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PEDIMENTS OF THE VERMEJO PARK AREA, NEW MEXICO

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INTRODUCTION

Geomorphic erosion surfaces or pediments distinguish the eastern flank of the Sangre de Cristo Mountains. In the area of Vermejo Park, New Mexico, and immediately west of there, an especially interesting assemblage is preserved; preservation is due, at least in part, to an abundant nearby source of rhyolite that forms much of the gravelly alluvium covering the surfaces. The extremely resistant nature of the rhyolite pebbles, cobbles and boulders constituting the alluvium has armored the pediment surfaces against erosion.

Several pediment levels have been studied in the area. Most levels can be related in time and origin to other Quaternary pediments along the Colorado Rocky Mountain front. Certain of the higher levels in the Vermejo Park area, however, appear older and may be middle to late Tertiary erosion surfaces.

PREVIOUS WORK

Few studies have been made of the geomorphic surfaces along the eastern flank of the Sangre de Cristo Mountains north of Cimarron, New Mexico, because most of the remnants of these surfaces are on private land of the Vermejo Ranch. Access to this area has been restricted since the early days of geologic exploration in the West. Levings (1951) has provided the most useful information on the area. He worked intermittently in the Raton-Trinidad area, along the eastern side of the Raton Basin, during the summers of 1945-50. The report includes descriptions of the relations of the surfaces underlying high-mesa basalt flows of the Raton-Trinidad area to the Ogallala Formation and defines three Pleistocene pediments that occur on the flanks of the high mesas near Trinidad and Raton.

PEDIMENTS

The term pediment, as used here, means a surface cut by water across both hard and soft rocks during a time of stable base level. Use of the word generally is restricted to surfaces of piedmont slopes. The water referred to can be either a perennial or ephemeral stream or a sheet flow.

The process of pediment formation commonly is called lateral corrasion, but includes all events that result in slope retreat and planation of a valley floor. In some parts of the world, geomorphologists do not consider lateral corrasion to be an important part of the pediment-forming process; however, under certain climatic and physiographic conditions, as along the Rocky Mountain front, lateral corrasion does appear to play a major role in pedimentation. Especially along ephemeral streams, flash floods resulting from torrential rainfall probably have a great influence on pediment formation, mainly by removing colluvium that may block the stream course. Flash floods also control the shape of the pediment; maximum depth of scour is reached only during flash floods. During quiet-water times, only a small fraction of the column of alluvium above bedrock is being moved, and a stream would impinge on bedrock only at the outer parts of its meanders (lateral corrasion).

The surface that results from this process slopes not only

away from the mountain front but also toward the local base-level stream; therefore, pediments tend to be fanlike in shape. The mountainward edge of the pediment rises topographically from the exit point of the main base-level stream to a crest at the interfluvium between two main base-level streams. The steepness of slope is measured in hundreds of feet per mile near the mountains, but only in tens of feet per mile several miles from the mountain front.

The breadth and perfection of a pediment are dependent on time; the perfect pediment would encircle a mountain range, but few pediments approach this ideal. Pediments begin as stream valleys. During stable base-level conditions, streams cut sideways and gradually widen their valleys. When base-level conditions change, streams stop cutting sideways and cut downward until a stable base level is again reached. The width of the pediment increases in proportion to the length of time that the base level is stable.

In cutting from a higher to a lower level, a stream generally cuts downward through soft bedrock on the edges of its old valley rather than down through the gravel armor on its valley floor. Thus it generally preserves the record of older pediments as a steplike sequence.

Irregularities are not uncommon on a pediment, even though they are not apparent on the surface of the gravel cap. The downslope profile of a pediment is generally smooth, but a profile along a line of equal altitude across the pediment may show channels 80 ft (24 m) deep or more. That deep a channel is rare, but it demonstrates the potential depth of scour during an unusually large storm runoff. The thickness of gravel generally is no greater than the depth of scour; indeed, in order to scour the bedrock, the stream must, at some time, move the whole column of alluvium. Where the thickness of gravel on a pediment is greater than the inferred potential depth of scour, then the upper part of the alluvium must be a fanlike accumulation. Gravel on all pediments is coarsest near the mountain source; boulders 20 ft (6 m) in diameter are common, but the size decreases rapidly away from the mountains. Stratification, sorting and roundness of particles are better along a main-stem stream than along an ephemeral stream. A pediment cover commonly contains an upper 2-4 ft (0.6-1.2 m) thick layer of silty to sandy, locally derived material of loessial, overbank stream flood or colluvial origin. Soils, which are formed in all the pediment covers, are much better developed in this fine-grained material than in the porous gravel.

SOILS

Soils were developed in the upper parts of the gravelly alluvium that caps all the pediments. They are brown soils characterized by gray, humus-rich, leached-surface A horizons; brown or reddish-brown, clay-rich B horizons having strong columnar structure and concentration of iron and aluminum; and weathered parent material (generally gravel) having a strong off-white concentration of calcium carbonate (Cca or K horizon) in its upper part.

