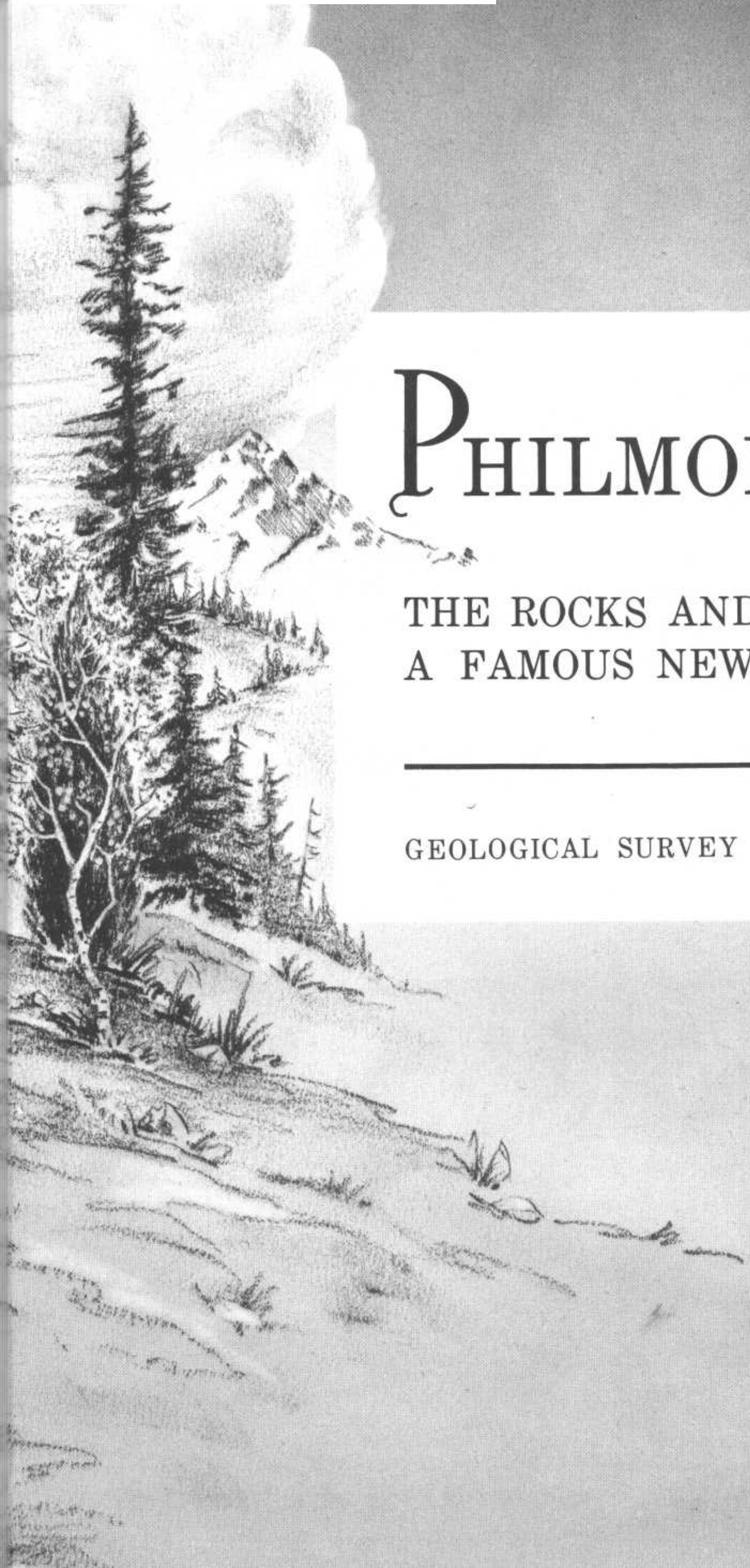

PHILMONT COUNTRY

THE ROCKS AND LANDSCAPE OF A FAMOUS NEW MEXICO RANCH

GEOLOGICAL SURVEY PROFESSIONAL PAPER 505

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A CAKE OF MANY LAYERS
The rock sequence

We now have a fairly good idea of the different kinds of rocks of which Philmont is made. We have seen, too, that they do not appear at random but have an orderly arrangement: black shale, which is the main rock beneath the lowland plains, is less common in the benchlands and along the mountain front and is absent from the mountain core; yellow sandstone and coal appear only in the northern benchlands; lamprophyre is found only in the plains; gneiss, schist, and pink granodiorite are only in the mountain core; and so on.

After we looked over the landscape, we found it possible and interesting to put together observations about landforms into the model of plate 1. We could try to make a rock map on a topographic map by drawing lines around the stripes and patches of each rock type exposed, and giving each a special color or pattern. If we did this, however, we would not have much of a map, mainly because the outcrops of most of the individual rock types are so small that they could not be shown at the scale of our map or, for that matter, on a piece of paper 10 times larger. Even if we could make such a map, it would be of little use, for it would be wildly complicated and at the same time too simple; to put all the rocks of a particular kind together is to imply that they are related in time, which may or may not be true.

We will have to find a better way to show where the rocks are and how they are related to each other. We might consider putting 10,000 bulldozers to work stripping off broken rock, soil, and vegetation, so that we could see how the rocks are arranged. Besides being somewhat impractical, this would be of little help where the rocks have been partly removed by erosion. Plainly, we need to know something of the third dimension. One way would be to drill deep holes wherever our curiosity led us, but this would be even slower and more expensive than bulldozing. Fortunately, observation and common sense open easier ways.

The most important clue is that the sedimentary rocks of Philmont are piled up in a regular way. Suppose we consider the arrangement of rocks visible on the north side of Highway 64 from near Cimarron town westward.

The sequence of rocks at the mouth of Turkey Canyon, 3½ miles west of town, is shown in figure 79 and also in figure 3. The rocks fall naturally into four units that look flat from the highway but actually dip gently northward. Beneath the highest bench is yellow sandstone and conglomerate in a few thick layers separated by thinner layers of brown sandy shale. These alternating layers add up to a total thickness of perhaps 300 feet at the bench edge. A 10-foot-thick ledge of conglomerate is at the bottom. For convenience, let us call this sequence of beds unit 1.

