Basins was partially filled by Lozinsky (1982, 1986). He proposed that upper Santa Fe Group deposits in the Elephant Butte area be designated the Palomas Formation.

Use of the term "Palomas" to designate upper Cenozoic deposits in this region is not new (Keroher et al., 1966, p. 2906). Gordon and Graton (1907) and Gordon (1910, p. 237, pl. XII) initially referred to the basin fill cropping out along Palomas Creek as the "Palomas gravel." Harley (1934, pp. 29–30, pl. II) referred to the coarse-grained, upper part of the basin fill as the "Palomas gravel," but he considered the older basin-fill deposits to be at least partly equivalent to the late Tertiary Santa Fe Formation. Kottlowski (1953, 1955) and Jahns (1955a, b) described the "Palomas gravels" as a unit that intertongued with upper Santa Fe strata. However, Kelley and Silver (1952) followed Bryan's (1938) terminology in designating the basin fill (exclusive of "valley fill and pediment-capping gravel") as Santa Fe Formation.

In ground-water studies of the Palomas and Animas Creek Basins, Murray (1959, pp. 7–8) and Davie and Spiegel (1967, p. 9) recognized that exposed basin-fill deposits are the "Palomas gravels." Davie and Spiegel (1967) included these deposits in the "upper part of the Santa Fe group" and showed that they comprised alluvial-fan (piedmont), axial-river, and transitional facies. The U.S. Geological Survey (Heyl et al., 1983) recently used the term "Palomas Gravel" to designate "purplish-gray gravel and sand about 300 m ☞

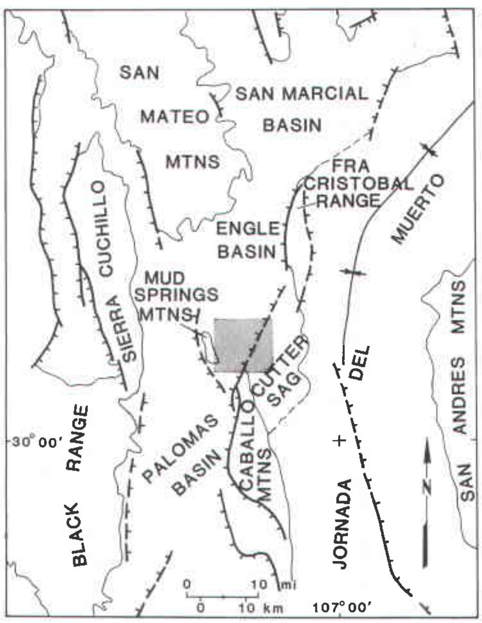

FIGURE 1—Generalized tectonic map of south-central New Mexico. Shaded area was covered by Lozinsky (1982, 1986). Lines with hachures are normal faults (hachures on downthrown side; dashed where inferred). Solid and hatched lines delineate major uplifts.

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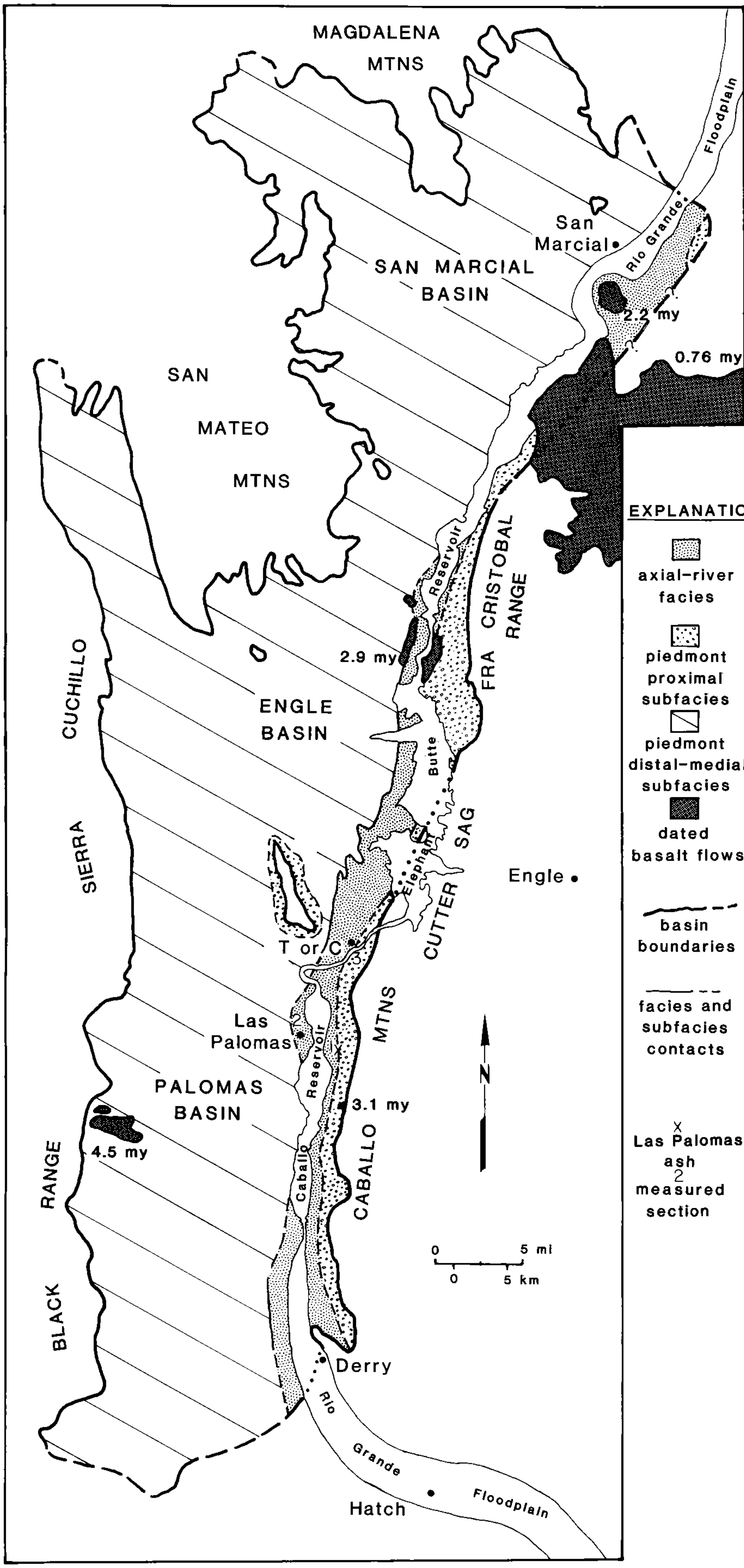