The soils in the pre-Bull Lake gravel caps of the pediments

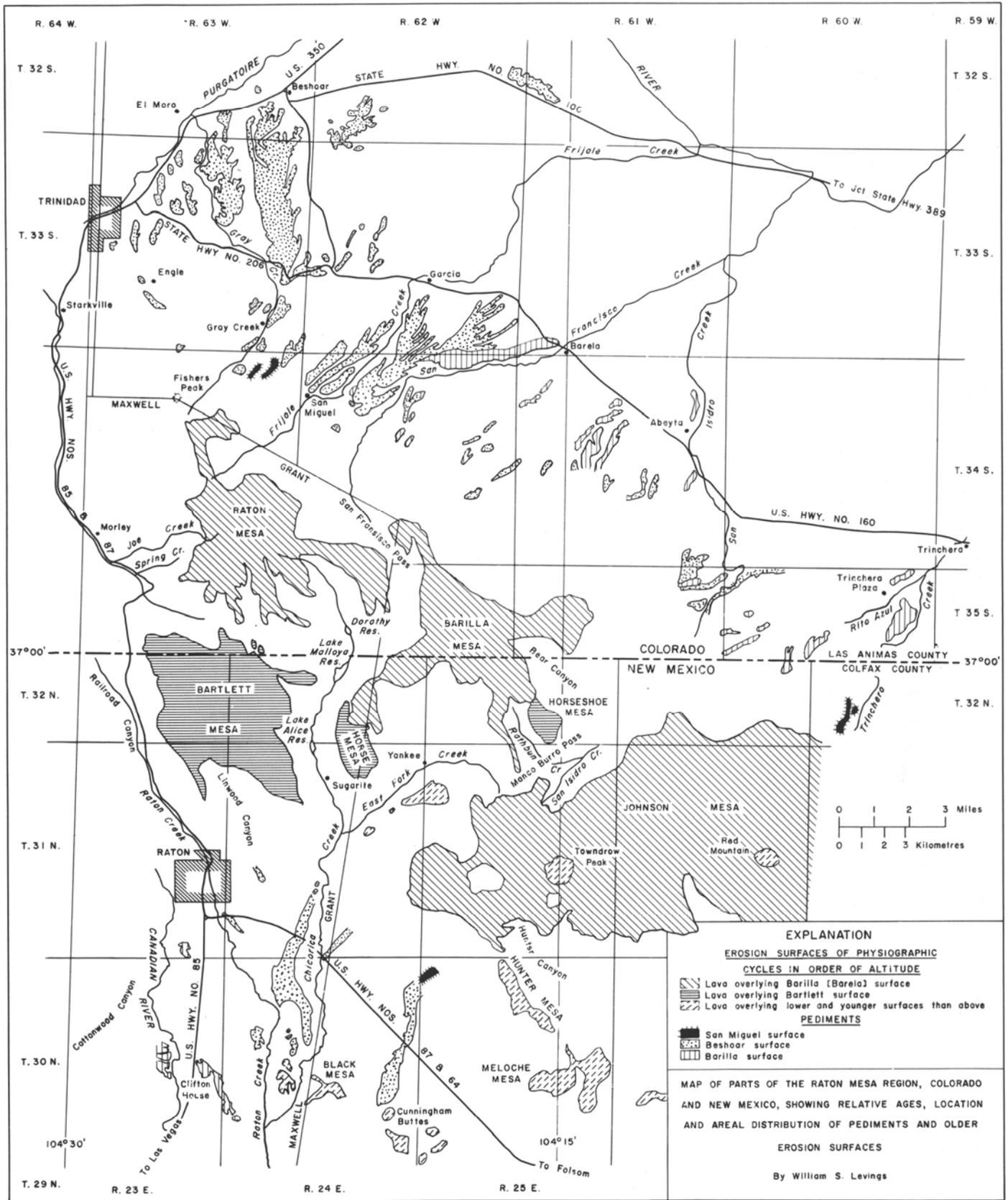


Figure 1. Map of part of Raton Mesa region, Colorado and New Mexico, showing relative ages, location and areal distribution of pediments and older lava-covered erosion surfaces (Levings, 1951).

discussed here differ in degree of development—the older the soil, the redder, more clayey and more intensely structured are the B horizons. These properties do not serve to differentiate the gravelly alluvium deposits on pediments discussed in this paper, but they do facilitate separation of them from Bull Lake, Pinedale and Holocene alluvial deposits, which contain much less intensely developed soils.

PEDIMENTS OF THE TRINIDAD, COLORADO AREA

Levings (1951) originally identified and named three pediments (which he termed surfaces) on the north side of Raton and Barilla Mesas near Trinidad, Colorado. There, the pediment remnants, in the form of dissected gravel-capped spurs and mesas, slope to the north toward the Purgatoire River.

San Miguel Surface

The name San Miguel was assigned to a few remnants of a high surface close to the mesa front (Fig. 1); they occur about 1 mi (1.6 km) west of the village of San Miguel, which lies about 7 mi (11 km) southeast of Trinidad. The pediment slopes to the north at gradients ranging from about 430 ft/mi (81 m/km) on the upper end to about 350 ft/mi (66 m/km) farther to the north. The height of the surface above modern drainage is about 340 ft (104 m).

Beshoar Surface

The Beshoar pediment, the best preserved of the three, extends over a large area. It was named by Levings (1951) for an abandoned railway station about 5 mi (8 km) northeast of Trinidad (Fig. 1). The average slope of the surface near Beshoar is about 140 ft/mi (27 m/km), and the height of the surface above modern stream levels is given as 260 ft (79 m) (Levings, 1951).

Barilla Surface

Some confusion exists about the naming of the lowest pediment. Levings (1951) named it the Barilla surface, "so called because of the excellent preservation of its remnants along San Francisco Creek near the farming community of Barela," about 12 mi (19 km) east of Trinidad (Fig. 1). Surely he meant to use the name of the town, but perhaps he was confused by the similar spelling and pronunciation of Barilla Mesa, one of the high basalt-covered mesas to the south, as shown on the old U.S. Geological Survey topographic map (1913) of the Raton 15-minute quadrangle. The confusion is compounded because he referred to "lava overlying the Barilla [Mesa] surface" (an older, higher surface) in his explanation and the "Barilla [pediment] surface" (the younger, lower surface) as well (Fig. 1). The recent (1972) Yankee, New Mexico, and Barela, Colorado, 7 1/2-minute topographic quadrangle maps by the U.S. Geological Survey further obfuscate the situation by changing "Barilla Mesa" to "Barela Mesa." To avoid additional confusion, we will continue to use Barilla for the lowest pediment, but will discontinue reference to the "Barilla Mesa surface" or "Barilla Mesa basalt."

Levings (1951) stated that slope gradients on the Barilla pediment range from 270 ft/mi (51 m/km) to about 135 ft/mi (26 m/km). The pediment forms a prominent and definite bench more than 100 ft (30 m) above modern streams; however, away from the mountain front, the pediments tend to

converge and the interval between the Beshoar and the Barilla decreases from 160 ft (49 m) to only 70 ft (21 m) in just a few miles. Further, the Barilla surface blends into alluvial terraces along major streams, and separation of pediment from terrace becomes impossible.

PEDIMENTS IN THE RATON, NEW MEXICO AREA

In New Mexico, Levings (1951) distinguished equivalent surfaces on the south side of the mesas and applied the same names that he had used in Colorado. We believe that he overlooked some major remnants of the Beshoar pediment and neglected to include extensive areas of the Barilla pediment on his map (Fig. 1).

