SCENIC TRIPS to the GEOLOGIC PAST

Circle Drive

Taos – Red River – Eagle Nest

New Mexico

Scenic Trips to the Geologic Past Series:

No. 1 - Santa Fe, New Mexico

No. 2 - Taos - Red River - Eagle Nest, New Mexico, Circle Drive

No. 3 - Roswell - Capitan Ruidoso and Bottomless Lakes Park, New Mexico

No. 4 - Southern Zuni Mountains, New Mexico

No. 5 - Silver City - Santa Rita - Hurley, New Mexico

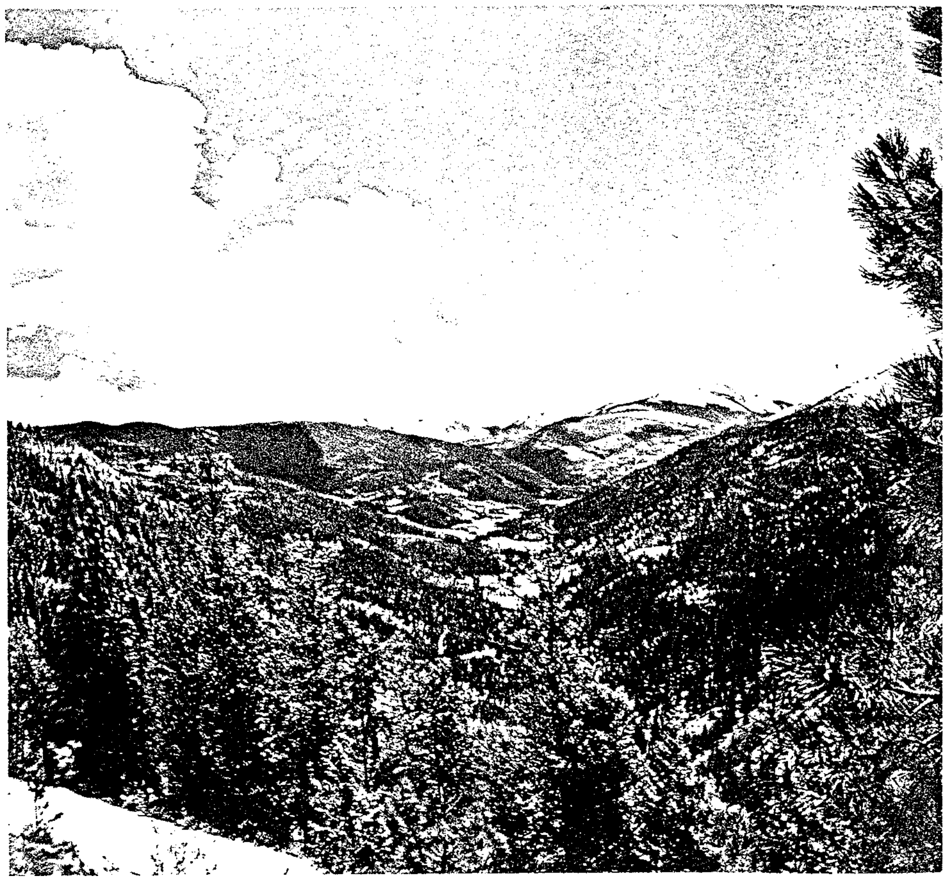
Additional copies of these guidebooks are available, for 25 cents, from the New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico.

They rise above the mesas, plains and valleys;
Great rocks to cast their shadow on the land.

Ruth K. Hall
N. Mex. Mag. - Sept. 1958

Stretches of desert and green valleys small,
Flat open prairies and blue mountains tall.

Grace Barker Wilson
N. Mex. Mag. - July 1951



Fall in the Sangre de Cristo Mountains ----
Red River Canyon and Wheeler Peak from
Red River Pass.

Scenic Trips to the Geologic Past

No. 2

TAOS-RED RIVER-EAGLE NEST, NEW MEXICO

CIRCLE DRIVE

by

JOHN H. SCHILLING

decorative drawings

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STATE BUREAU OF MINES AND MINERAL RESOURCES
a division of
NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY
Socorro - New Mexico

Third Edition, 1960

PREFACE

Much of the work undertaken at the New Mexico Bureau of Mines and Mineral Resources is done to help the mineral industries --- the geologist, Prospector, oil man, miner. This work is published in technical reports -- dry at their best.

There are many who are not interested in these reports but would like to know more about the geology and mineral industries of New Mexico. To meet this need, the Bureau publishes a series of guidebooks ("Scenic Trips to the Geologic Past") designed to tell New Mexico residents and visitors about the many scenic and geologic attractions in the State. Other booklets in this series (see the inside front cover) describe areas around Santa Fe, Roswell and Ruidoso, Gallup and Grants, and Silver City.

For this new edition of the booklet, a colored frontispiece has been added, the bibliography enlarged, and a few other minor changes made. We hope this will make the booklet more enjoyable.

John H. Schilling

INTRODUCTION

Taos is located at the edge of two strikingly different landscapes. To the west stretches the Taos Plain, flat except for a few hills and the deep gorge of the Rio Grande. To the east towers the Taos Range of the Sangre de Cristo Mountains.

What geologic processes, working patiently through millions of years of geologic time, formed these two contrasting landscapes? This is one of the questions the geologist tries to answer when he studies this area. Like a detective he hunts for clues which, when added together properly, give a picture of happenings in the past. When the detective tries to reconstruct an event that took place during the previous year, his task is much more difficult than if the incident occurred only a few days before, because many of the clues will have been destroyed. Imagine how difficult it is for the geologist to reconstruct events which took place, not a year ago, but millions of years ago. He seldom can find enough clues to give more than a general picture of the geologic history of an area. And more detailed study may uncover new clues, which in turn may prove some of his previous deductions to be wrong!