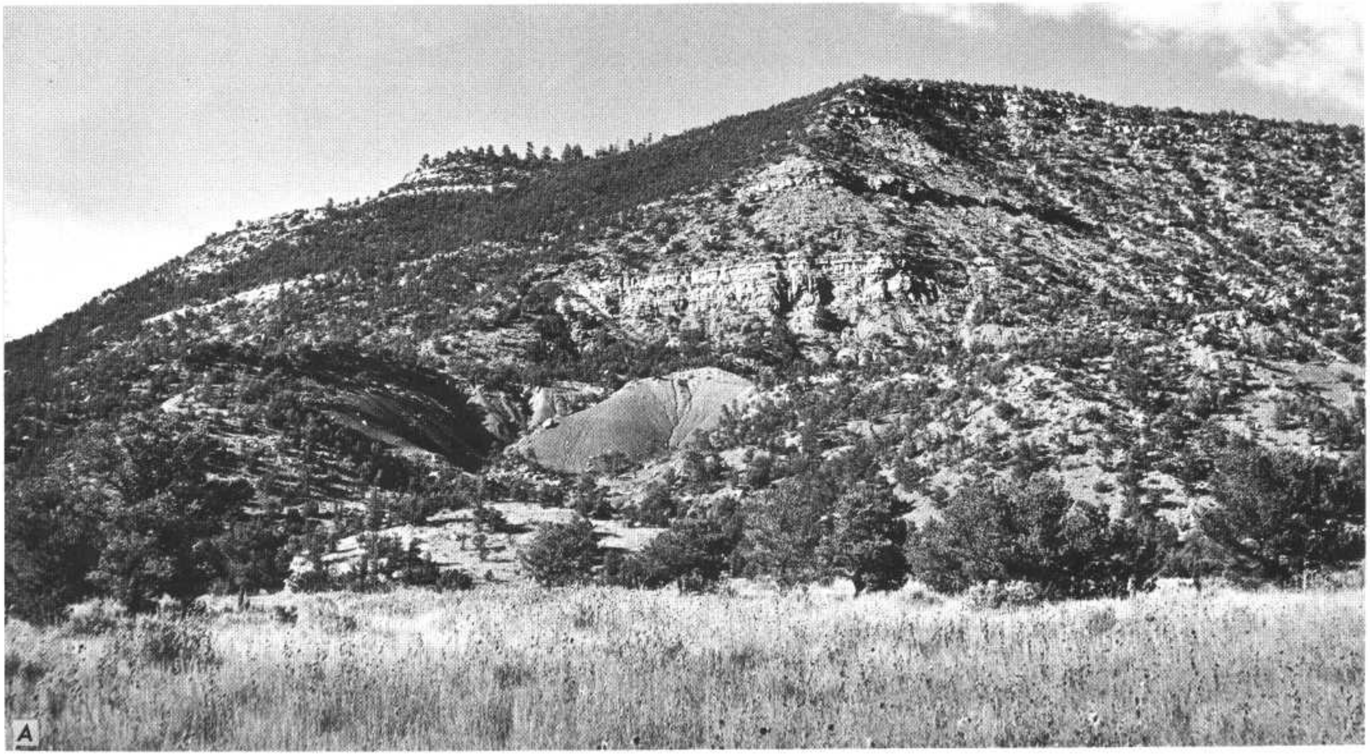
Beneath it are alternating much thinner layers of yellow and gray sandstone, black shale, and coal, each layer only a few feet thick. The whole sequence is about 150 feet thick and stands out from the rocks above and below; this will be unit 2.

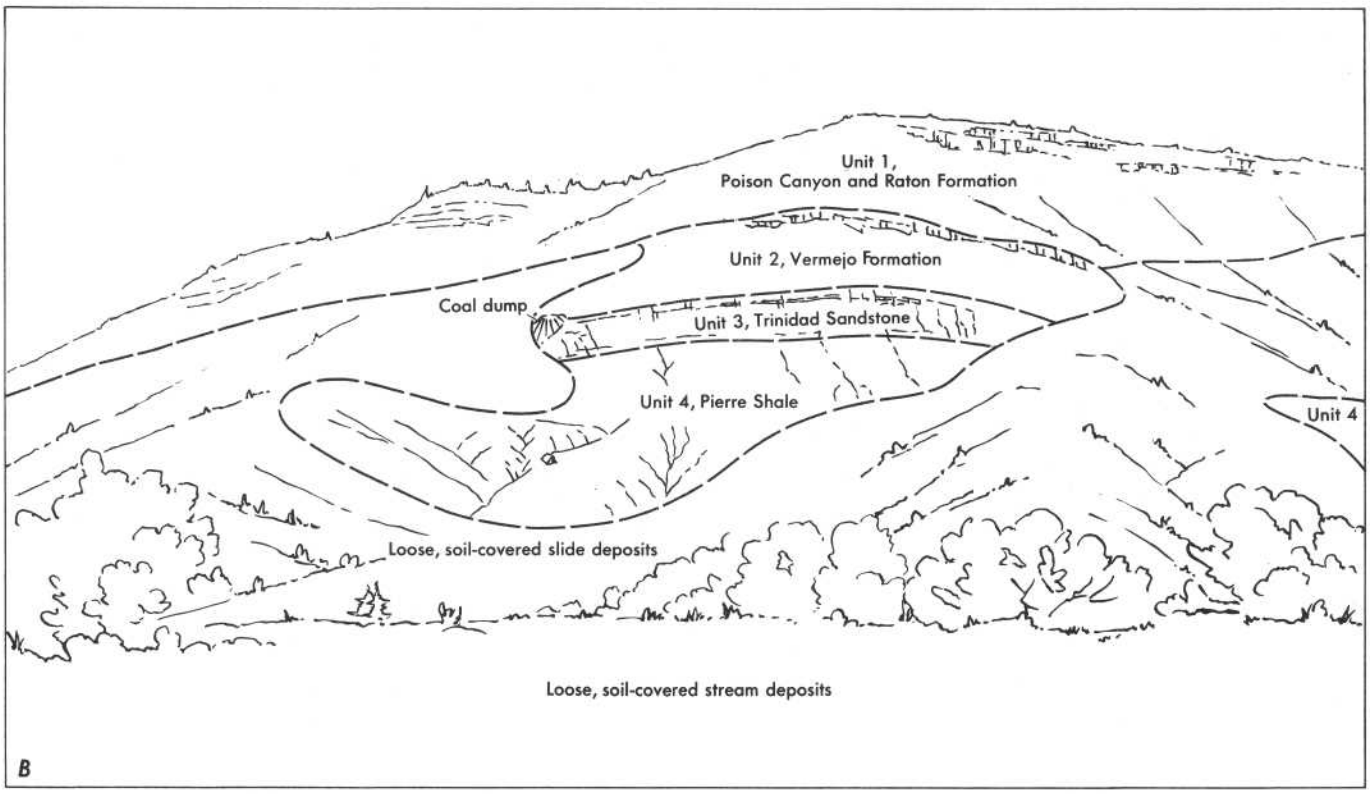
Still lower is a cliff of light-gray sandstone that has two dark layers—stained by dried oil—near the top. This sandstone sequence, about 100 feet thick, is unit 3.

Below the sandstone is black shale—unit 4. Only about 100 feet of this shale is exposed in the hillside near town; but the shale must be much thicker elsewhere, for it also appears beneath gravel in the creek bank on the south side of the road. We have no way of knowing, in this vicinity, how much thicker the shale body may be, because we cannot see the bottom of it.

Once we start thinking of rocks not as specimens or scenery but as huge layers, we realize that rock units continue beyond the bare outcrops beneath a mantle of soil, slide rock, and, near the creeks, of loose stream deposits; further, they once continued across what are now stream valleys.