San Miguel Surface

Levings (1951) reported a single well-developed remnant of the San Miguel surface in the New Mexico portion of his study area. The remnant (Fig. 2) lies about 2.5 mi (4 km) west of Hunter Mesa and covers an area of less than 0.25 mi² (0.65 km²) (Fig. 1). At a height of roughly 240-260 ft (73-79 m) above small streams on either side of the remnant, it slopes steeply south, away from the mesa front, at 430 ft/mi (81 m/km). At the lower end, a 160-180 ft (49-55 m) interval, rather than the 80 ft (24 m) interval reported by Levings, separates the San Miguel from the Beshoar pediment below; and the height above adjacent streams is 240 ft (73 m), rather than 160 ft (49 m) as measured by Levings (1951). However, on his map (Fig. 1), Levings showed two additional remnants on Trincherero [Trincher] Creek, T. 23 N., R. 27 E. We did not examine these remnants in the field, but inspection of the U.S. Geological Survey Trincher Pass 7 1/2-minute topographic quadrangle map shows that the smaller of the remnants lies 260 ft (80 m) above modern streams and 80 ft (24 m) above the larger remnant, which is probably Beshoar.

Beshoar Surface

Remnants of the Beshoar pediment are scattered all around the town of Raton (Fig. 1). East of town, the remnants are well displayed (Fig. 3); and, according to Levings (1951), they



Figure 2. San Miguel surface lying above the Beshoar surface. View east from highway (87 & 64) about 3.5 mi (5.6 km) east of Raton, New Mexico.

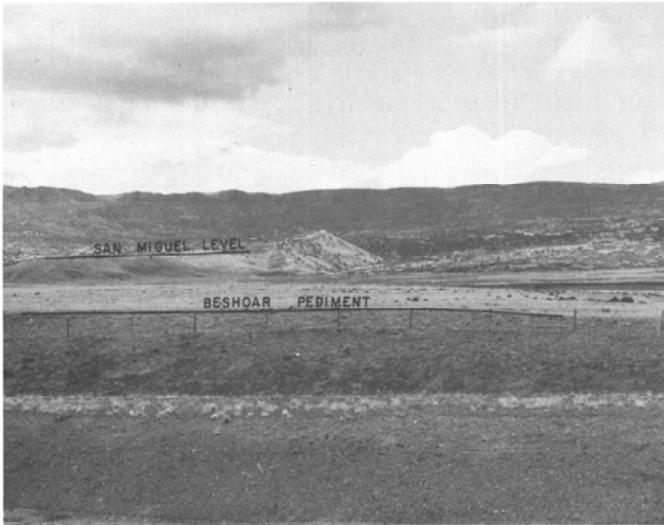


Figure 3. View looking north from highway (87 & 64) about 6 mi (9.6 km) east of Raton, New Mexico, over the Beshoar pediment. Johnson Mesa edges the skyline; San Miguel pediment forms the ridge above the Beshoar.

slope to the south about 100 ft/mi (19 m/km) and lie about 75 ft (23 m) above present stream gradients at the upper part. Measurements that we made on modern topographic maps show that the Beshoar consistently lies about 100-120 ft (30-37 m) above modern streams, even at some distance south. Levings (1951) also stated that the surface in the Chicorica Creek drainage lies 210 ft (64 m) above present stream levels at the north end and 70 ft (21 m) at the south. The new topographic maps do not show any place on this surface to be higher than about 150 ft (46 m) above modern streams, and the height of this surface appears to remain consistent at about 100-120 ft (30-37 m) throughout its length. Figure 4 shows a



Figure 4. Soil of pre-Bull Lake age developed on very coarse gravelly alluvium exposed in ditch dug on Beshoar pediment (Fig. 5) about 0.5 mi (0.8 km) east of Raton, New Mexico. Coarseness of the gravel is indicated by a basalt boulder nearly 6 ft (2 m) in diameter. Well developed Cca horizon at contact of light and dark alluvium in sides of ditch.

soil developed on gravelly alluvium lying on a remnant of the Beshoar pediment about 0.5 mi (0.8 km) east of Raton. The soil development and accompanying zone of caliche indicate a pre-Bull Lake age.