...like a detective the geologist hunts for clues...

After studying an area, the geologist might deduce that an ocean once covered the area, slowly flooding in, then draining off; that ancient mountain ranges have pushed upward, only to be worn away by slow but ceaseless erosion; and that volcanoes have spewed lava and ash over the area. Probably he will also have made a map showing which areas are covered by the different rock types--by lava from the volcanoes, by gravels from the eroded mountains, and by limestone deposited in the ancient ocean.

You may be asking, "But of what use is such information about the geology of an area?" Actually there are many ways in which this information can be used. The prospector often can be told in which rocks certain ore deposits (uranium, for example) occur; using a geologic map, he can find out where the right rocks are exposed at the surface, and thus not spend his time searching in unfavorable areas. The rancher, farmer, or water company can be shown where to drill for water, probable depth to water, how much hard rock must be drilled through, etc. The oil company can be guided as to the most favorable place to drill for oil, how deep to possible oil-bearing rocks, etc.

And the civil engineer can learn the best place to build a dam so that it will rest on solid bedrock. These are only a few examples of the many possible uses.

* *. * * * * *

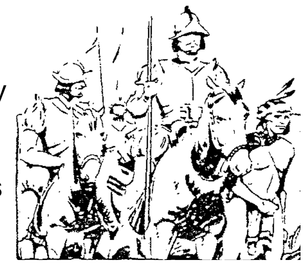
Let's take a circle drive from Taos, a leisurely trip across the plain and through the mountains. The map on page 6 shows the route followed. Some of the things we see will give us clues about the geologic past, why the plain and mountains are so different.

Geologists have divided geologic time into ages, and have given each age a name, much as historians have divided human history into the Stone Age, Bronze Age, etc. This geologic timetable, showing the ages of the different rocks found in this area, is given on page 8. The other maps, cross-sections, drawings, and pictures also will help to describe what well see.

There are many interesting things to do and see along the way. I'11 tell you about them as we drive along. Don't forget your camera; there's lots of picture-snapping scenery ahead. And you might throw in your fishing rod; you may get bored with the rocks.

ABOUT THIS AREA

The first Spaniards to reach this area, an exploratory party of Coronado's expedition from Mexico, visited the Taos Pueblo in 1540.



The Spaniards who first settled this area about 1615 lived near the pueblo of the friendly Taos Indians, because of the safety it afforded against the raids of hostile tribes. But as the Spanish colony grew rapidly in size, the Indians became alarmed and asked the Spanish to move further away--thus the two villages separated. Although a Catholic church had been built at the pueblo before 1617, ill feeling increased until, in 1631, the priest and two soldiers were killed by the Indians. In 1680 the pueblos bonded together in a successful rebellion which drove the Spanish out of New Mexico. But their freedom was short lived. In 1692 De Vargas reconquered New Mexico, and the Spanish colony at Taos was reestablished on the old site.

Beginning as an agricultural community, Taos soon became an important trading center, as its annual trade fair attracted the Plains and Pueblo Indians, traders from Mexico and Spain, and Spanish settlers from all over New Mexico. After 1802, when the Louisiana Purchase made the Mississippi River Basin part of the United States, American fur trappers, the "mountain men," swarmed into the area. Not only did Taos provide a market for their pelts, but the beautiful senoritas and famous "Taos lightning" (raw whiskey made locally) were important attractions. The famous Indian scout and trapper, Kit Carson, settled here and married one of the local beauties.

Another important influence was the coming of Padre Martinez in 1826. For 40 years he fought ignorance and superstition, and strove to educate the people. He established the first coeducational school in the Southwest, ran a printing press, and published a paper called "El Crepusculo" (the dawn).

In 1821 Mexico became independent, but was in control of New Mexico for only a short period. In 1846 the United States declared war on Mexico, and invaded New Mexico. No important resistance occurred, and New Mexico was organized as a territory of the United States. Charles Bent, an influential fur trader, who had settled in Taos, was appointed the first governor.

On January 19, 1847, Spanish residents of Taos, by liberal application of "Taos lightning," stirred up the Taos Indians to help scalp alive, then murder, Governor Bent. Several other officials also were murdered. This attempt to overthrow the new government was subdued quickly when 350 soldiers from Santa Fe surrounded and fired into the Taos Pueblo church, where the insurgents had gathered.

The Civil War had little effect on Taos. A group of citizens, led by Kit Carson, nailed the Union flag to a pole in the plaza and made it clear that they expected to see it stay there--and that settled the matter!

As early as 1866 gold was found in quantity in the mountains. The bulk of the production came from the placer deposits at Elizabethtown, although some gold was produced in the "Red River country." Other metals were mined, but none of these operations proved really profitable until the Questa Maly mine was opened in 1916.

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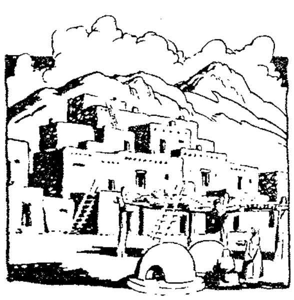
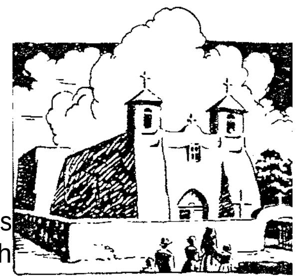
Today Taos is a tourist center, art colony, and trading center for the surrounding countryside. No railroads enter Taos County, and there is no heavy industry. The outlying villages are poor, and although the people raise food enough for themselves on their small irrigated farms, there is little left to sell. The mountain area is thinly populated; tourists, mining, summer grazing of cattle and sheep in the high country, and lumbering are the four important sources of revenue.