Because the particles that make these rocks settled out of running or standing water, each lower bed had to be deposited before the bed above it. Unit 4 is the lowest, and





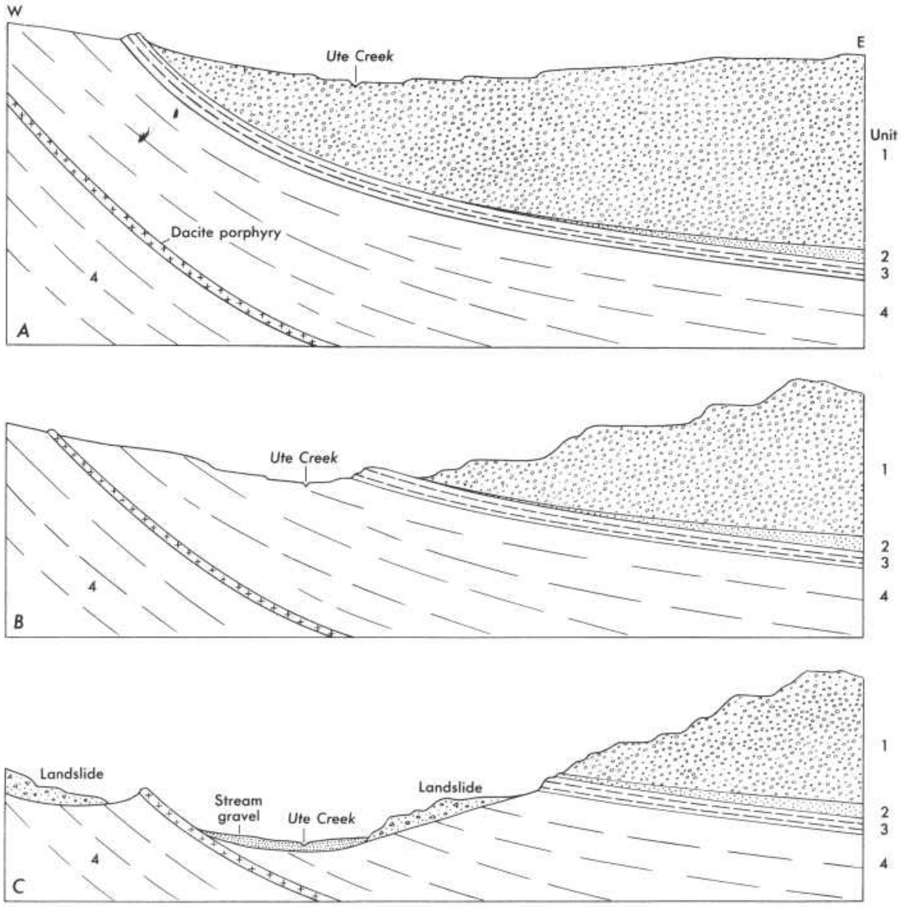
ROCK SEQUENCE on Cimarron Creek. Photograph (A) and sketch (B) of four rock units at mouth of Turkey Creek canyon, 3½ miles west of Cimarron town. (Fig. 79)

FOUR ROCK UNITS that crop out near Cimarron are still recognizable at the base of Midnight Mesa, 6½ miles west of town. (Fig. 80)

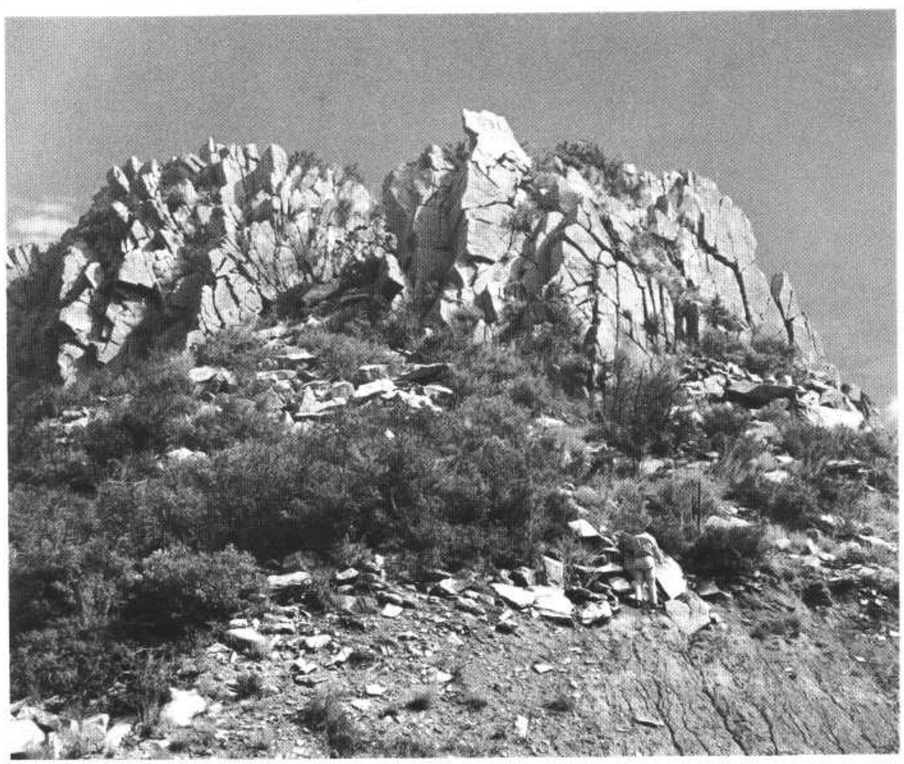
therefore the oldest, set of rocks in this exposure; and unit 1 is the highest, and therefore the youngest. This simple idea, that younger sedimentary rocks lie on older ones, is a basic principle in geology and is the main tool in working out the rock timetable. It is often called the principle of stratigraphic succession, or the law of superposition. It fits all rocks that form on the earth's surface—glacier deposits, sand dunes, volcanic ash falls, lava flows, and landslides, as well as waterlaid deposits.

The sequence stays about the same all the way up the lower canyons to Ute Creek valley; figure 80 shows the sequence at a point 6½ miles west of town. The sequence looks different opposite The Bench because the road rises above the top of the lower units for a little more than a mile, so that only yellow sandstone and conglomerate of unit 1 are visible at road level near Bear Canyon; but the lower units again are seen at the edge of Ute Creek valley, where they dip gently to the northeast. Going up the lower canyon, however, we begin to realize that unit 1 is far more than 300 feet thick; rather, it must be many hundreds of feet thick because it makes most of the high benchlands north of the canyon.

The rocks on the floor of Ute Valley are soil-covered landslides, except for some rounded gravel near Ute Creek. (See fig. 5.) (The road is on slide rock; Ute Creek, at the far left, is marked by a winding belt of trees.) These materials are lower on the land surface than the rocks of units 1–4 but do not really lie under them and are not older. Rather, they must be younger, for they were not formed until Ute Valley was cut down through the rocks of units 1–4 (fig. 81).