Barilla Surface

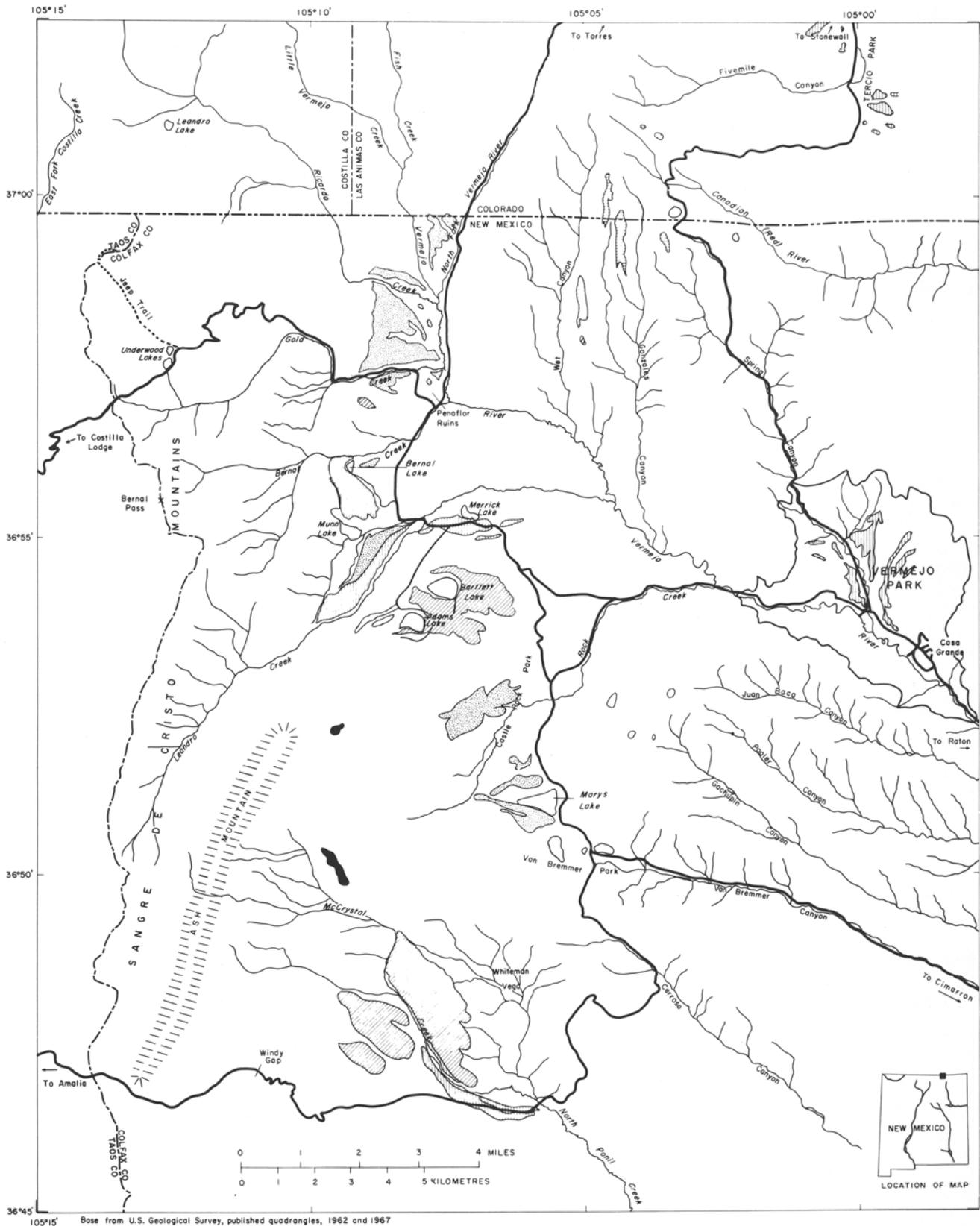
Levings assigned only a few limited remnants to the Barilla surface in New Mexico. We believe that the extensive surface that developed between ridges of the Beshoar pediment should be included in the Barilla designation. The remnants of this surface lie mostly 40-80 ft (12-24 m) above modern stream levels and exhibit gentle slope gradients (Fig. 5). On the other hand, several pediment remnants that Levings showed as Barilla should be reassigned to the Beshoar on the basis of their positions above modern stream levels. For instance, east of Clifton House (Fig. 1) he identified surface remnants as Barilla that lie 120-140 ft (37-43 m) above present streams according to modern topographic maps.

Levings (1951) suggested that the surfaces both north and south of the high mesas along the New Mexico-Colorado border in the Trinidad-Raton area are of like origin, Pleistocene in age, and correlative on the basis of similar attitudes and sequences of pediment remnants. He further believed that these surfaces are of the same origin and approximately correlative with a set of surfaces in the Moreno Valley, New Mexico (Ray and Smith, 1941) and in the vicinity of Spanish Peaks, near La Veta, Colorado (Levings, 1951). Though not mentioned by Levings, the Cimarroncito, Philmont and Rayado sequence of pediments, described by Smith and Ray (1943) in the vicinity of Cimarron, New Mexico, and their heights above modern drainage closely resemble those characteristics of the pediment suite near Trinidad and Raton and also appear correlative.

We feel that the surfaces described by Levings and by Smith and Ray fit a general classification of pediments established by Scott in the Denver and Pueblo areas (Scott, 1963, 1969), primarily because the number of surfaces is the same, the soils formed on their gravel caps are similar, and the heights above modern stream levels are nearly identical. The remainder of this paper will describe the pediment suite to the west of Raton in the Vermejo Park area.



Figure 5. View taken from about 1 mi (1.6 km) east of Raton, New Mexico, looking north across Barilla pediment. Beshoar remnant in middle distance is identified on photograph.



Base from U.S. Geological Survey, published quadrangles, 1962 and 1967

Figure 6. Map showing distribution of pediments in the Vermejo Park area, northern New Mexico. The areas shown by vertical hachures include surfaces considered equivalent to the Barilla surface of Levings (1951). The stippled areas include surfaces equivalent to the Beshoar; San Miguel equivalents are shown by the inclined hachures. The high-pediment remnants near the state line are shown by horizontal lines, and the Ash Mountain surface is solid black. Unpatterned, unlabeled areas represent small blowouts.

PEDIMENTS OF THE VERMEJO PARK AREA

An assortment of surfaces can be observed along the east side of the Sangre de Cristo Mountains in the Vermejo Park area (Fig. 6). These gravel-covered surfaces, thought to be pediment remnants, range in height above modern stream levels from about 40 ft (12 m) to more than 1,000 ft (305 m). Most are commonly less than 1 mi² (2.6 km²) in area, but in total they represent quite a large area (10+ mi² (26+ km²)) along the mountain front. The surfaces can be roughly separated into two main groups: a low pediment group, thought to be correlative with the Pleistocene surfaces in the Raton-Trinidad area; and a high pediment group, here considered to be early Pleistocene and older in age.

Low Pediment Group

The low pediment group includes steplike surfaces adjacent to modern streams along the mountain front and lying within the confines of the restricted valleys at Vermejo Park and Tercio, as well as several gravel-covered pediments capping high mesas along the east side of the mountains. Pediment remnants of the low group are widely scattered along the mountain front in the main river valleys (Fig. 6). The lower surfaces range from 40-100 ft (12-36 m) above present stream levels along Leandro Creek to as high as 600 ft (183 m) on Gold Creek, near Peñaflores Ruins. The surface remnants represent the San Miguel, Beshoar, and Barilla pediments of Levings (1951).

Beshoar-Barilla Equivalents

Vermejo Park: At Vermejo Park proper (Fig. 6), three levels can be mapped on the basis of their respective heights above modern stream levels (Pillmore, 1969); however, the differences between the levels are not appreciable and the likelihood that more than the two lower levels of the Raton-Trinidad area are represented is small. All three pediments are covered with

gravelly alluvium composed of angular to subrounded fragments of locally derived sandstone and siltstone. The oldest and highest surface, which we consider equivalent to the Beshoar of Levings (1951), is represented by a few scattered remnants that lie about 120 ft (37 m) above present drainage levels. An intermediate surface is the most extensive; its gravels cover most of the long fingerlike ridges that cross the central part of Vermejo Park (Fig. 7). The lowest pediment lies just below the intermediate surface, at about 50-60 ft (15-18 m) above present stream levels. Adjacent to the Vermejo River, gravels on these lower surfaces, here considered equivalent to Levings' Barilla surface, merge with terrace-type gravels that were derived from rocks of varied lithologies in the mountains to the west.