Taos is actually three distinct towns: the Indian pueblo (San Geronimo de Taos), the Spanish town (Don Fernando de Taos), and the old farming center (Ranchos de Taos), familiarly called simply Taos Pueblo, Taos, and Ranchos. This area, like much of New Mexico today, is a blend of three cultures: Indian, Spanish, and Anglo-American. You'll hear all three languages spoken on the streets.

Taos Pueblo appears much as it did when the first Spaniards visited it, except that doors and windows have since been cut in the adobe walls, and access to the rooms is no longer through hatchways in the roofs. The two large communal houses, four and five stories high, face each other across Taos Creek, which flows through the large central plaza. Huge, hand-hewn logs serve as footbridges across the creek. *Tapestes* (Spanish, platforms) for storing corn and other produce, and *hornos* (Spanish, ovens) for baking, are scattered along the edges of the plaza. *Kivas*, underground ceremonial meeting places, are marked by long ladder-ends sticking up. Visitors are not allowed in the kiva areas. A few families keep small stores, usually indicated by a blanket hung outside the door. Permission to use your camera must be obtained from the pueblo governor; this does not include the right to photograph individuals. The ruins of the old church where the Indians took refuge during the Taos Revolt in 1847 can be seen northwest of the main pueblo.



Taos has many attractions. There are art galleries, shops selling native crafts, and good eating places. The Kit Carson House on Kit Carson Avenue, was the famous Indian scout's office and home from 1858 to 1866. The house of Governor Bent, where he was scalped and murdered, is located on Governor Bent Street. His family escaped into the house next door by digging through an adobe wall.



The Ranchos de Taos Church, built about 1734, is considered one of the finest examples of Spanish mission architecture in the South-west. Visitors are welcome.

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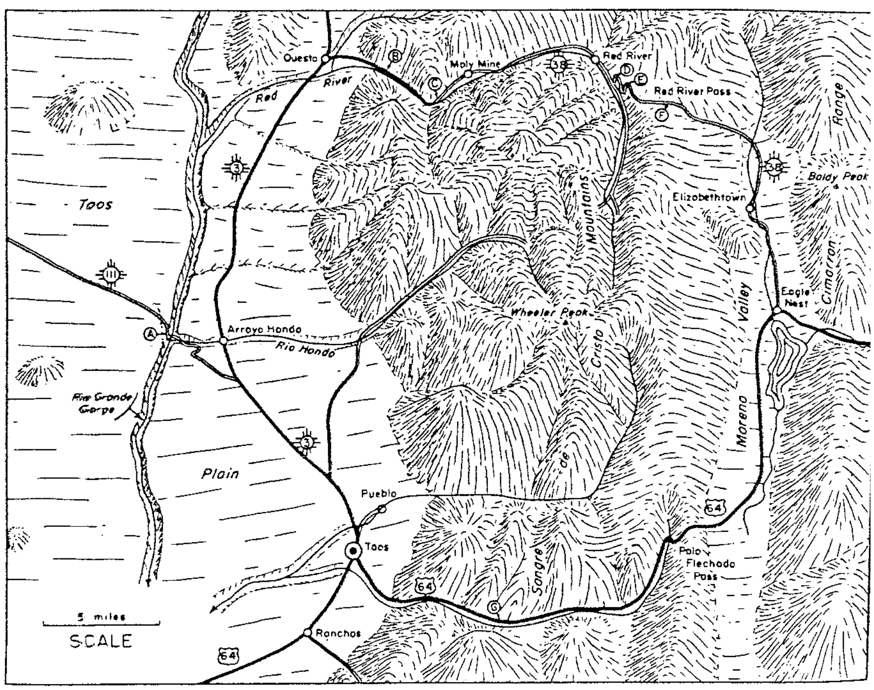
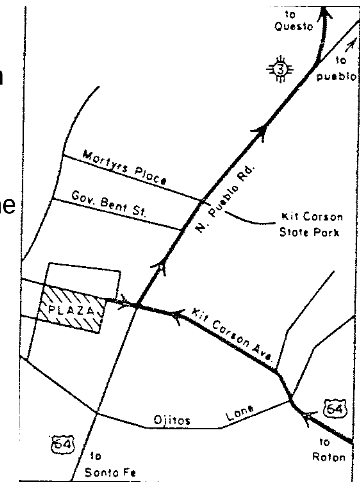


Map of Taos-Red River-Eagle Nest Area

THE CIRCLE DRIVE

The trip (driving time, without stops, about 4 hours) starts from the Taos Plaza in the center of town. Zero mileage k at the northeast corner of the Plaza; both cumulative mileage and mileage between points are shown.
Mileage as indicated here may vary slightly from that registered by your car.

Mileage



0.0 Leave plaza from northeast corner and turn north (left) onto North Pueblo Road (State Highway 3).

0.15 Continue straight ahead. Entrance at right to Kit Carson State Park and the grave of Kit Carson, the famous Indian scout.

0.5 Curve to left; continue on Highway 3. Road straight ahead leads to Taos Pueblo--1 mile.

3.9 Continue straight ahead. Road to right (mostly dirt) leads into the mountains to Twining (16 miles), once a copper mining camp, now a skiing center. The scenery is well worth a trip, especially in the fall. From the end of the road trails lead to the high country around Wheeler Peak (elevation 13,151 ft.), the highest point in New Mexico.