RELATIONS OF LANDSLIDES AND GRAVEL in the Ute Creek valley to other rock units. A, Before Ute Creek valley was cut by Ute Creek. B, Early stage in valley cutting. C, Ute Creek valley today. (Fig. 81)



DACITE PORPHYRY LEDGE above weathered outcrop of shale, part of unit 4 (Pierre Shale) near Ute Creek. (Fig. 82)

ROCK SEQUENCE on upper Cimarron Creek. Ledge of yellow quartz sandstone—upper part of unit 5 (Dakota Sandstone)—at mouth of upper canyon 0.3 mile west of Ute Park. Low outcrops of black shale of unit 4 (Graneros Shale) on the right (east) are concealed by vegetation. Light-colored rock at left edge is part of a dacite porphyry sheet. (Fig. 83)

Just west of Ute Creek is a bare ledge of dacite porphyry (fig. 82). Because the porphyry was not formed at the surface but was squeezed between layers as a melt, the rule of superposition does not apply, and we will not include the porphyry in our numbered sequence; but, at any rate, it is surely younger than the rocks into which it has been squeezed. At the west base of the porphyry ledge are outcrops of black shale, exactly like that of unit 4 on the east side of the valley a mile away but dipping more steeply eastward; clearly, the shale body of unit 4 is very thick, indeed.

From this point until we pass Ute Park, the only visible rocks on the north side of the road are young landslide and stream deposits and another bare ledge of dacite porphyry. But as we approach the upper canyon, still more black shale appears in a narrow belt; dipping eastward, the shale must be beneath the rocks we have been following. This black shale is like that of unit 4, which must be thousands of feet thick.

Now we enter the upper canyon (fig. 83), where great light-colored ledges loom on both sides. Four ledges are dacite porphyry, but two, separated by one of the dacite porphyry sheets, are of the yellow quartz sandstone that runs along the entire mountain front; one of these is shown in figure 83. These quartz sandstone ledges, each of which is about 50 feet thick, dip eastward beneath unit 4, and so must be older. Let the two sandstone ledges together be unit 5; its true thickness cannot be measured here because of the dacite sheets.

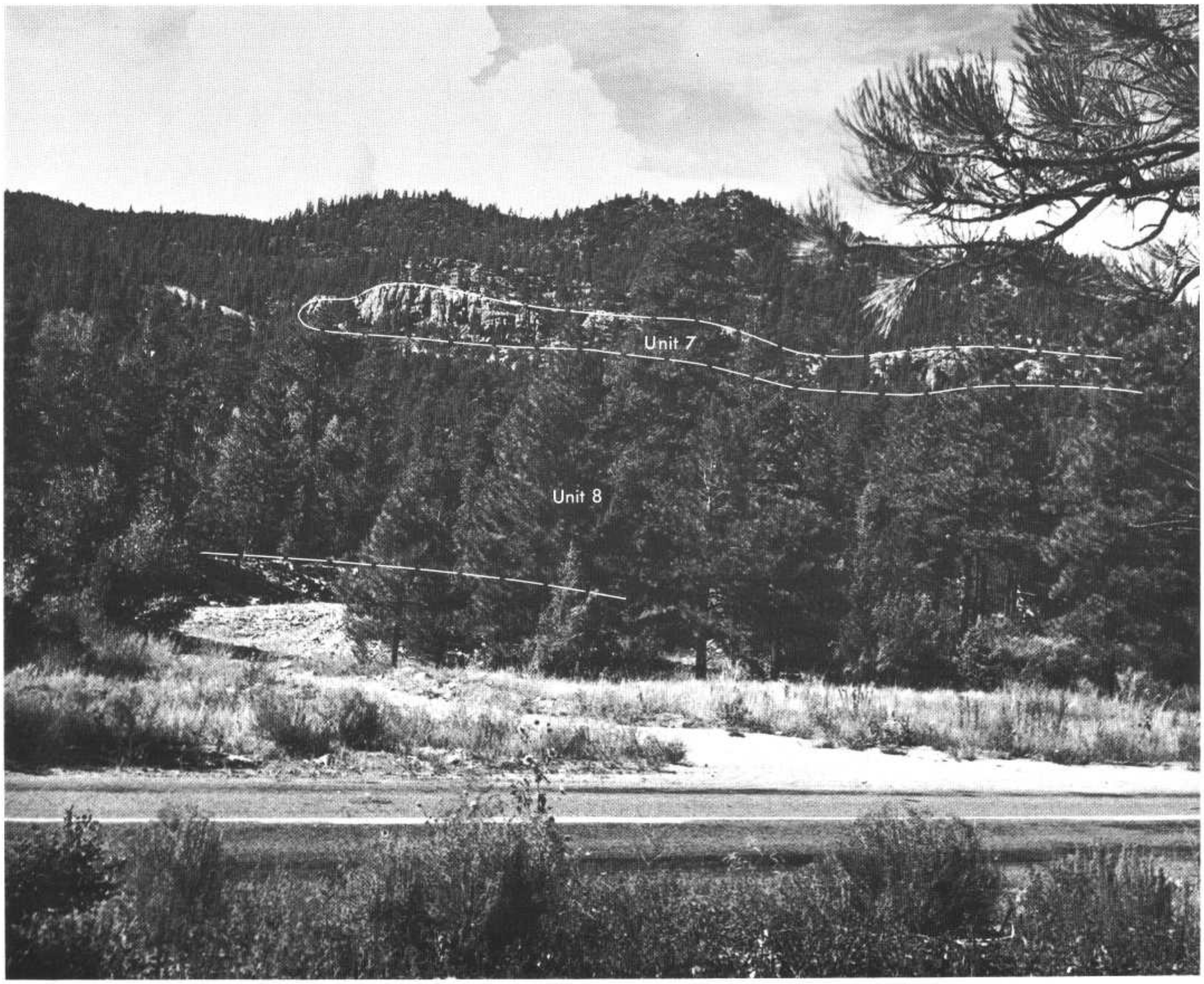
Half a mile farther west, after crossing the fourth ridge of dacite porphyry, and past the lower ledge of quartz sandstone of unit 5, we cross a grassy saddle broken by a few low outcrops of red shale and sandstone—unit 6—that dips eastward underneath unit 5. Because exposures are poor, the thickness of unit 6 is hard to measure; also, it is hard to see and is not shown in any of this group of photographs.

On the far (north) side of this saddle, and just above Gravel Pit Lakes, is another ledge of east-dipping yellow quartz sandstone—unit 7—much like that of unit 5 but only about 30 feet thick. Figure 84 shows this sandstone ledge a little west of Gravel Pit Lakes.

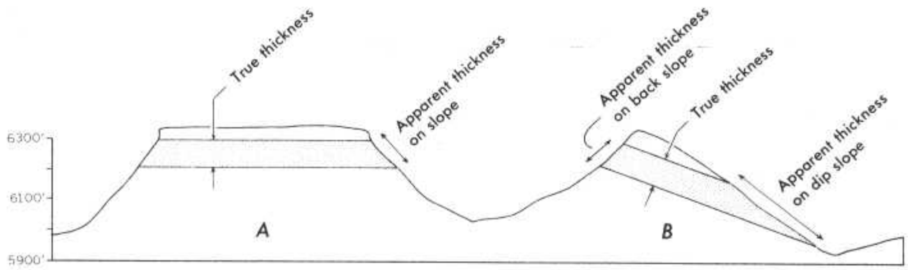
The lakes themselves are in young creek gravel, but between them and the light-colored ledge of unit 7 are scattered exposures of another body of red shale and sandstone—unit 8—that dips below unit 7. (See fig. 84.)