FIGURE 2—Geologic map of the Palomas Formation showing aerial extent of facies and subfacies and locations for dated basalt flows, volcanic ash, and measured sections.

thick" exposed along and between Alamosa and Cuchillo Negro Creeks in the northwestern part of the Palomas Basin. However, their map unit may also include lower Santa Fe deposits. Maxwell and Oakman (1986) used the term "Palomas Gravel" in the same general sense as Palomas Formation is used in this paper, but they did not include the rock unit in the Santa Fe Group.

Despite long usage, the name Palomas has never become adopted fully. No type section has ever been described, and the rock-stratigraphic unit has not been defined formally. The objectives of this article and a companion paper by Lozinsky and Hawley (1986) are to define formally the Palomas Formation as a lithostratigraphic unit that comprises all upper Santa Fe deposits in the Palomas, Engle, and San Marcial Basins (Fig. 1) between Derry and San Marcial (Fig. 2), and to describe a composite type section of the formation in the northern Palomas Basin (Table 1). Due to its varied lithologic character, the Palomas is here designated as a formation rather than a gravel.

Description of the Palomas Formation

The Palomas, Engle, and San Marcial Basins are located in the southern part of the Rio Grande rift and cover an area of 3,800 km^2 (Fig. 1). The Palomas Formation is exposed throughout these basins (Fig. 2), and it can be divided into two major facies: piedmont and axial river. The composite type sec-

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tion (Table 1) comprises three measured sections. The mostly constructional Cuchillo geomorphic surface caps the piedmont facies and marks the end of Palomas Formation deposition (Lozinsky and Hawley, 1986).

Piedmont facies

The piedmont facies composes the major portion of the Palomas Formation. It rests with an angular unconformity on a variety of bedrock units along the major uplifts bordering the basins. However, in many central-basin areas the piedmont facies appears to grade downward into similar coarse-grained deposits of the lower Santa Fe Group (refer to Seager et al., 1984, fig. 6). The contact with possible lower Santa Fe beds can be observed just south of Truth or Consequences (T or C) in the lower part of the composite type section exposed along the Rio Grande (Table 1, section 3). The poorly exposed contact shows a fanglomerate of the Palomas Formation overlying a reddish-brown silty claystone that may correlate with the Miocene Rincon Valley Formation mapped by Seager et al. (1982) south of Caballo Reservoir. However, due to the limited exposure area, the designation of the silty clay unit as Rincon Valley is not certain. Maxwell and Oakman (1986) showed lower Santa Fe Group deposits cropping out along the south side of Cuchillo Negro Creek about 1.5 mi east of Cuchillo and 2 mi west of the area mapped in detail by Lozinsky (1982, 1986).

Based on lithologic character, the piedmont facies can be grouped into proximal, medial, and distal subfacies. Outcrops of the proximal subfacies seldom extend more than 3 km from mountain fronts. The term proximal refers to the local provenance and short transport of sediments. The proximal subfacies is described in the upper part of the composite type section southeast of Las Palomas (Table 1, sections 1 and 3). The proximal subfacies consists primarily of light-brown to reddish-brown, poorly sorted, lenticular to weakly stratified fanglomerates and fan gravels. These deposits were laid down by debris-flow-dominated alluvial fans that derived detritus from adjacent uplifts. Thus, clast composition reflects the lithologies of the nearby uplifts, and beds tend to coarsen and become more massive closer to the uplifts. Scattered reddish-brown clay interbeds represent argillic paleosols that locally include basal, light-colored calcic soil horizons. The proximal subfacies ranges from nonindurated to strongly indurated. Cliff-forming fanglomerate beds that are moderately to well cemented with calcium carbonate are commonly present in this unit.