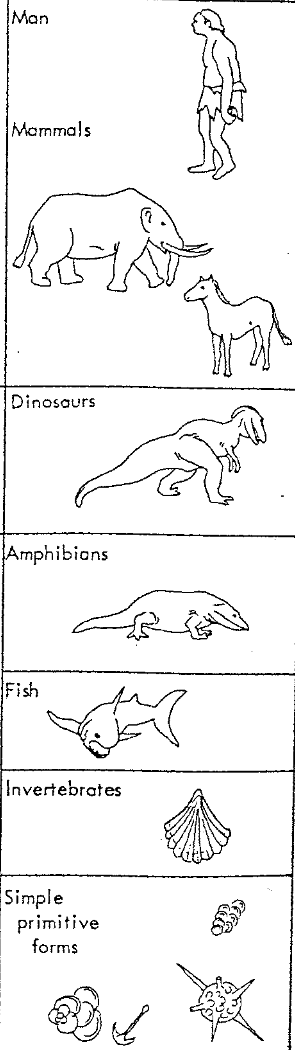
We continue on across the Taos Plain, which supports little but sagebrush, with the Taos Range of the Sangre de Cristo (Spanish, Blood of Christ; for their red color at sunset) Mountains to our right. The distant hills on the plain to the left are the remnants of extinct volcanoes.

9.3 Junction; turn left onto State Highway III, a dirt road.

11.8 Highway begins winding descent into canyon cut by the Rio Hondo (Spanish, deep river).

12.3 The black rock along the road and in the opposite wall of the canyon is *basalt*. The basalt forms a layer along the canyon rim. This layer is a lava flow poured out from the volcanoes to the west. The basalt contains many small holes formed when gas bubbles were trapped in the hot, molten lava as it cooled. The many vertical cracks (columnar jointing) in the lava also were formed as the lava

Scale of geologic time (millions of years)	Geologic age	Rock units	Dominant life
1	Quaternary: Recent, Pleistocene	gravels and basalt (black lava)	Man
70	Tertiary: Pliocene, Miocene, Oligocene, Eocene, Paleocene	granite volcanic rocks (lava and ash beds)	Mammals
130	Cretaceous, Jurassic, Triassic		Dinosaurs
300	Permian, Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, Cambrian	conglomerate, sandstone, shale, limestone	Amphibians; Fish; Invertebrates
1500	Precambrian	granite gneiss, other metamorphic rocks	Simple primitive forms



Geologic timetable

cooled, shrank, and cracked. Similar lava flows of basalt have been poured out during many recent eruptions in the Hawaiian Islands, at Vesuvius in Italy, at Paricutin in Mexico, and elsewhere.

13.2 Road crosses the Rio Hondo. Here is another lava flow exposed at a much lower level in the canyon.

Lava flow of basalt resting on gravel. Along Highway III in Rio Grande gorge.

13.3 Road crosses the Rio Grande (elevation 6,501 ft), the lowest point on this trip. As we turn left and start the climb out of the gorge, we see more black basalt resting on top of loose gravel. This lava flow baked the gravel below, turning it red.

Continue on up road to flat at top of gorge. Notice the loose gravel and lava flows in the road cuts.

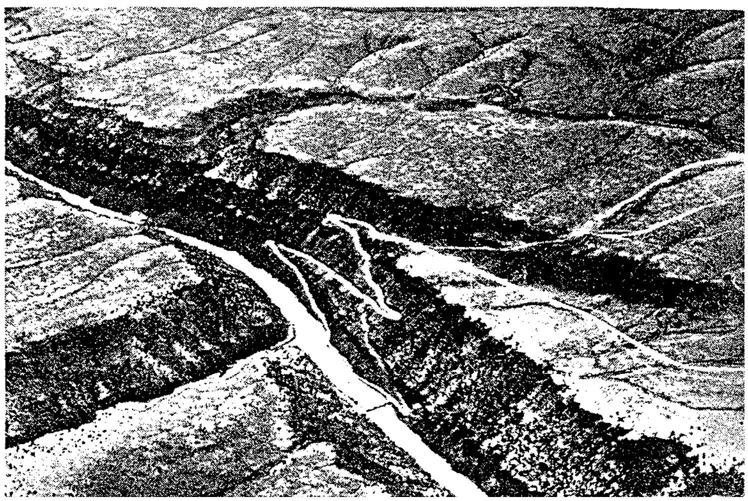
14.2 STOP A (elevation 7,005 ft). Park car and walk to edge of 500-foot-deep gorge.

We are standing on the upper lava flow and can see the same flow near the rim of the gorge opposite us. Above and below the flow is loose gravel like that scattered over the lava on which we stand. And near the bottom of the gorge is another lava flow. Pieces of the upper lava cover the gravel slopes.

The lava poured out from the now extinct volcanoes to the west and spread over this area. But where did the gravel come from? Notice the many different types of rocks in the gravel scattered between here and the car. These same rocks make up the gravel in the opposite wall of the gorge. If we had time to hike through the

Sangre de Cristo Mountains to the east, we'd find the same rock types, not as loose gravel but as solid bedrock. As the mountains were worn down, the solid bedrock was eroded, and the loose material was washed into this area.

Notice the boulders in the Rio Grande at the mouth of the Rio Hondo. These boulders, as well as smaller sized gravel, have been carried down the Rio Hondo during floods. Probably much of the gravel we see in the walls of the gorge was moved here during floods of streams like the Rio Hondo.