Beginning at the next ledge, dacite porphyry is exposed continuously for nearly a mile in the towering Palisades. (See fig. 54.)

Beyond the Palisades, to the west edge of our area at the Horseshoe mine (fig. 6), only metamorphic and igneous rocks crop out along the road. The metamorphic rocks are mainly



ROCK SEQUENCE on upper Cimarron Creek. Light-colored ledge of sandstone—unit 7 (Entrada Sandstone)—lying on red shale of unit 8 (Dockum Group), concealed by vegetation, in canyon wall west of Gravel Pit Lakes. (Fig. 84)



TRUE AND APPARENT THICKNESSES of rock units. A, In flat rocks, the true thickness of a unit is the vertical distance between the top and bottom. B, In dipping rocks, the true thickness can be found by drawing a diagram to scale or by using trigonometry. (Fig. 85)

mica schist but include some gneiss and quartzite. The igneous rocks are coarse-grained pink granodiorite (fig. 62) and dark pepper-and-salt diorite. The dip of layers in the metamorphic rocks is not parallel to the easterly dip of the sedimentary rocks but is nearly vertical. The red shale of unit 8 is not in contact with the metamorphic rocks along the highway, so that we cannot use superposition as a guide to their relative ages. Here, we do not need it. The schist and gneiss must be much older, for if any of the sedimentary units 1–8 had existed here when the metamorphism was going on, they, too, would have been metamorphosed.

An easy way to visualize the sequence of bedded rocks in this traverse up Cimarron Creek is to arrange the units in a vertical column, as though pushing together a spreadout hand of cards, and give each unit a pattern or color of its own and a thickness proportional to its observed thickness. For units that are flat or nearly so, the thickness can be measured directly by measuring the difference in altitude between the top and bottom; this can be done in many ways with instruments, or, on a good topographic map, by counting the contours and estimating the fractions of contours between top and bottom (fig. 85*A*).

For units that dip steeply, such as those west of Ute Creek, measuring thickness is more complicated. It is necessary to measure both the vertical distance between the top and bottom of a unit and the horizontal distance from top to bottom; measuring the slope distance from top to bottom gives the same result. Next, the amount of dip must be measured. After all these measurements are made, the thickness can be determined by trigonometry or, as in figure 85*B*, by using a simple diagram drawn to scale.

The rock sequence seen along Cimarron Canyon, with the thickness of each unit drawn to scale, is shown in the second column of figure 86. Traverses on several other roads and trails will show how regular the rock sequence is.

Take Ponil Creek, for example. Starting north up Ponil Creek from the Highway 64 junction, we recognize units 1, 2, 3, and 4 in the benchlands on either side of the wide valley. As on lower Cimarron Creek, only a little of unit 4 is visible near the valley floor, because it is mostly covered by soil and loose gravel. The same units are exposed for 3.5 miles. The abandoned coal mine of figure 49 is on the west side of the creek in this stretch; the coal is in unit 2. A little way upstream from Templeton Canyon, the shale of unit 4 dips beneath the valley, and only units 1, 2, and 3 are exposed. Just upstream from the mouth of Chase Canyon, the sandstone of unit 3 also dips beneath stream level, and only units 1 and 2 are visible in the canyon walls. Sandstone and coal from unit 2 are shown on figure 112.

At the mouth of North Ponil Creek, unit 2 dips beneath the surface, and from here to the edge of the map area Ponil Creek runs entirely in rocks of unit 1; figure 34 shows sandstone and conglomerate of unit 1 at Ponil Base Camp. Along Ponil Creek we can observe that, in this part of Philmont, unit 1 includes many layers of shale—some of them coaly—and much sandstone but very little of the conglomerate which is the main rock type in unit 1 farther west. The rock sequence along Ponil Creek is shown in the first column of figure 86.

Traveling west up the Cimarroncito Creek trail from the Philmont Scout Ranch Headquarters to the Lambert Mine Camp and on into the Red Hills, we pass through much the same sequence of rocks as we passed through going up Cimarron Creek. At the start of this journey, however, two more rock types are added to the sequence. One is rounded gravel that caps Horse Ridge. Lying on the black shale of unit 4, the gravel is younger than the shale but older than both the deposits of Cimarroncito Creek or the landslides at the base of Tooth of Time Ridge and Deer Lake Mesa; for the rounded gravel, like the solid rocks below, has been cut away to form the valleys in which the stream deposits and landslides lie. The other new rock type is the lamprophyre sheet of Horse Ridge, seen in figure 31. Though it is not a surface deposit, we can at least be sure that, because it cuts across the shale of unit 4, it is younger than unit 4 and all underlying units.

The sedimentary rock units 1, 2, and 3 of the Cimarron Creek sequence do not appear above the black shale on the Cimarroncito trail, but they form Antelope Mesa and Deer Lake Mesa to the north. As on lower Cimarron Creek, the beds dip gently northward. At the mountain front is Cathedral Rock, the first dacite porphyry ledge met on this journey. At its base is black shale of unit 4, which dips eastward and more steeply than the same rock on the plains, exactly as on Cimarron Creek at Ute Creek junction. Slide rock and young stream deposits cover the wooded valley that extends north from Cimarroncito Reservoir. In this valley is Cimarroncito Base Camp. On the west side of this valley, the creek cuts another, thinner sheet of dacite porphyry; exposes more black shale—still unit 4—in a narrow wooded valley; runs in a narrow canyon across a thick porphyry sheet for a quarter of a mile; and then meets the familiar double ridge of yellow quartz sandstone (unit 5), again separated by a porphyry sheet. Then comes the red shale and sandstone of unit 6, here, too, poorly exposed and also cut by a porphyry layer (fig. 87). The thin ledge of yellow quartz sandstone of unit 7 follows, and then the second red shale and sandstone, unit 8 (fig. 88).

Now we find sedimentary rocks older than unit 8 that were not seen on Cimarron Creek. For 0.7 mile upstream from the base of unit 8, the creek crosses coarse red and gray sandstone and conglomerate—unit 9 (fig. 86)—split by two sheets of porphyry. As on upper Cimarron Creek, all these layers dip rather steeply northeastward.

For the next mile, to and beyond Lambert Mine Camp, the creek runs in dacite porphyry. Then it is in gneiss and schist the rest of the way to its head in the Red Hills.