The medial and distal subfacies crop out extensively in the region between the western margin uplifts and the Rio Grande and intertongue with proximal subfacies deposits. The medial subfacies is transitional between the proximal and distal piedmont units. It forms a broad belt of deposits in parts of the Palomas, Engle, and San Marcial Basins west of the Rio Grande valley. Excellent exposures of the medial subfacies, which mainly consist of gravelly deposits of coalescent alluvial fans, occur in the deep arroyo valleys west of I-25 between Caballo Dam and San Marcial (e.g., valleys of Percha, Animas, Seco, Cuchillo Negro, Alamosa, Nogal, and Mulligan Gulch arroyos). Piedmont gravels of this subfacies are illustrated in Hawley (1978, pp. 91–92) and Seager et al. (1984, fig. 6).

The term distal refers to a distant source area and long transport. The distal subfacies forms most of the type section along Palomas Creek (Table 1, section 2). Alternating beds of light-pink to dark reddish-brown sandy silt, conglomerate, and clay compose the distal subfacies (Fig. 3). Sediments within the distal subfacies are generally better sorted, finer grained, and better stratified than proximal subfacies deposits. In particular, conglomerates show better clast rounding, are less massive, and contain a variety of volcanic clasts including rhyolites, tuffs, basalts, and andesites. Interbedded argillic and calcic paleosols also occur. The distal subfacies is interpreted to have been deposited in channels and on channel margins of a large piedmont-fan system that extended from the western uplifts into the basins. Clast composition and imbrication direction indicate that the source area was mainly the volcanic terranes to the west. Deposits of the distal subfacies range from nonindurated to moderately indurated and weather to form either badland topography or cliffs of resistant ledges.

Axial-river facies

The axial-river facies crops out within a 3-km-wide strip that extends through the length of the three basins and roughly follows each basin axis. This fluvial facies is composed of a thick accumulation of internally cross stratified sandstones and sands, with pebble conglomerate, gravel, and clay lenses. Calcite is the dominant cementing agent. The unit intertongues with the piedmont facies (Table 1, sections 1 and 2). The thickest axial-river deposit described herein (7.1 m) occurs in measured section 1, units 1 and 5; however, fluvial sequences exposed along the Rio Grande valley are commonly much thicker. The moderately to well sorted, fine- to medium-grained sand is typically light gray and arkosic. Gravel lenses commonly occur along the bottom of trough crossbeds. Clay lenses and mudballs are scattered throughout the unit. The abundant crossbeds, lack of clay, and the good sorting suggest that the unit was deposited by an aggrading, through-flowing braided river, the ancestral Rio Grande. The nonindurated to moderately indurated character of the axial-river facies results in a low rolling erosional topography.

Thickness

Limited data exist on the maximum thickness of the Palomas Formation because no complete section through the unit has been observed in outcrop. The three measured sections that make up the composite type section (Table 1) include representative thicknesses of piedmont and axial-river facies components. However, no aggregate thickness can be calculated by summing up thicknesses of the individual sections because they probably include time-correlative facies units. The maximum exposed thickness of combined distal-piedmont and axial-river facies in the type area is about 66 m along the north side of Palomas Creek (Table 1, section 2), but this is an incomplete section. As much as 90 m of Palomas piedmont gravels are exposed in cuts along both sides of Monticello Canyon (Hawley, 1978, pp. 91–92).

The maximum measured (or recorded) thickness of the Palomas Formation was obtained from the West Elephant Butte Federal 3 No. 2 wildcat well completed in 1983 by Getty Oil Company. This well was spudded in the axial-river facies, and preliminary ex- ☞