Rio Grande gorge from the air. Rio Hondo enters the gorge from the left. Lava flows show as darker, cliffy layers. Picture was taken before the present bridge was built.

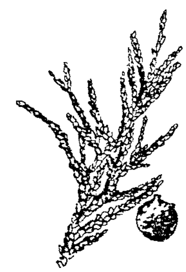
From the clues we've seen and the deductions we've made, the geologic history of this area can be pieced together. At one time the land surface must have been at the level of the bridge below us. Volcanoes to the west erupted and covered this land surface with a lava flow. High mountains to the east slowly were being worn down, and streams heading in these mountains carried gravel into this lower area or basin, burying the lava flow. But before the streams could fill the basin with gravel to the level of the present Taos Plain, another eruption spread lava over the gravel. More gravel was spread over this second flow. Imagine how different this area must have looked. But then the ancestral Rio Grande began cutting down into the gravels and lava flows faster than the streams from the mountains could carry in more gravel. The Rio Grande continued downcutting, exposing the lower lava flow, and forming the gorge as it is today.

Geologists believe that these events began a few million years ago, in late Tertiary time. Quite awhile ago, but recent events in the perspective of geologic time.

14.2 Leave Stop A. Turn around and return to the blacktop and Highway 3. You might like to try fishing in the Rio Grande; some mighty big trout are caught here.

19.4 Junction with Highway 3; turn left onto highway. Highway dips into the Rio Hondo valley. The gravel in the roadcut is like the gravel we saw in the Rio Grande gorge.

20.2 Highway crosses a flat bench. This *terrace* (former valley bottom) has been cut into by the Rio Hondo to form the present valley floor.



Rocky Mountain juniper
(Juniperus scopulorum

20.9 Village of Arroyo Hondo. Highway crosses the Rio Hondo.

For the next 12 miles, until we reach Questa, most of the roadcuts are in gravel which, like the gravels in the Rio Grande gorge, was carried into this area from the mountains. A few roadcuts expose lava flows of basalt interbedded with the gravel. No other rock types are exposed along this stretch of road. The similarity between the geology here and in the Rio Grande gorge shows that this entire area has the same geologic history.

The little trees you see along the highway are juniper (scalelike "leaves" and blue berries) and pinon pine.

Pinon pine
(Pinus edulis)

32.9 Road crosses the Red River. The trees along the stream are cottonwoods and willows.

33.8 Entering Questa (elevation 7,461 ft).

34.2 Junction; turn right onto State Highway 38. Well be on Highway 38 for the next 31 miles--to Eagle Nest.

35.2 Road enters Red River Canyon. The geology well see in the mountains is quite different and more complex than that of the Taos Plain.

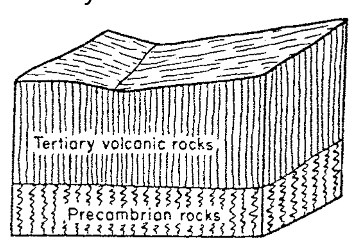
36.2 Cliffs along both sides of the canyon for the next 0.7 mile are granite.

36.5 STOP B. Park on wide shoulder to right. Let's stop and see what the granite looks like.

Granite cliffs at Stop B.

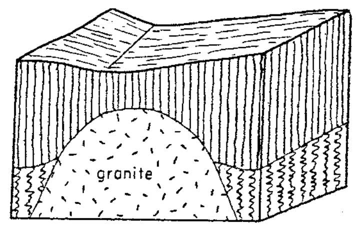
Granite is an igneous rock (rock formed from the cooling and solidification of molten rock). The granite in the cliff is pale pink, and made up of grains of quartz (clear, glassy), feldspar (white), and biotite mica (black flakes). The minerals can be seen best by breaking a piece of the granite and examining a freshly broken surface.

A hot pasty mass of the granite forced its way upward from a mile or more below and formed a stock (dome-shaped body of igneous rock). This took place during late Tertiary time, about 12,000,000 years ago. More recently the Red River has cut down into the stock, exposing the granite and forming Red River Canyon.



...rocks before granite pushed up...

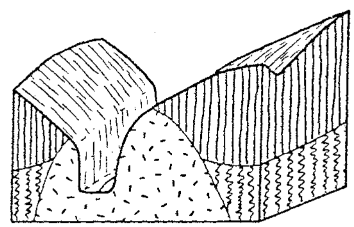
Such igneous rocks that solidified before reaching the surface are *intrusive*; igneous rocks that solidified on the surface, like the lava flows along the Rio Grande, are *extrusive*.



...granite stock formed...

36.5 Leave Stop B. Continue on up canyon.
The trees along the canyon are cottonwoods, willows, spruce, Douglas-fir, and Ponderosa pine (tall, straight trunks with yellow-brown bark).

36.9 Mountainside ahead has no bold outcrops or cliffs and is underlain by volcanic rocks--lava flows and tuff (ash beds) of white rhyolite, gray latite, and purple andesite. These volcanic rocks were formed in late Tertiary time, about 20,000,000 years ago, and are older than the granite, inasmuch as the granite pushed up through them.
Notice the yellow, bare areas. We'll see more of these areas on up the canyon.



...Red River cut canyon through granite...

37.6 Yellow-stained rocks along the road. This is what the yellow, bare areas look like at close range.

38.2 Cross Goat Hill Gulch on short bridge. For the next 0.8 mile the gravel along the left side of the road has been washed down Goat Hill Gulch and deposited here during flash floods.

39.0 Road crosses the Red River. Cliffs to the left are of the same granite as at Stop B. But here the granite is exposed over a much smaller area.