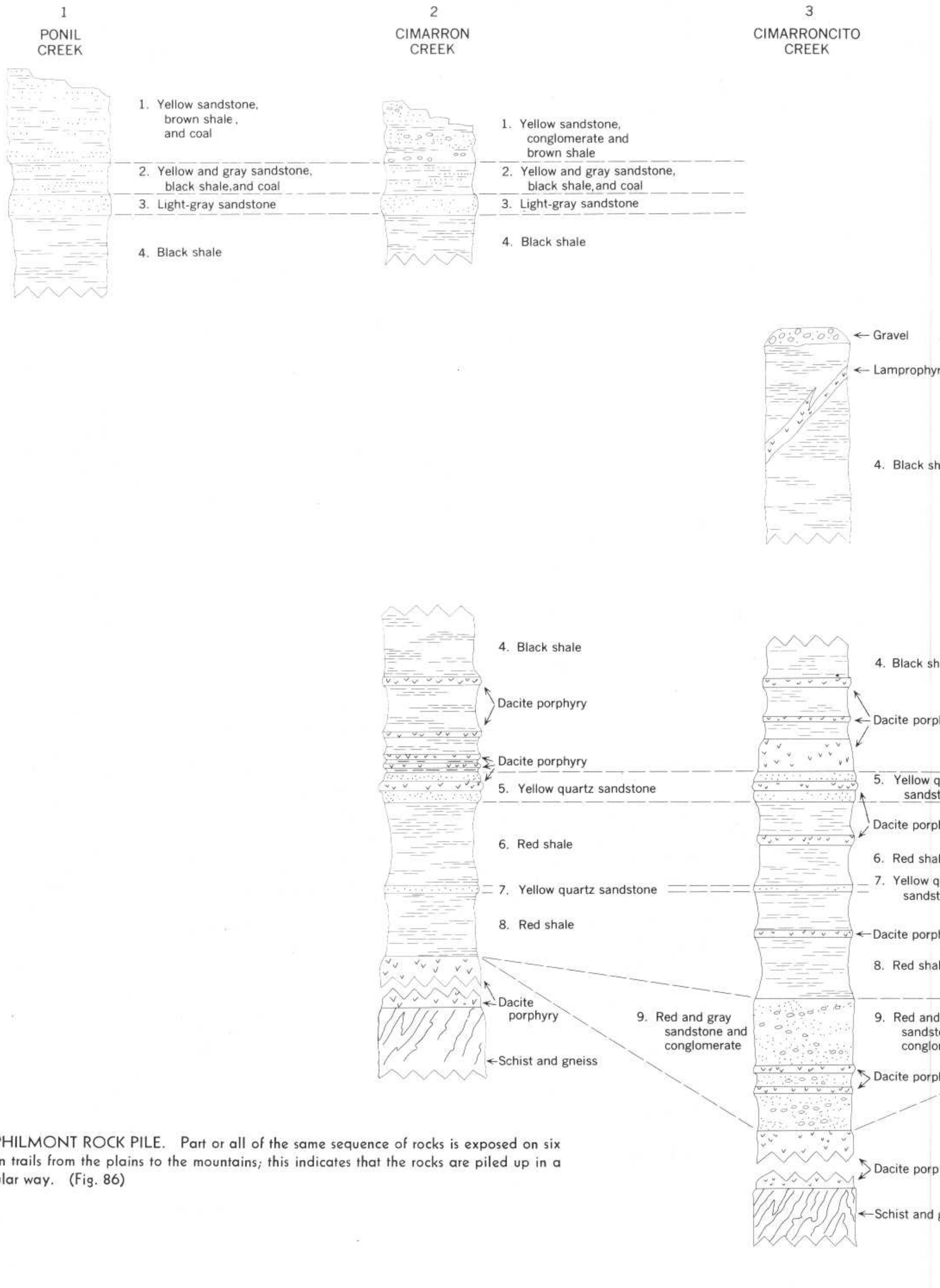
The sequence of rocks met in this traverse is shown in column 3 of figure 86. Two new units of sedimentary rock—unnumbered young gravel, and old unit 4, and one of igneous rocks—lamprophyre—have been added, but there has been no change in the order or in the general thickness of the units seen along Cimarron Canyon.

Practically the same sequence is repeated up the next main stream, South Fork Urraca Creek (column 4, fig. 86). Units 1–3 do not appear, but all the other numbered units do, and a few more. From the Camping Headquarters to the vicinity of the Stockade, the trail runs in young stream deposits on black shale (unit 4), which crops out here and there along the south side of the creek and around the small reservoir southeast of the Stockade. Then the trail and creek abruptly pass into 0.6 mile of canyon country, cut in a great mass of dacite porphyry.

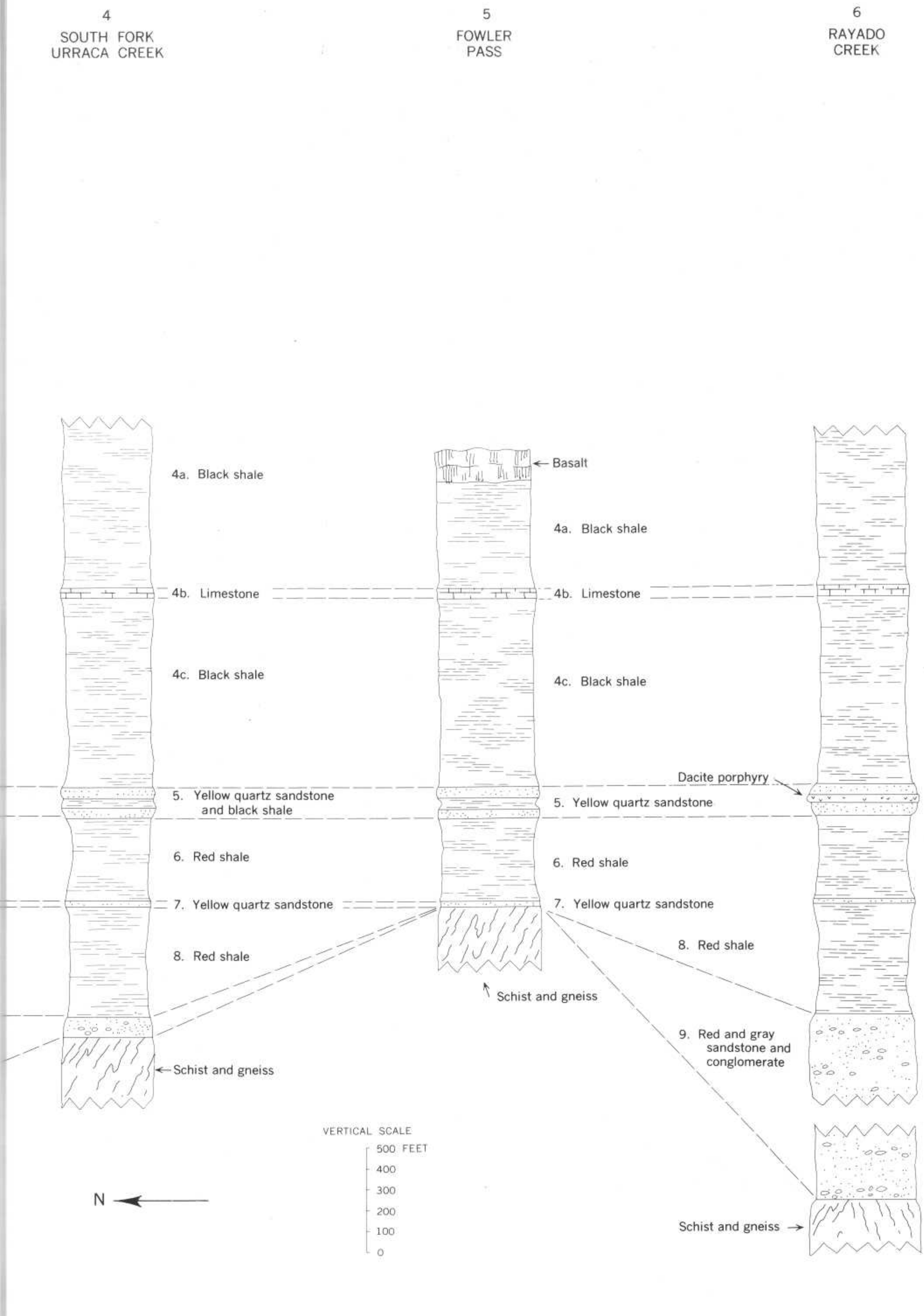
For the next 2 miles, all the way to the mountain front, the trail again crosses lowlands formed on landslide and stream deposits mantling unit 4, but a complication turns up in the simple picture of unit 4 as a vast body of black shale. Beginning near the turnoff to Stone Wall Pass and continuing 0.6 mile west, low ledges of limestone (shown in fig. 30*A*) crop out along the north side of the trail. Several ledges, each a few feet thick, separated by thin layers of black shale, add up to a limestone unit about 40 feet thick. Another change from the usual pattern is that the limestone dips rather steeply south, or toward the creek. Although outcrops are few, we realize that great thicknesses of shale lie both above and below the limestone unit, so that unit 4 now has three recognizable parts—an upper shale, 4a; a middle limestone, 4b; and a lower shale, 4c (fig. 86; and pl. 2).