Tercio area: A parallel set of surfaces occurs in a similar erosional regime in the Tercio area, in the valley of the south fork of the Purgatoire River (Fig. 8). The highest level (possibly equivalent to the Beshoar) is represented by an isolated remnant on the east side of the valley, about 200 ft (60 m) above adjacent stream levels. The intermediate level, about 120-160 ft (37-49 m) higher than modern stream levels; and the lowest level, 60-80 ft (18-24 m) above stream level, are probably Barilla equivalents. The intermediate level is most extensive. The lowest level is represented by benches cut into ridges capped by the higher pediments and by low spurs that slope gently toward the valley floor away from the ridge front. At Tercio, just as at Vermejo Park, the erosional surfaces formed in a restricted area and are not nearly as extensive as in the Raton-Trinidad area.

San Miguel Equivalents

The pediment remnants capping Adams-Bartlett Mesa north of Castle Rock Park, the broad McCrystal flat to the west of Whiteman Vega and the small flat-topped hill south of Gold Creek near Peñaflores Ruins (Fig. 6) represent the oldest level of the low pediment group. They are here considered to be

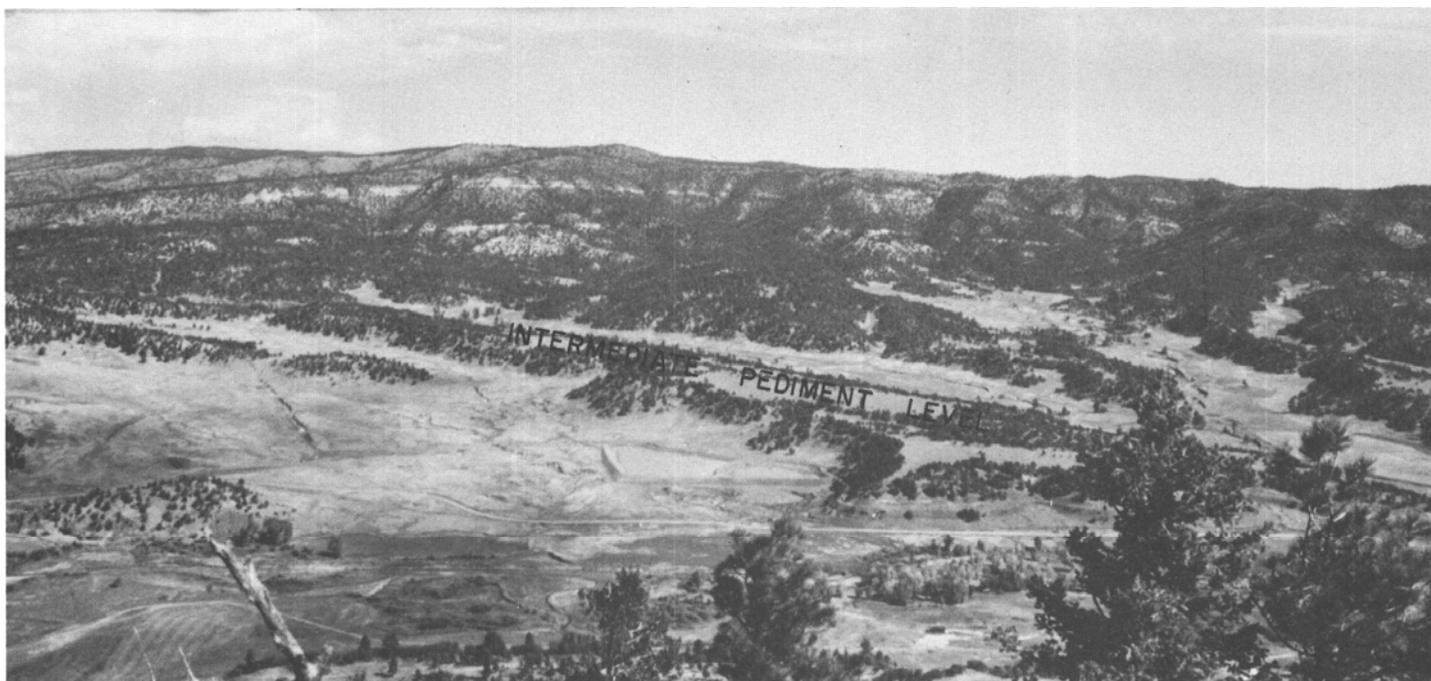


Figure 7. View looking north from south rim of Vermejo Park showing grass-covered intermediate pediment level in valley bottom.

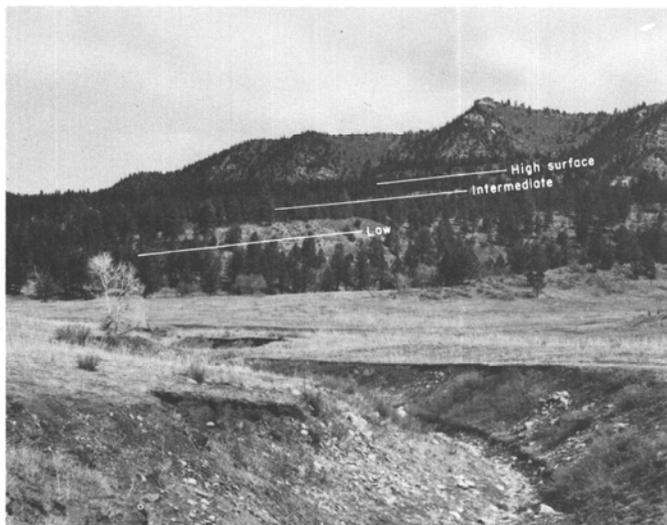


Figure 8. View of pediments on the east side of the valley about 2 mi (3.2 km) south of Tropic, Colorado.



Figure 9. Air view of Adams and Bartlett Lakes lying on top of Adams-Bartlett mesa, about 6 mi (10 km) west of Vermejo Park, New Mexico.

equivalent to Levings' (1951) San Miguel surface in the Raton-Trinidad vicinity and to the Rayado surface in the Cimarron area (Smith and Ray, 1943) (Table 1). All three surfaces represent one event in the erosional history of the area and display certain similarities.