39.4 End of blacktop. Road crosses the Red River.

39.5 STOP C. On outside of curve, opposite light-colored rock.
This rock is *granite gneiss*. It has grains of quartz (clear, glassy) and feldspar (white), and flakes of biotite mica (black). But unlike the granite we examined at the last stop, it is streaked or banded. This granite gneiss once looked much like the granite of Stop B. However, it has been altered by heat, pressure, and/or

chemical action, giving it a banded or streaked appearance; such rocks are *metamorphic* rocks. Thinly banded metamorphic rocks are called *schist*; coarsely banded metamorphic rocks are called *gneiss*.

Metamorphism may take place when heat from molten rock bakes other rocks it touches. Earth movements may subject rocks to great pressure, causing metamorphism. Or hot water and gases given off by cooling igneous rocks may penetrate the surrounding rocks, changing them chemically. Any kind of rock can be metamorphosed -- even a metamorphic rock! Shale is metamorphosed to slate, limestone to marble, and granite to granite gneiss. The changes that take place may be physical, with changes in shape and distribution of the minerals making up the rock, or may be chemical, with the formation of new minerals, or a combination of the two.

This granite gneiss is Precambrian in age. Precambrian is the oldest geologic age and includes the first three-quarters of geologic time.

The band of black rock slanting across the granite gneiss is a dike (sheet of igneous rock which filled a crack cutting other rocks, then solidified).

39.5 Leave Stop C.

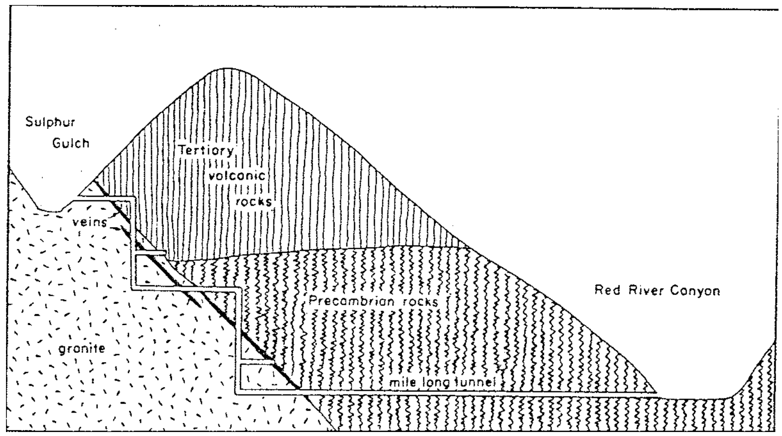
39.7 Dump and ore bins of Moly mine on left. Notice the bare, yellow-stained area high above the dump.

40.2 Moly mine portal (elevation 8,000 ft). Tunnel extends more than a mile straight into the mountain before reaching the veins. There are over 35 miles of tunnels in the mine--quite a lot of digging

The mineral molybdenite, an ore of the metal molybdenum, is being mined. The soft, shiny, black, greasy-feeling molybdenite occurs in veins in cracks along the edge of a stock (dome-shaped body of igneous rock) of the same granite we saw at Stop B. These molybdenite-bearing veins are exposed to the north, where Sulphur Gulch has cut down into the stock and veins.

In 1916 tunnels were driven into the veins along Sulphur Gulch, and the molybdenite was mined. Some of the portals were high on the steep gulch walls, and burros were used to haul the ore. As mining continued downward along the veins, it cost more and more to haul out the ore and pump out the water. In 1945 the mile-long tunnel was driven from Red River Canyon to connect with the lowest level of workings in the mine. Now the ore could be hauled out through the level tunnel, much cheaper than hauling it back up through the older portals, and the water could drain out without expensive pumping.

Holes are drilled into the veins with jackhammerlike drills powered by compressed air. Dynamite is placed in the holes and the ore blasted down. Then the ore is loaded into cars on a narrow-gauge track, and hauled out through the mile-long tunnel and over the surface track to the ore bins we saw down the canyon.



Cross-section through Moly mine
(looking east; north to the left).

Let's continue on another mile to the mill, where the ore is being processed.

41.2 Moly mine camp and mill (elevation 8,141 ft). Office of the Molybdenum Corporation of America (the owners) on left; mill at right.

The ore from the mine contains only a small percentage (as little as 2% of molybdenite. The job of the mill is to remove as much of the waste material as possible. The *flotation* process is used. The large chunks of ore are first crushed to thumb-size pieces, then fed by conveyor belt into a *ball mill* (a large cylinder, lying on its side, containing large iron balls). As the ball mill rotates, the iron balls tumble around, smashing and grinding the ore; water and ore are fed continuously into one end, and powdered ore and water pour out from the other end into a tank. Any oversize pieces settle to the bottom of the tank and are raked back into the ball mill by a *classifier*, and reground.

The powdered ore is mixed with various chemicals and oils and then fed into *flotation machines* (eggbeaterlike devices which churn the mixture into a froth of oily bubbles). The tiny particles of molybdenite stick to these oily bubbles and are skimmed off the top of the tank. Particles of other minerals in the ore will not stick to the bubbles and sink to the bottom. Some of the other minerals would like to stick to the bubbles, but the chemicals act to prevent this. The molybdenite particles will stick only to certain kinds of oil; a mixture of several kinds, including motor oil, is used here. To separate out a different mineral, a different combination of chemicals and oils would be used.

The waste material is carried in water out to the *tailings pond* (just west of mill), where it settles out of the water and slowly builds up a pile of waste.