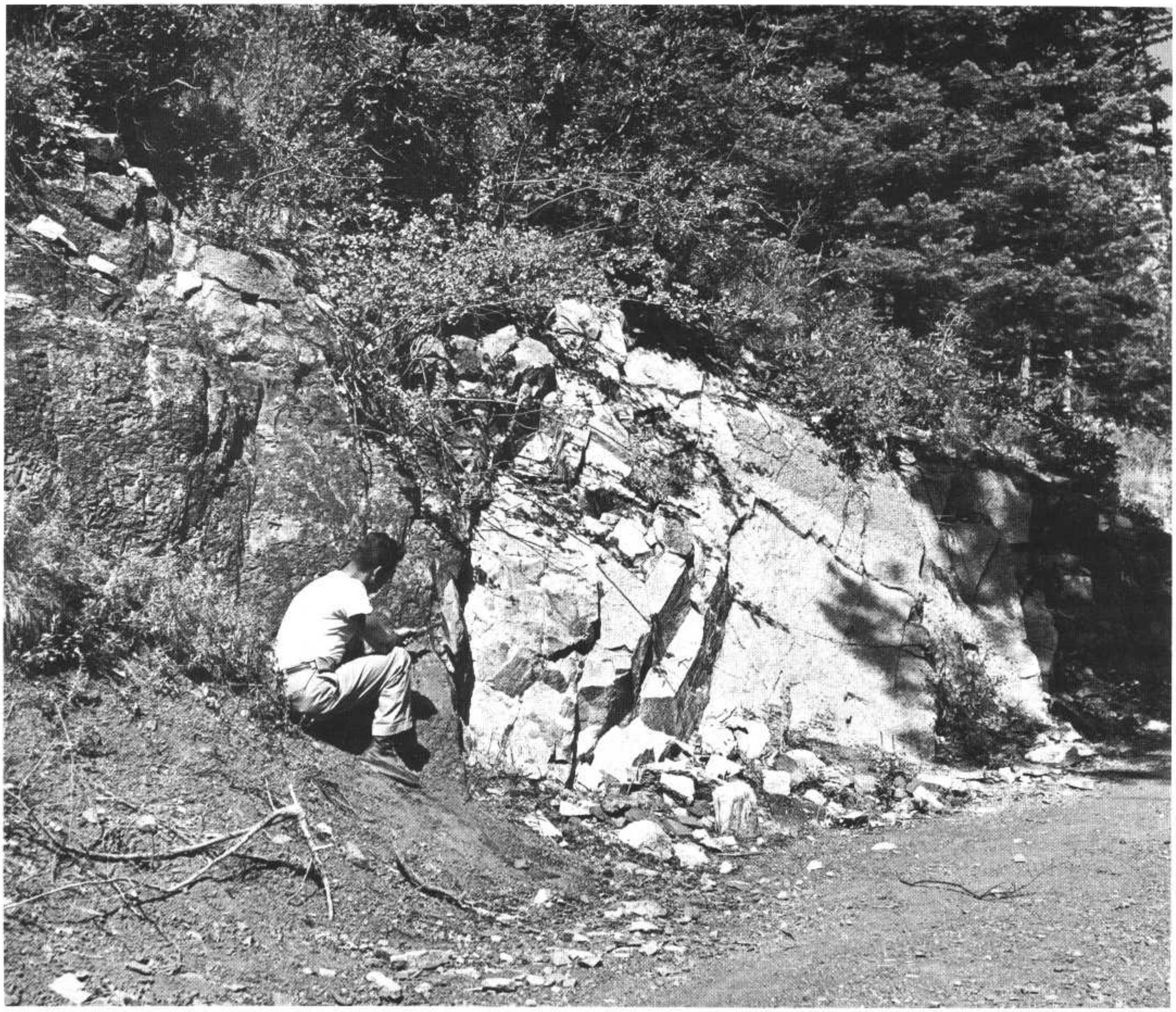
At the mountain front the familiar sequence of sedimentary rocks reappears, but here there is little interruption by dacite porphyry. Units 5–9 are all present, but unit 9, which is hundreds of feet thick on Cimarroncito Creek, is less than 100 feet thick here. At first glance, all the other units below unit 5 seem much thinner, too, but this is only because they are standing nearly vertical, so that their width of outcrop is nearly their true thickness; beds that dip more gently have outcrops much wider than the true thickness. Unit 9 lies directly on gneiss and schist, without the intervening dacite porphyry that we met farther north. The trail remains in igneous and metamorphic rocks the rest of the way to Beaubien Camp and beyond. Exposed along the trail are pepper-and-salt diorite, diorite porphyry, and garnet schist, as well as the more common gneiss, mica and hornblende schist, and granodiorite.

To include all the bedded rocks in this vicinity, we must retrace our steps to the limestone outcrops of unit 4b and travel westward to Crater Lake Base Camp and along the mountain-front trail to Fowler Pass (column 5, fig. 86). The camp itself is on landslide rocks. Above the base camp the trail starts climbing and crosses black shale, in the base of unit 4c, that dips eastward more steeply than the slope of the mountain front. As the trail climbs westward, it crosses lower and lower units. At the lowest switchback the trail passes on top of a magnificent ledge made by the upper quartz sandstone of unit 5 (shown in fig. 94). Then we cross the lower sandstone layer of unit 5, the red shale of



THE PHILMONT ROCK PILE. Part or all of the same sequence of rocks is exposed on six main trails from the plains to the mountains; this indicates that the rocks are piled up in a regular way. (Fig. 86)