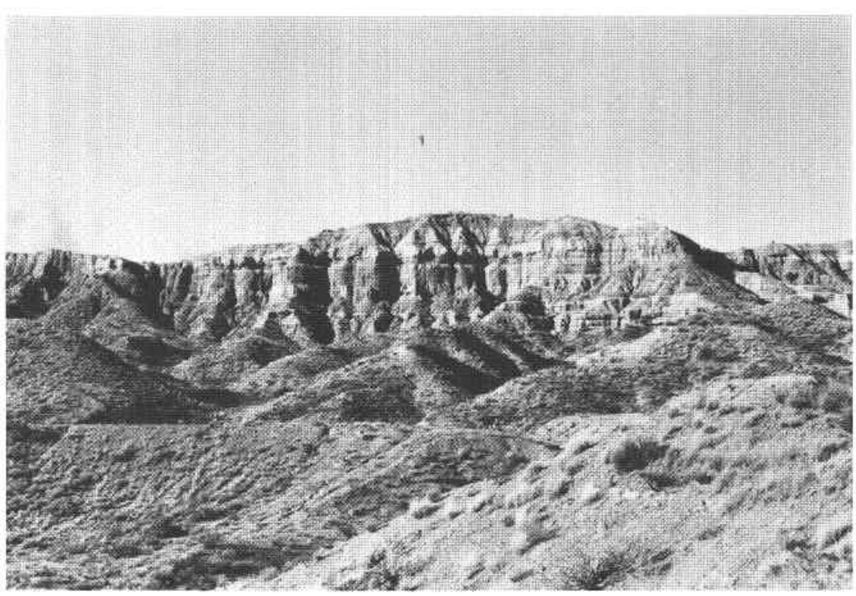

FIGURE 3—Outcrop of distal subfacies along south side of Palomas Creek. This is Gordon and Graton's (1907) type area for the Palomas gravel.

amination of well cuttings shows a thickness of 131 m for this one facies. Thus, the Palomas Formation ranges in thickness from 100 to at least 131 m.

Age of the Palomas Formation

The age of the Palomas Formation is not known precisely; however, using faunal remains, volcanic material, and correlations with other units, upper and lower age limits can be approximated.

Lucas and Oakes (1986) reported a Cuchillo Negro Creek fauna of medial Blancan age or about 3 Ma at the intertonguing contact between the piedmont and axial-river facies. Repenning and May (1986) reported the oldest faunal dates from the Palomas Formation based on vertebrate fossils that were found in the lower part of the axial-river facies near T or C. These fossils include aff. *Oryzomys* (rice rat), *Prosigmoden intermedium* (cotton rat), and *Paraneotoma fossilis* (pack rat), and indicate an early Blancan age between 4.05 and 4.2 Ma.

Dated volcanic features include scattered basalt flows in all three basins and tephra in the Palomas Basin; the locations are shown in Figure 2. K–Ar ages of basalt flows, unless otherwise noted, were taken from Bachman and Mehnert (1978).

Three dated basalt flows are located along the eastern margins of the San Marcial and Engle Basins. The oldest flow is located in the Engle Basin at the northern end of Elephant Butte Reservoir (Mitchell Point). This flow is interbedded in axial-river sand and has been dated at 2.9 ± 0.1 Ma. The Black Mesa flow at San Marcial overlies about 90 m of axial-river sands and has a radiometric age of 2.2 ± 0.1 Ma. Located just south of Black Mesa is the extensive Jornada flow, which has the youngest radiometric date for the Palomas Formation of 0.76 ± 0.1 Ma. This flow was possibly once interbedded in the uppermost deposit of the axial-river facies and has since become exhumed.

The Palomas Basin contains three dated volcanic units (Seager et al., 1982, 1984). The oldest, located along the western margin of the basin northeast of Animas Peak (Copper Flat), is a basalt flow dated at 4.5 ± 0.1 Ma (Seager et al., 1984, UAKA 79–139). This partly exhumed flow was buried within the basin by upper Santa Fe piedmont gravels. Along the western slope of the Caballo Mountains, a basalt flow dated at 3.1 ± 0.1 Ma is interbedded with piedmont fanglomerates (Seager et al., 1984, UAKA 79–127). About 6 km north of this flow is a lenticular bed of volcanic ash capping axial-river sand that intertongues with the piedmont facies (Table 1, section 1). This ash-fall deposit is informally called the "Las Palomas ash" and has been correlated with an unspecified member of the Cerro Toledo rhyolite in the Jemez Mountains (M. Machette, written comm. 1982). The Cerro Toledo eruptions occurred 1.2 to 1.45 m.y. ago (Izett, 1981; Izett et al., 1981; Heiken et al., 1986). Ages younger than the 0.76 Ma date have not been established for the Palomas Formation, but when correlated with the Camp Rice Formation to the south, the uppermost Palomas beds may be 400,000 to 500,000 years old (Gile et al., 1981; Seager et al., 1984).

These dated sections, although restricted to a few areas, do establish a general age range for the Palomas Formation. The lower part of the axial-river facies is older than 4.2 Ma, and parts of the piedmont facies may be significantly older than 4.5 Ma. The upper part is at least 1.4 Ma and locally may be as young as 400,000 to 500,000 years old. This indicates that the Palomas Formation was deposited over a time span of at least 5 million years.

Distinguishing features of the Palomas Formation

The Palomas Formation is lithologically similar to and can be correlated with two other upper Santa Fe formations: the Sierra Ladrones to the north and the Camp Rice to the south. However, there are some important differences, specifically in the physiographic framework of the basins and in the mode of deposition of the axial-river facies.