The molybdenite sticking to the oily bubbles is skimmed off the top or allowed to overflow. The molybdenite and water go to a large tank; the molybdenite settles to the bottom and much of the water can be removed from the top. The molybdenite then passes through a filter and dryer, where the, remaining water is removed.

This dry concentrate, containing over 85 percent molybdenite, is sacked, shipped to Pennsylvania, and smelted and refined into molybdenum compounds used by industry. These compounds are used in chemical processes, in fertilizers, for lubrication, to harden steel, etc.


Ponderosa pine
(Pinus ponderosa)

Continue on up canyon.

41.9 Look at the hill ahead and slightly to the left. The gray rock is part of the same Tertiary volcanic rocks exposed back down the canyon. But notice the two bands of lighter rock. These are dikes (crosscutting sheets of igneous rock) of the same granite we saw at Stop B.

42.2 Moly mine flume at left.

42.6 Cross Moly mine flume. Water is diverted from the Red River and carried to the mill.

43.0 Road begins to climb across loose, yellow-stained gravel. Flash floods carried this loose material down side gulches into Red River Canyon in *mud-flows* (mixtures of water, mud, and gravel having the same consistency and appearance as wet cement). The trees are being buried slowly by successive mud-flows, which often block the highway during the rainy season in July and August.

For the next 2.2 miles well cross several other mud-flow deposits, and see many treeless, yellow-stained areas higher on the canyon walls.

We've seen many such areas along Red River Canyon, and you may be wondering how they were formed. The rock under such areas has been *brecciated* (crushed). Hot water from below escaped to the surface through the many cracks, depositing several minerals.

As these minerals become exposed to the air and rain by erosion, they decompose and stain the outcrops yellow. The mud-flows are made up of gravel eroded from these bare areas, which explains their yellow color.

Douglas-fir
(Pseudotsuga taxifolia)

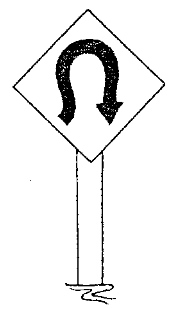
44.0 Elephant Rock campground. Picnic tables, fireplaces, toilet facilities.

44.6 Junebug campground. Picnic tables, fireplaces, toilet facilities.

45.3 Douglas-fir trees to right across meadow.

46.3 Enter Red River village (elevation 8,693 ft). Once a booming mining town when gold was found in the surrounding area. Although rich at the surface, the gold deposits petered out rapidly with depth, and the boom collapsed.

Today Red River is a resort town--headquarters for hunting, fishing, camping, hiking, pack and jeep trips to the high country or just loafing.



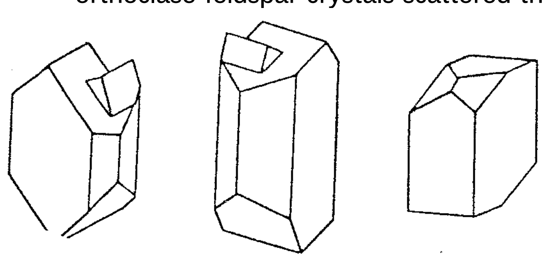
46.8 Take left fork in road.

47.3 Leaving town.

48.4 Take left fork up Red River Pass. Road to right continues 7 miles up Red River Canyon. There are many beaver dams along the road. And good trout fishing! Trails from the end of the road lead to Wheeler Peak and many beautiful timberline lakes--and more good fishing.

49.1 First switchback (hairpin curve).

49.4.1 STOP D (for the mineral collector). At second hairpin curve. Park car OFF road on outside of curve. Walk 100 feet up road. There are large orthoclase feldspar crystals scattered through the light-colored



orthoclase crystals

rock in the roadcut. If you're careful, complete crystals can be broken out of the rock with a hammer. There are many different crystal forms.

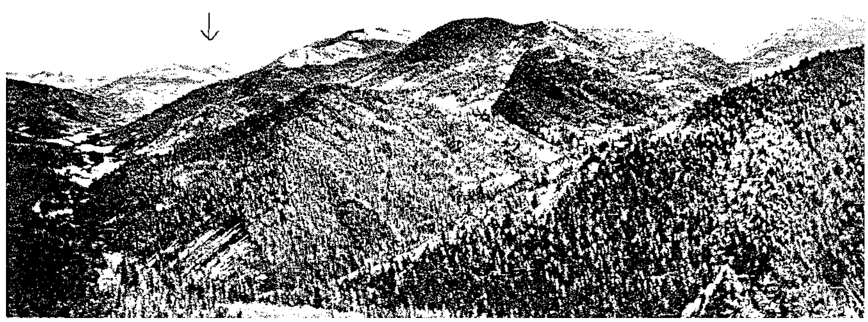
49.9 Third hairpin curve.

50.1 Fourth hairpin curve.

50.7 Fifth hairpin curve.

51.0 STOP E. At sixth hairpin curve. Park OFF road at curve.

Let's review the geology we've seen since entering the Sangre de Cristo Mountains. The only Precambrian (over a half billion years old) rock we've seen is the granite gneiss at Stop C. Actually there are many other types of Precambrian metamorphic rocks (rocks altered by heat, pressure, or chemical action) in these mountains; we'll see some before we leave the mountains. Resting on top of the



Upper Red River Canyon (left), Wheeler Peak (arrow), and Gold Hill (upper right) from Stop E.

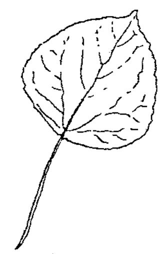
Precambrian rocks are late Tertiary volcanic rocks (about 20,000,000 years old). Tertiary granite (about 12,000,000 years old) later forced its way up into the older rocks, forming stocks (dome-shaped bodies) and dikes (sheetlike bodies).