4
SOUTH FORK
URRACA CREEK
5
FOWLER
PASS
6
RAYADO
CREEK
4a. Black shale
4b. Limestone
4c. Black shale
5. Yellow quartz sandstone and black shale
6. Red shale
7. Yellow quartz sandstone
8. Red shale
Schist and gneiss
Basalt
4a. Black shale
4b. Limestone
4c. Black shale
5. Yellow quartz sandstone
6. Red shale
7. Yellow quartz sandstone
Schist and gneiss
Dacite porphyry
8. Red shale
9. Red and gray sandstone and conglomerate
Schist and gneiss
VERTICAL SCALE
500 FEET
400
300
200
100
0
N

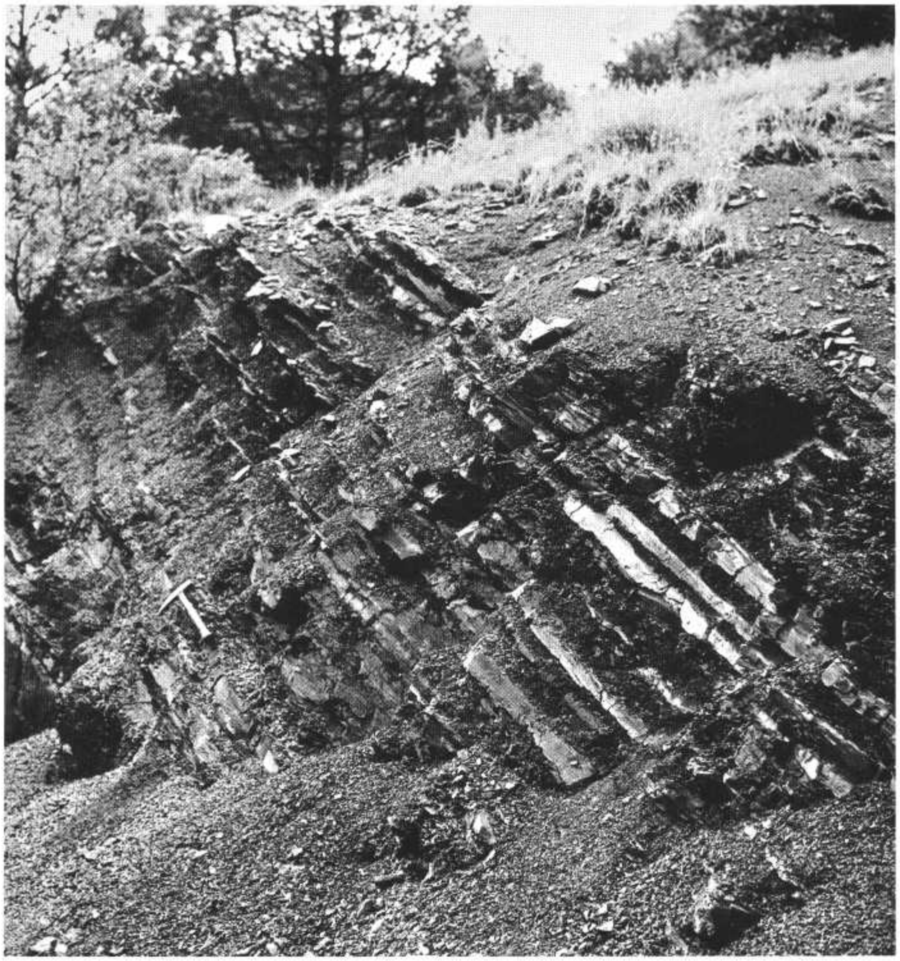


RED SHALE AND SANDSTONE OF UNIT 6 (Morrison Formation) on Cimarroncito Creek. Light-colored rock to right of man is dacite porphyry. (Fig. 87)

unit 6, and the thin yellow quartz sandstone of unit 7. But units 8 and 9 are missing—the trail passes abruptly, in the highest switchback, into gneiss and schist. The boundary between the metamorphic and the sedimentary rocks is roughly parallel to the trail, which turns and runs south for about a mile to the base of Fowler Mesa, so that the trail is now in gneiss and schist and now in quartz sandstone. The trail ascends Fowler Mesa by another series of steep switchbacks; here we see that not only units 8 and 9 but also units 6 and 7 are missing, and quartz sandstone of unit 5 is in contact with gneiss and schist.

On the upland surface at Fowler Pass itself, the trail is in gneiss and schist, mostly concealed by soil and vegetation; but just to the east, capping Fowler Mesa, is basalt. Although the basalt is an igneous rock, it flowed out on the surface and therefore can be regarded as part of the sequence of bedded rocks. It lies as an almost flat sheet across the upturned edges of units 4 and 5 and on gneiss and schist, so it is younger than all these. It must be older than the landslides, however, for we have already noticed that the slides flanking Fowler Mesa are made mainly of basalt chunks, surrounded by shale fragments.

Finally, a traverse up the southernmost of Philmont's large streams, Rayado Creek, repeats almost the entire sequence—units



RED SHALE AND SANDSTONE OF UNIT 8 (Dockum Group) on Cimarroncito Creek. (Fig. 88)

1–3 are missing, but units 8 and 9, missing near Fowler Pass (column 6, fig. 86), are present. All three subdivisions of unit 4 are well exposed, and the limestone of 4b crops out at the entrance to New Abreu Base Camp. (See fig. 30*B*.)

The two ledges of yellow quartz sandstone of unit 5, here again separated by a thin sheet of dacite porphyry, cross the creek about 3,000 feet above Old Abreu Lodge; and all the familiar units below it are present here, though some of them are hard to find because of the dense brush. The coarse red sandstone and conglomerate of unit 9 is very thick and can be seen dipping steeply in outcrops along the creek for 1¼ miles. The contact with gneiss and schist is below the saddle between Crater Peak and Rayado Peak.

We get a suggestion of what the rock sequence is like on the west side of the Cimarron Range by going up Agua Fria Creek, which branches west from Rayado Creek at Rayado Base Camp, and by crossing the crest of the range. Half a mile above Agua Fria Trail Camp, we leave gneiss and schist and pass onto the red rocks of unit 9, here dipping westward. These continue along the creek for 0.7 mile to where it rises to the rim of the Ocaté Mesa; there the sedimentary sequence is covered by basalt. Continuing across the Mesa and down West Agua Fria Creek, on the west side of the Cimarron Range, we cross units 8, 7, and 6, in that order, all dipping west. Clearly, the range is a great arch over which many, if not all, of the nine units of solid sedimentary rocks were once continuous.

So, by using the simple idea that in bedded rocks any layer is younger than the layers beneath it and older than the layers above it—the principle of superposition—we have been able to recognize the same rock sequence throughout the Philmont region. We also are beginning to get some ideas about the structure of the rock bodies.

We may think of the rocks of the Philmont area as a huge layer cake. It has, however, been baked by a careless baker, as the layers are not neatly shaped or arranged. Almost every layer changes in thickness and in other details from place to place, some within inches, others in miles; many thin to nothing within Philmont. Others disappear by gradually passing into a different type of rock. For example, a single bed may be a pebble conglomerate near a source of pebbles, shale miles away, and sandstone in between. The layers change in the same way from top to bottom. Many have distinct tops and bottoms, whereas others pass gradually above and below into other rocks. But despite all the changes and irregularities, there is no mistaking an overall orderliness of the rock strata.

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