Adams-Bartlett Mesa: The broad, nearly planar surface of the Adams-Bartlett pediment on Adams-Bartlett Mesa dominates the view across Castle Rock Park and is the most conspicuous pediment in Vermejo Park. The Adams-Bartlett pediment is here named for two large lakes, Adams and Bartlett (Fig. 9), that occupy unusual positions on the top of

the pediment (Pillmore, this Guidebook). The surface lies about 350 ft (107 m) above the broad valley floor of Castle Rock Park on the south and 600 to 800 ft (183 to 244 m) above the present level of streams tributary to Leandro Creek on the north. The pediment bevels steeply eastward-dipping rocks of the undivided Upper Cretaceous and Paleocene Raton and Poison Canyon Formations and slopes evenly to the southeast at 200 ft/mi (38 m/km). Elevations range from 9,000 ft (2,740 m) on the west to about 8,500 ft (2,590 m) on a small outlier of the pediment to the southeast. Actually; levels of two surfaces make up the western part of the pediment, but they are separated by only 20-30 ft (6-9 m) and should not be

Table 1.--Correlation of Tertiary? and Quaternary surfaces along the eastern front of the Rocky Mountains

[Modified from Scott, 1963, p. 53. Leaders (---) indicate no correlative surface. Questioned leaders (---?) indicate uncertain correlations. Figures roughly indicate the elevations of each surface above modern streams]

NEW MEXICO				COLORADO				
Vermejo Park area, (this report)	Cimarron area, (Smith and Ray, 1943)	Moreno Valley, (Ray and Smith, 1941)	Raton area, (Modified from Levings, 1951)	Trinidad area, (Levings, 1951)	Pueblo area, (Scott, 1969)	Air Force Academy site, Colorado Springs (Varnes and Scott, 1967)	Kassler quadrangle, near Denver (Scott, 1963)	Eldorado Springs quadrangle, north of Denver (Wells, 1967)
HIGH GROUP								
Ash Mountain ---?---	Mid-Tertiary	Mills Divide	Raton Mesa	---	---	---	---	High-level alluvium
State Line (Park Plateau surface) ---?---	Urraca Stage	Broad Valley Stage	---?---	---	Nussbaum	---	---	Pre-Rocky Flats
					320-360 ft (97-110 m)			450 ft (135 m)
LOW GROUP								
<u>Adams-Bartlett</u>	<u>Cimarroncito</u>	<u>Pediment 1</u>	<u>San Miguel</u>	<u>San Miguel</u>	<u>Rocky Flats</u>	<u>Lehman Ridge</u>	<u>Rocky Flats</u>	<u>Rocky Flats</u>
350-400 ft (107-120 m)	250 ft (75 m)	140-150 ft ¹ (42-45 m)	240-260 ft (73-79 m)	340 ft (104 m)	250-260 ft (76-79 m)	400 ft (120 m)	350 ft (107 m)	350 ft (107 m)
<u>Intermediate</u>	<u>Philmont</u>	<u>Pediment 2</u>	<u>Beshoar</u>	<u>Beshoar</u>	<u>Verdos</u>	<u>Douglass Mesa</u>	<u>Verdos</u>	<u>Verdos</u>
120-200 ft (37-60 m)	100 ft (30 m)	60-75 ft ¹ (18-23 m)	100-120 ft (30-37 m)	260 ft (79 m)	200-220 ft (61-67 m)	250 ft (76 m)	250 ft (76 m)	250 ft (76 m)
<u>Lowest</u>	<u>Rayado</u>	<u>Pediment 3</u>	<u>Barilla</u>	<u>Barilla</u>	<u>Slocum</u>	<u>Pine Valley</u>	<u>Slocum</u>	<u>Slocum</u>
50-80 ft (15-24 m)	45 ft (14 m)	20-40 ft ¹ (6-12 m)	40-80 ft (12-24 m)	100 ft (30 m)	110-120 ft (34-37 m)	100 ft (30 m)	100 ft (30 m)	100 ft (30 m)

¹Spot checks of these elevations on recent (1963) U.S. Geological Survey 7 1/2-minute topographic quadrangle maps (Red River Pass and Eagle Nest, New Mexico) indicate that Ray and Smith's measurements were conservative; some of our measurements are nearly twice those reported by them.

considered individually. The Adams-Bartlett pediment is covered with an armoring gravel composed mostly of fragments of hard, extremely resistant rhyolite from a dike that was intruded into the Pierre Shale to form Ash Mountain, a dominant high ridge about 3 mi (5 km) southwest (Fig. 6). The rhyolite occurs in the gravel as subangular to rounded pebbles, cobbles and boulders that weather to a distinct yellowish-orange color. Rhyolite clasts compose roughly half of the gravel; the remainder is mostly quartzite, chert and resistant clasts from older formations. Amphibolite, granite and pegmatite clasts generally are not as commonly seen. Clast sizes from 6 in. (0.15 m) to 2 ft (0.6 m) in diameter compose most of the coarse fraction of the gravel, but boulders as large as 5 ft (1.5 m) across are commonly seen.

The northeast strike of the Adams-Bartlett pediment surface indicates formation by a southeast-flowing stream. Ash Mountain, the most likely source for the rhyolite composing most of the pediment gravel, lies about 2 mi (3.2 km) to the southwest. A second possible source for the rhyolite is located directly up the pediment slope on the west flank of the Sangre de Cristo Mountains, along the Taos-Colfax County line immediately south of Bernal Pass. No outcrops have been discovered there, but an entire hill is covered with pieces of rhyolite nearly identical to that of Ash Mountain. It is conceivable that during formation of the pediment this area may have provided a source for the gravel. We believe, however, that the apparent absence from the pediment gravel of any of the other volcanic rocks that lie immediately north of this area precludes derivation of the rhyolite from this site. A northern part of the dike at Ash Mountain may have extended into the upslope area of the pediment at the time that it formed. It seems more likely, however, that northward-flowing streams eroding the present position of Ash Mountain turned sharply to the east to form the pediment as we see it today.