The Sierra Ladrones Formation occurs in the Socorro and Albuquerque Basins. These basins have irregular boundaries and are flanked by major uplifts only locally. The Albuquerque Basin is also much wider than the basins containing the Palomas Formation. The axial-stream facies associated with ancient basin-floor environments covers a much larger area than the piedmont facies and is the dominant lithology of the Sierra Ladrones Formation. This facies-distribution pattern resulted from fluvial deposition by several major tributary streams (including the ancestral upper Rio Grande, Rio Puerco, and Rio San Jose) on a very broad basin floor rather than deposition by a single river following the axis of a narrow basin. The resulting distributary pattern of the fluvial facies is very complex and several belts of axial-stream deposits may be present that converge southward to a single trunk stream near Socorro.

Contrasting depositional environments also characterize the Camp Rice Formation. The Mesilla Basin, like the Albuquerque Basin, lacks a major bounding uplift to the west and is very broad. The Camp Rice Formation is also dominated by a basin-floor fluvial facies, but unlike the contributory drainage system associated with the Sierra Ladrones Formation, the Camp Rice was mainly deposited by fan-delta distributaries extending southward into the bolsons of Trans-Pecos Texas and Chihuahua. The fan-delta deposits begin in the southern Palomas Basin just north of Hatch and widen to the south (Hawley et al., 1969, 1976; Seager, 1981; Gile et al., 1981). At its widest point near El Paso, the width of the fan-delta exceeds 65 km.

The Palomas Formation is a piedmont-facies-dominated deposit associated with the present series of north-trending rift basins between Derry and San Marcial that formed in late Miocene and early Pliocene time (9–3 Ma; Seager et al., 1984). The basins containing the Palomas Formation are much narrower than the basins to the north and south (i.e., Albuquerque and Mesilla Basins) and have major uplifts bounding the basins to the east and west. No fan-delta deposits occur in the axial-river facies. Rather, this facies comprises braided river deposits that seldom exceed 3 km in width.

In contrast to the Palomas Formation, lower Santa Fe units of latest Oligocene and Miocene age are dominated by intertonguing, coarse piedmont-alluvial and fine-grained basin-floor facies, which include fanglomerates and playa sediments (Seager et al., 1982, 1984). These deposits partly fill remnants of early rift basins and are only exposed in a few areas near the modern margins of the Palomas, Engle, and San Marcial Basins.

Summary

The Palomas Formation is here designated as the name for all upper Santa Fe Group deposits occurring in the Palomas, Engle, and San Marcial Basins of south-central New Mexico. The formation consists of alluvial-fan and coalescent-fan deposits (piedmont facies) and ancestral Rio Grande fluvial deposits (axial-river facies). The unit is capped by the mostly constructional Cuchillo surface. Based on vertebrate fossils and radiometric dates, the age ranges from 5 Ma to 400,000 years old. The Palomas Formation is a piedmont-facies-dominated deposit possessing a relatively narrow (3 km wide) axial-river facies deposit that roughly follows the basin axis.

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TABLE 1—Composite type section for the Palomas Formation; locations are shown on Figure 2. Sections 1, 2, and 3 make up the composite type section.

Section 1
Upper Palomas Formation

This part of the composite type section includes proximal subfacies, two fluvial sand intertongues (units 1 and 5), and a dated volcanic ash bed (unit 6). It is located about 3 km southeast of Las Palomas on the south side of Red Wash (Palomas Gap arroyo) in the NE¼ SW¼ sec. 33, T14S, R4W. Section begins on the hilltop overlying the ash bed.