McCrystal Creek: McCrystal Creek nearly bisects the broad flat west of Whiteman Vega (Fig. 6). The pediment forming this flat is considered equivalent to the San Miguel of Levings (1951) and to the Adams-Bartlett pediment a few miles to the north. The southeastward-sloping surface (Fig. 12) bevels east-dipping sandstone and mudstone of the undivided Raton and Poison Canyon Formations. It resembles the Adams-Bartlett pediment in elevation, proximity to Ash Mountain (the probable source of rhyolite), lithologies of rocks in the gravel, gradient, direction of slope and height above the adjacent valley bottom at the upper end. Although the upper part of the pediment is about 400 ft (120 m) above the adjacent valley floor of Whiteman Vega, at a distance of only 2.5 mi (4 km) downslope the lower part is less than 200 ft (60 m) above

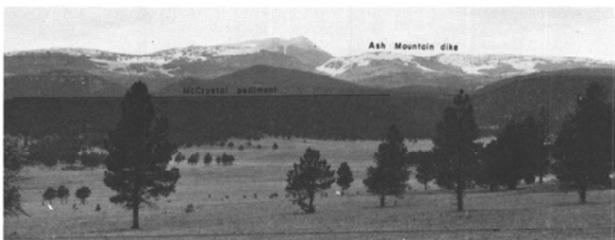


Figure 10. View to west across Whiteman Vega showing sloping surface of McCrystal pediment. Ash Mountain dike and Little Costilla Peak are on the skyline.



Figure 11. View looking north to high gravel-covered pediment (tree-covered) at Gold Creek in middleground of photograph. Lower intermediate-level pediment in left foreground.

drainage; the gradient of the slope exceeds the gradient of North Ponil Creek, the adjacent stream. The absence of any major streams in this part of the area makes it difficult to relate this pediment to the Adams-Bartlett surface with any degree of certainty. At the south end of the pediment, two additional levels, probable Barilla equivalents, can be recognized: a low surface, 50-60 ft (15-18 m) above present drainage; and an intermediate level, 70-80 ft (21-24 m) above drainage (Pillmore, 1974).

Gold Creek: A high, gravel-covered pediment remnant forms the south valley wall of Gold Creek just to the east of where the creek cuts through the Wall (Fig. 11). The surface lies at an elevation above 9,000 ft (2,740 m) and is about 600 ft (183 m) above the level of Gold Creek. Cut on steeply dipping shales of the marine Pierre and Niobrara formations of Late Cretaceous age, the surface slopes to the east at roughly 200 ft/mi (38 m/km). The gravel clasts capping the pediment range from 1 in. (2.5 cm) to greater than 8 ft (2.4 m) in diameter. The gravel consists mostly of basalt and an assemblage of rocks representative of other mid-Tertiary volcanics to the west, together with pieces of Precambrian gneiss, quartzite, quartz and chert, with distinctive clasts from the Dakota and Sangre de Cristo Formations. The gravel was apparently deposited on a reddish-gray weathering soil that is exposed in coyote burrows dug into the hillside nearly 80 ft (24 m) below the top. The large number and size of basalt fragments on the slope indicates that a flow may overlie the soil zone, but no basalt has been found in place and we continue to interpret the land form as a pediment remnant.

The surface at Gold Creek is correlated with the Adams-Bartlett pediment on the basis of similar elevations above a modern drainage that is common to both surfaces; however, the rock assemblages composing their gravel caps originated in different source areas. The pediment at Gold Creek is particularly significant because the gravels covering its surface represent a suite of rocks that, at a particular time in geologic history, were eroded from the volcanic field in the Underwood Lakes area only 2 or 3 mi (3.2 or 4.8 km) to the west.

High Pediment Group

The high pediment group includes two major surfaces: a surface represented by several pediment remnants that lie near the Colorado-New Mexico state line at about the same height above present drainage as the Adams-Bartlett and Gold Creek surfaces but that is probably early Pleistocene in age and not related to the San Miguel; and a pediment lying along the east

side of Ash Mountain that rests well above any other pediment level in the area and that is considered older, perhaps middle to late Tertiary in age.

State Line Pediment

The high ridge crests of the Park Plateau define the approximate level on which the distinctive gravels of the State Line pediment were deposited. Remnants of this surface are found near the head of the Canadian (Red) River along the New Mexico-Colorado state line adjacent to Gonzales and Wet Canyon (Fig. 1); they lie at elevations ranging from 9,643 ft (2,939 m) at the north end to about 8,950 ft (2,728 m) on the south. A related but lower surface farther south lies at elevations from about 8,800 ft (2,680 m) to 8,600 ft (2,620 m). The age of the State Line pediment and its correlation with known surfaces are uncertain. At its maximum, the pediment lies 520 ft (158 m) above Wet Canyon in Colorado; most other remnants lie 350-400 ft (107-122 m) above their adjacent drainage levels. These measurements to adjacent stream levels were made in the headwaters of three streams, and we question the validity of relating age of the surface to height above drainage in this instance. Instead, we feel that the position of the depositional surface at the level of ridge crests representing the Park Plateau surface (Ray and Smith, 1941) may be the best indication of the age of the surface (Table 1). The State Line surface is characterized by a distinctive, nearly monolithic gravel that consists of fragments of light-blue weathering andesite ranging from about 1-2 in. (2.5-5 cm) to greater than 15 ft (4.6 m) in length. The surface slopes nearly due south at about 320 ft/mi (61 m/km); it bevels coarse-grained to conglomeratic sandstone beds of the Poison Canyon Formation that strike north and dip about 15° to the east. Pieces of metamorphic rocks, quartzite and chert occur near the base of the gravel along with fragments of sandstone from older formations to the west. These fragments are mostly rounded to subangular, in contrast to the andesite, which rarely shows any evidence of stream transport. This fact, together with the immense size of some of the blocks, at first suggested a lava flow over an existing gravel-covered pediment; but lack of conclusive evidence and absence of any outcrops to substantiate the idea led to its abandonment. The probable source of the andesite is a partially exposed pluton about 3 mi (4.8 km) north of the state line. The surface was formed and the gravel was deposited by southward-flowing streams. The lower surface to the south lies about 350-400 ft (107-122 m) above the stream level in Wet Canyon, but it rests below the other remnants and must represent a somewhat later period of sedimentation, perhaps equivalent to the Adams-Bartlett pediment.