Unit	Lithology	Thickness ft	Thickness m
10	Fanglomerate, light reddish brown (5YR 6/3), weathers reddish yellow (5YR 6/6). Poorly sorted, matrix-supported, moderately indurated, massive fanglomerate with sandy silt matrix. Pedogenic calcium carbonate horizon (Stage III–IV) for top 1 m. Clasts are angular to subrounded and include limestone, red siltstone (Abo), chert, minor granite, and vesiculated olivine basalt. Clasts up to 10 cm in size. Scoured contact at base.	12.2	3.7
9	Sandy silt, red (2.5YR 4/6), weathers to light reddish brown (2.5YR 6/4). Contains thin (<30 cm) pebbly lenses and rare scattered pebbles with lithologies same as unit 10. Unit weakly to moderately indurated and bedding is weakly developed. Red (10R 4/6), 30-cm-thick clay zones are scattered throughout unit and may be paleosols. Grades into lower unit.	10.4	3.2
8	Fanglomerate, light reddish brown (5YR 6/3), weathers reddish yellow (5YR 6/6). Similar to unit 10, but without pedogenic zone and with a few very coarse-grained sandstone lenses; about 30 cm thick. Scoured basal contact.	13.2	4.0
7	Sandy silt, red (2.5YR 5/6), weathers to light reddish brown (2.5YR 6/4). Same as unit 9. Sharp basal contact.	21.3	6.5
6	Volcanic ash, white (7.5YR N8/) to pinkish white (5YR 8/2). Bed thickness up to 30 cm near base and becomes almost laminated near top. Weakly indurated, friable, powdery, and clean. Sharp basal contact. Has been correlated with Cerro Toledo ash of the Jemez volcanic center, which has a fission-track age of about 1.45 Ma (Izett et al., 1981; Machette, written comm. 1982).	4.2	1.3
5	Medium- to fine-grained sand, light gray (10YR 7/2). Well sorted, loosely consolidated; exhibits weak trough crossbedding. Fines upward and contains silt with thin (<20 cm thick), pale olive (5Y 6/3), red (2.5YR 5/6), and pale yellow (2.5Y 7/4) clay lenses for top 0.5 m. Sharp basal contact.	6.7	2.0
4	Fanglomerate with sandy silt interbeds, red (2.5YR 4/6), weathers light reddish brown (2.5YR 6/4). Poorly sorted, moderately indurated, lenticular to thick bedded fanglomerate with a sandy silt matrix. Fanglomerate beds are better cemented near base and show weak planar crossbeds. Beds up to 3 m thick. Clasts are angular to subrounded and mainly consist of limestone, chert, and red siltstone (Abo) with minor granite, sandstone, and scoriaceous basalt. Clasts average 6–8 cm in size, but can be up to 50 cm and are slightly imbricated westward. Most beds are clast supported near base and become matrix supported near top. Sandy silt beds contain pebbly lenses and scattered pebbles throughout unit with lithologies similar to fanglomerate beds. Fanglomerates usually have scoured basal contact with sandy silt beds, but grade upward into sandy silt beds. Unit as a whole is very resistant and is a traceable cliff former.	28.9	8.8
3	Sandy silt, reddish brown (5YR 5/4) to brown (7.5YR 5/4). Similar to units 9 and 7, except unit is less indurated and no red clay zones were observed. Unit grades into unit 2. Slope former.	10.1	3.1
2	Alternating beds of medium- to coarse-grained sand, sandy silt, and pebbly conglomerate. Sand is moderately sorted and pale brown (10YR 6/3). Sandy silt beds are similar to unit 3. Pebbly conglomerate is poorly sorted; clast lithologies are similar to unit 7. Bed thickness ranges from 30 to 60 cm, averaging about 30 cm. Unit appears to represent transition between fluvial and fanglomerate material. Slope former. Sandy silt unit grades into unit 1.	14.1	4.3
1	Medium- to fine-grained sand, light gray (10YR 7/2). Loosely consolidated, well sorted, trough crossbedded, massive sand with scattered rounded pebbles (quartz, rhyolites, tuff) and pebble lenses. Clasts average 3–4 cm in size. Red (2.5YR 5/6) and pale yellow (5Y 7/3) clay balls and lenses are scattered throughout unit. Laterally (eastward) grades into sandy silt unit. Fines upward near top. Section ends where covered by tributary arroyo.	16.7	5.1
	Total thickness:	137.8	42.0

Offset section to main tributary. Units 1, 2, and 3 repeated. Section begins on bottom of traceable unit 4.

Unit	Lithology	Thickness ft	Thickness m
d	Sandy silt, light reddish brown (5YR 6/3). Similar to unit 3. Sharp basal contact. Weakly to moderately indurated.	12.2	3.7
c	Fanglomerate, light reddish brown (5YR 6/4). Poorly sorted, matrix-supported, pebble-size fanglomerate with silty matrix. Similar to pebbly conglomerate in unit 2, except thicker. Scoured basal contact. Moderately indurated and cliff former.	5.5	1.7
b	Sandy silt, reddish brown (5YR 5/4). Similar to sandy silt in unit 2. When combined, both this unit and unit c are similar to unit 2, except no sand beds were found. Grades down into unit a. Weakly to moderately indurated.	5.2	1.6
a	Medium- to fine-grained sand, light gray (10YR 7/2). Loosely consolidated, well sorted with trough crossbedding. Scattered rounded pebbles (mostly quartz and volcanics) occur throughout the exposure. Section ends where colluvium buries unit. Only small exposure occurs.	3.1	0.9
	Total thickness:	26.0	7.9

Section 2
Upper Palomas Formation

This part of the composite type section includes the Cuchillo surface(?), distal subfacies, and fluvial sand intertongues (units 1 and 3). It is located just north of Palomas Creek and west of Las Palomas in the NW¼ NW¼ sec. 30, T14S, R4W. Section begins on top of Cuchillo surface(?).

Unit	Lithology	Thickness ft	Thickness m
7	Conglomerate, reddish brown (5YR 5/4) to light brown (7.5YR 6/4). Plugged pedogenic calcium carbonate horizon for top 80 cm (stage IV). Conglomerate is clast supported (60–70% clasts), poorly to moderately sorted, and massive with a medium-grained sand matrix. Subrounded to rounded clasts include tuffs, basalt, porphyritic and nonporphyritic rhyolites and andesites, and siliceous fragments (chalcedony and chert). Clasts up to 40 cm in size average 5–6 cm and are imbricated eastward. Unit is a moderately cemented cliff former with a scoured basal contact.	42.6	13.0
6	Alternating beds of sandy silt and clay, reddish brown (5YR 6/4; mostly clay) to pink (5YR 7/3). Beds vary in thickness (4 cm–		

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Unit	Lithology	Thickness ft	Thickness m
	1 m) and in cementation. Sandy silt beds are moderately to well cemented and can contain scattered 1–3-cm-size pebbles with lithologies similar to unit 7. Clay beds are darker colored, sometimes laminated, and may represent paleosols where calcareous zones occur. Scattered 25–50-cm-thick, well cemented, crossbedded, coarse-grained sand lenses are also present. Unit is a cliff former with prominant ledges. Grades down into unit 5.	16.4	5.0
5	Conglomerate, pinkish gray (7.5YR 6/2). Mainly moderately sorted, clast-supported (50–60% clasts), massive conglomerate, but top 2 m grades into predominantly medium-grained sand with 30% clasts. Clast size and lithologies same as unit 1. Matrix and some 10–30-cm-thick lenses are composed of medium-grained sand. Unit is a moderately cemented cliff former with a scoured basal contact.	34.1	10.4
4	Alternating beds of sandy silt and clay. Same as unit 2. Grades down into unit 3.	29.2	8.9
3	Medium-grained sand with silty sand interbed, reddish yellow (7.5YR 6/6) on top to very pale brown (10YR 7/3) on bottom. Sand is poorly indurated, well sorted, and faintly crossbedded. Silty sand bed is 40 cm thick and occurs between sand beds. Slope former. Contains a basal pebble lag deposit on scoured contact with unit 2.	5.2	1.6
2	Alternating beds of sandy silt and clay. Same as unit 6. Sharp basal contact with unit 1.	74.5	22.7
1	Medium-grained sand, light yellowish brown (10YR 6/4). Loosely consolidated, well sorted, trough crossbedded sand with scattered pebbly and coarse-grained sand lenses. Subrounded to rounded pebbles (1–2 cm in size) include basalt, schist, siliceous fragments (quartz, chert, petrified wood), and granite. Pebbly and coarse-grained sand lenses are moderately to well indurated. Generally a slope former. Section ends in arroyo about 5 m above Rio Grande floodplain.	13.4	4.1
	Total thickness:	215.4	65.7

Section 3
Upper Rincon Valley(?) and Lower Palomas Formation

This part of the composite type section includes the fluvial facies (unit 8), the proximal subfacies (unit 7), and possibly the top of the Rincon Valley Formation of the lower Santa Fe Group (units 1–6). Units 9 and 10 are younger pediment and terrace deposits and not part of the Palomas Formation. The section is located south of T or C and the Rio Grande in secs. 3 and 4, T14S, R4W. Section begins on hilltop along the east-side access road.

Unit	Lithology	Thickness ft	Thickness m
10	Conglomerate, white (5YR 8/1) to light brown (7.5YR 6/4). Poorly sorted, massive, well cemented, clast-supported (60–70% clasts) pediment veneer. Top 40 cm intensely calcium carbonate impregnated (pedogenic—stages III–IV) and forms resistant cap. Clasts similar to unit 7. Section ends on top of pediment surface. Sharp upper contact.	2.6	0.8
9	Medium- to fine-grained sand, reddish yellow (7.5YR 7/6) to light yellowish brown (2.5YR 6/4). Loosely consolidated and primarily massive, but locally shows faint trough crossbedding. Slope former. Contains scattered pebble lenses with clasts similar to unit 8. Grades down into unit 8.	14.4	4.4
8	Conglomerate, light gray (10YR 7/1) to light yellowish brown (2.5YR 6/4). Moderately sorted, matrix-supported, massive conglomerate with a medium to fine sand matrix. Contains a well cemented, 30-cm-thick basal layer with coarse sand; otherwise, the unit is weakly consolidated and is a slope former. Subrounded to rounded clasts compose about 25–35% of the unit and include porphyritic volcanics, tuffs, chert, basalt, and quartz. Clasts become less numerous and smaller towards the top. Clast size averages 5–10 cm, but can be up to 20 cm. Sharp basal contact.	9.5	2.9
7	Fanglomerate, light reddish brown (5YR 6/4) to light brown (7.5YR 6/4). Poorly sorted, lenticular to weakly stratified, moderately to well indurated fanglomerate with 40–50% clasts. Clasts are angular to subrounded and include limestone, chert, siliceous rocks, granite, and schist. Clasts up to 20 cm in size are slightly imbricated to the west. Mainly matrix supported with sandy silt. Prominant ridge former. Has scoured contact with underlying unit.	53.1	16.2
6	Silty clay, brown (7.5YR 5/4) to reddish yellow (7.5YR 6/6). Thin bedded (5 cm thick). Top 60 cm consists of light red (2.5YR 6/6), massive clay bed with scattered calcium carbonate concretions similar to unit 1. Generally a slope former except for top 60 cm, which is a cliff former. Grades down into unit 5.	12.8	3.9
5	Very fine sandstone, light brown (7.5YR 6/4). Thin bedded (<5 cm thick) at base and bedding becomes poorly developed near top. Contains a 6-cm-thick calcium carbonate layer in middle. Generally a slope former. Sharp basal contact.	7.5	2.3
4	Massive clay with 2–3-cm-thick fine sand interbeds, reddish brown (5YR 4/4). Poorly developed bedding with scattered calcium carbonate concretions similar to unit 1. Slope former. Sharp basal contact.	15.7	4.8
3	Massive clay with minor silt, brownish yellow (10YR 6/6). Contains thin (5 cm thick), reddish brown (5YR 4/4) clay interbeds. Slope former. Sharp basal contact.	7.2	2.2
2	Alternating beds of silty clay and very coarse sand with scattered pebbles up to 3 cm in size. Sand grains and clasts are angular to subangular and are poorly sorted. Beds range in thickness from 20 to 30 cm. Color similar to unit 1. Coarse units from resistant ledges. Scoured basal contact.	3.6	1.1
1	Silty clay, yellowish red (wet, 5YR 4/6), reddish yellow (dry, 5YR 6/6). Massive with scattered very fine sand and silt interbeds. Contains calcium carbonate concretions up to 6 cm long, which are elongated vertically. Weakly consolidated and slope former. Section ends where buried by recent Rio Grande floodplain deposits.	9.2	2.8
	Total thickness:	135.6	41.4