Another surface, a ridge crest that lies between Van Bremmer Park and Whiteman Vega to the south, may be correlative; however, no gravel was observed on the ridge. Elevations of the surface range from about 8,800 to 9,100 ft (2,687-2,774 m). Although the direction of dip and surface slope are the same, the dip of the sandstone beds of the Poison Canyon Formation, seen on the south wall of the ridge, is discernibly greater than the slope of the surface (Fig. 12). The surface lies 600-800 ft (183-244 m) above the adjacent valley floor, slopes to the east about 100 ft/mi (19 m/km) and extends several miles east. The tops of adjacent mesas to the north are at about the same elevation and probably are part of the same surface.

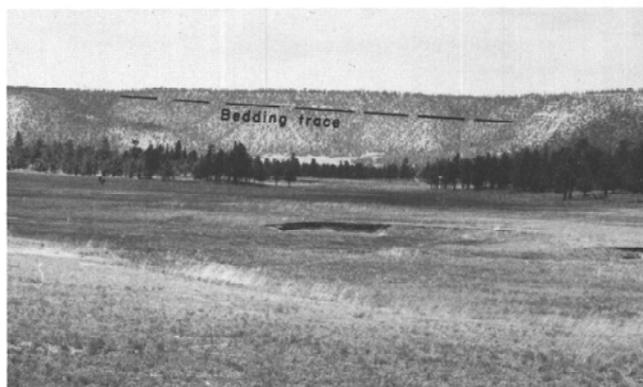


Figure 12. View looking north across Whiteman Vega showing apparent beveling of sandstone beds of the Poison Canyon Formation.

Ash Mountain Pediment

The remaining surface can be seen in two places high on the east flank of Ash Mountain dike (Fig. 6) and is here called the Ash Mountain pediment. The two remnants of this surface are not definitely correlative, but they rest at about the same altitude and occupy similar positions with respect to the mountain front. Height of the surface above present stream levels does not appear to be a usable parameter here. When the 8,700 ft (2,650 m) contour is projected from the Adams-Bartlett pediment, it falls 1,300 ft (400 m) below the Ash Mountain pediment. Does this mean that the Ash Mountain pediment is 1,900 ft (580 m) above modern stream levels? Needless to say, height above modern drainage is not a realistic factor to consider here.

The northernmost remnant lies about 2 mi (3.2 km) south of Adams Lake on a small spur of a high ridge above Castle Rock Park. On the north side of this spur, defined by the 10,000-ft (3,050-m) contour, gravel overlying the pediment apparently consists of two different deposits. The lower one rests on tilted beds of the undivided Raton and Poison Canyon Formations; it consists of 15-20 ft (4.5-6 m) of gravel comprising sandstone and conglomerate clasts as large as 2 ft (0.6 m) in diameter from the Sangre de Cristo Formation. Other materials in the gravel include pieces of sandstone from the Dakota Sandstone and Precambrian amphibolite gneiss, quartzite, pegmatite, granite and bull quartz. Significantly, rhyolite pieces from Ash Mountain are not included in the suite of lithologies making up the lower gravel. A thinner upper deposit, however, resting on the lower one, consists almost entirely of rhyolite fragments from Ash Mountain. We interpret this relationship to mean that at the time of deposition of the lower gravel on the Ash Mountain surface, the rhyolite was not yet exposed in the source area. As erosion continued, streams eventually cut into the rhyolite and the upper layers of rhyolite-bearing gravel were deposited. Limited exposures and thick soil and vegetation prohibit examination of more than a small part of the deposit. Rhyolite debris from the upper layers further confuses the picture, precluding alternate interpretations.

East of the small spur, a colluvial deposit slopes steeply to the east at about 800 ft/mi (153 m/km). It consists of several feet of very coarse gravel, composed almost entirely of rhyolite fragments mostly 6-12 in. (0.15-0.3 m) in diameter

but reaching sizes as large as 10-12 ft (2-3.7 m) across. The deposit thins to the east and consists only of scattered blocks and pieces of rhyolite near the edge of the mesa.

The southern remnant of the Ash Mountain pediment lies about 600 ft (180 m) above the north fork of McCrystal Creek (Fig. 6). It is separated from the talus deposits on the east side of Ash Mountain by a low saddle and appears to be a pediment cut on dipping sandstone beds of the undivided Raton and Poison Canyon Formations. The highest point on the surface is nearly 10,000 ft (3,050 m) in altitude, and the surface slopes to the southeast at about 200 ft/mi (38 m/km). It is covered with gravel that is composed almost entirely of rhyolite from Ash Mountain, but soil and vegetation cover the deposit and details are consequently obscured. The surface is correlated with the northern remnant of the Ash Mountain pediment principally on the basis of elevation and position on the mountain front.

Levings (1951) gives a thorough discussion concerning the Raton Mesa surface and its probable correlation with the 10,000-ft (3,050-m) mid-Tertiary surface of Ray and Smith (1941; Smith and Ray, 1943) (Table 1). The Ash Mountain pediment probably represents this high erosion surface in the Vermejo Park area and may possibly be middle to late Tertiary in age.

CORRELATION OF THE PEDIMENTS

Without diagnostic fossils, igneous rocks that overlie or cut the gravels, or datable volcanic-ash deposits, ages of pediments are impossible to determine. We can make certain assumptions regarding the ages by attempting to correlate surfaces in the report area with those of known or postulated ages outside the report area. The correlation of the surfaces discussed here with others of the Front Range and the Cimarron-Moreno Valley area is shown in Table 1.

The low pediments of the Vermejo Park area are correlated with the San Miguel, Beshoar and Barilla pediments of Pleistocene age (Levings, 1951). The pediment remnants along the New Mexico-Colorado state line are considered here to be

possibly early Pleistocene or older, on the basis of their position on the high crests representing the Park Plateau surface. The Ash Mountain pediment, which we consider to be middle to late Tertiary in age, possibly is correlative to the high-level surface underlying the basalt lava on Barela (formerly Barilla) Mesa, considered mid-Tertiary in age by Ray and Smith (1941). Since writing the body of this report, field work at Mills Divide, on the east side of the Moreno Valley, New Mexico, resulted in discovery of a porphyry dike, apparently previously unnoticed (Smith and Ray, 1943; Levings, 1951). This hornblende-rich dike apparently cuts the gravel; dating of this dike should provide the youngest possible age for this gravel. To date, only work by Stormer (1972), who dated the Raton Basalts at 7.2 to 3.5 m.y. B.P., has provided age information that can be used to date the gravels.

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