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MINING REGISTRATIONS

(May 1, 1986, through August 19, 1986)

Bureau of Mine Inspection   Energy & Minerals Dept.   2825–E Broadbent Pkwy. NE   Albuquerque, NM 87107

Date and operation	Operators and owners	Location
5–1–86 gold, silver	Operator—Midnight Mine, Goldfields Consolidated Mines Co., P.O. Box 1670, T or C, NM 87901; Gen. Mgr.—Patrick Freeman, 1006 Kopra, T or C, NM 87901, phone: 894–7739; Gen. Supt.—James Ray Nation, General Delivery, Winston, NM, phone: 894–7495. Property owner—Goldfield Consolidated Mines Co.	Sierra County; private land; sec. 1, T12S, R9W; directions to mine: about 4 mi southwest of Chloride up Byers Run; go about 1 mi west of St. Cloud Mill up S. Fork Creek, turn south up Byers Run and go about 2 mi south; the mine is about 0.25 mi west up a small arroyo off Byers Run.
5–1–86 storage vault	Operator—CST Project, P.O. Box 2534, Las Vegas, NM; Gen. Mgr.—Russ Bellin, P.O. Box 8775, Santa Fe, NM 87502–8725, phone: 641–5340; person in charge—F. E. Valencia, same address and phone; Gen. Supt.—Richard Ung, same address and phone. Property owner—Church of Spiritual Technology, 5299 Countain Ave., Ste. 285, Hollywood, CA 90029, phone: (213) 669–8465.	San Miguel County; private land; directions to vault: go 50 mi east of Las Vegas, NM, on NM–65/104 to Trementina School; go past school on NM–65; turn left at cattle crossing on county road 56A and go 13 mi.
5–19–86 gold	Operator—LaPaz Bear Creek Placer, LaPaz Bear Creek, Inc., P.O. Box 17, Pinos Altos, NM 88053; Gen. Mgr.—Joy Merz, same address, phone: 538–9611; person in charge—Leslie Billingsley, same address and phone; Pres.—Dan E. Lewis, LaPaz Mining, Inc., 1803 W. Grant Rd., Tucson, AZ 85745. Property owner—Ruth Ann and Jim E. Rodgers, P.O. Box 111, Silver City, NM 88061.	Grant County; sec. 24, T16S, R14W; directions to mine: turn left at mile 9.4 of Hwy. 15; go 1.1 mi to plant site.
6–27–86 gold, silver	Operator—Big G., Dynapac, Fairway Dr., T or C, NM 87901; Gen. Mgr.—Harold Smith, same address, phone: 894–2593; person in charge—Dene Pierce, 310 Vetter, T or C, NM 87901, phone: 894–7589. Property owner—Harold Smith.	Socorro County; federal land; sec. 13, T9S, R6W; directions to mine: Springtime Campground Rd., between Luna Park and Springtime.
6–27–86	Operator—WIPP Site, U.S. Dept. of Energy, P.O. Box 3090, Carlsbad, NM 88220; Const. Mgr.—U.S. Army Engr. Dist., Albuquerque District Engr., P.O. Box 1580, Albuquerque, NM 87103, phone 766–2732; person in charge—Area Engr., P.O. Box 2346, Carlsbad, NM 88220, phone: 887–0586; Const. Contractor—Brinderson Corp., 19700 Fairchild, Irvine, CA 92715, phone: 885–2197; Const. Contractor—Foley Co., 7501 Front Street, Kansas City, Missouri 64120. Property owner—U.S. Dept. of Energy, P.O. Box 3090, Carlsbad, NM 88220.	Eddy County; federal land; directions to mine: 34 mi south of Carlsbad, NM on NM–285.