But what happened during the millions of years between Precambrian and late Tertiary time? We've seen no clues. Either rocks were not deposited during this time, or are covered by other rocks and are not exposed, or have been eroded away.

During Pleistocene time, and until some 25,000 years ago, the higher peaks in this area were covered by glaciers. These mountaintype glaciers scooped out the depressions (cirques) and U-shaped valleys high on the mountains around Wheeler Peak. This took place during the Ice Age, when continental-type glaciers covered the Great Lakes region, New England, and much of Canada. But here the climate was warmer and drier, and the glaciers could not survive except in the higher (colder and wetter) areas above 11,000 feet.

Today, snow can be found in shady spots on the higher peaks late into the summer. If the climate were only slightly cooler this snow would not melt completely but slowly accumulate, turn to ice, and form small glaciers. Such glaciers are found in Colorado.

51.0 Leave Stop E. Proceed up pass.



Quaking aspen (*Populus tremuloides*)

51.7 Top of Red River Pass (elevation 9,852 ft)--highest point on trip. Trees with smooth, yellowish-green or white bark are aspens. Road begins descent into Moreno Valley.

53.3 Pinkish rock in roadcut to left at curve.

53.5 STOP F. At outcrop of pinkish-tinted white rock in roadcut.

This stop is mainly for the mineral collector but will give us a chance to see a different kind of Precambrian metamorphic (altered by heat, pressure, and chemical action) rock. This rock is a gneiss (coarsely banded metamorphic rock), although it contains different minerals from the granite gneiss we saw at Stop C. It is made up of quartz (clear, glassy), feldspar (white), muscovite mica (pink flakes), and magnetite (black).

The mineral collector can collect attractive specimens of this rare pink variety of muscovite. Muscovite usually is transparent and colorless.

53.5 Leave Stop F. Rocks for the next 3 miles are Precambrian in age.

57.7 Road turns south down the Moreno Valley. Mountains to the left are the Cimarron Range; the highest mountain is Baldy Peak (elevation 12,549 ft). The highest bare peak to the right is Wheeler Peak.

60.0 Elizabethtown. Now a ghost town, but once a rip-roaring mining town with over 7,000 people! The few remaining buildings are on the hill to the right.

60.6 The piles of gravel to the left mark the site of placer mining operations.

In 1866 prospectors found placer gold in this area. The next spring, during a rush to this discovery, gold was found along most of the creek bottoms on the west side of Baldy Peak.

Placer gold deposits are formed when gold veins are eroded, the gold carried away by a stream, and then concentrated In the stream bed at the first spot where the stream no longer is moving swiftly enough to carry the heavy gold further.

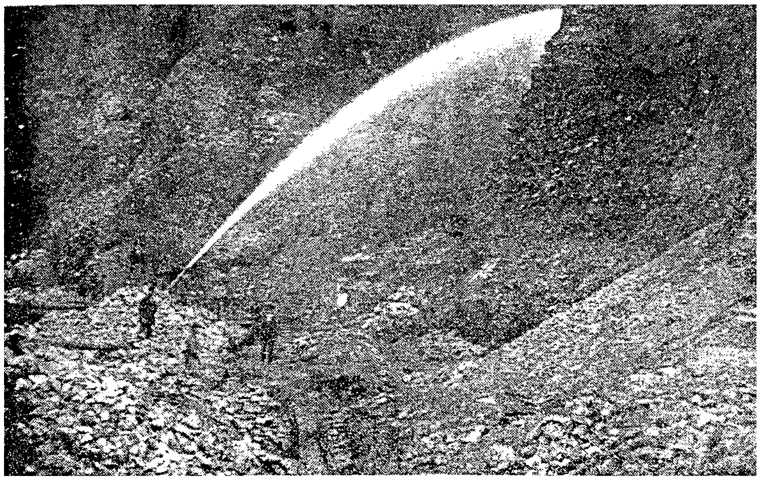
Many different methods were used to recover the gold. The gold-bearing stream gravels were washed through a *sluice box* (wooden trough with cleats fastened across the bottom at intervals). The heavy gold settled to the bottom and was caught by the cleats (*riffles*). To keep from losing the finer gold flakes, mercury was placed in the riffles, the gold and mercury combining to form *amalgam*. The various methods differed mainly in the way the gold-bearing gravels were dug up and delivered to the sluice box. In the

Dredge of the
Oro Dredging Company
at Elizabethtown,
about 1902.

simpler methods the gravel was shoveled by hand. Dredges used an endless chain of buckets to scoop the gravel out of the bank of the pool In which the dredges floated. *Hydraulicking*, in which powerful jets of water from giant nozzles were used to wash down high banks of gravel, was another method used at Elizabethtown.

To supply the large amounts of water needed to recover the gold, an aqueduct was constructed to bring water from the headwaters of the Red River. Because of the rugged country it had to cross, the "Big Ditch" was 41 miles long, although its two ends were only 11 miles apart. And it leaked so badly that less than 8 percent of the water reached the placers!

The flush production was soon over, although the placers have been worked intermittently ever since. About 3 million dollars worth of gold has been produced.



Hydraulicking at Elizabethtown,
about 1900.

64.7 Entering Eagle Nest (elevation 8,220 ft)--a resort town.

64.9 Junction; turn right onto blacktop. Remainder of trip is on U. S. Highway 64.

66.9 Eagle Nest reservoir and Cimarron Range to the left; Taos Range of the Sangre de Cristo Mountains to the right.

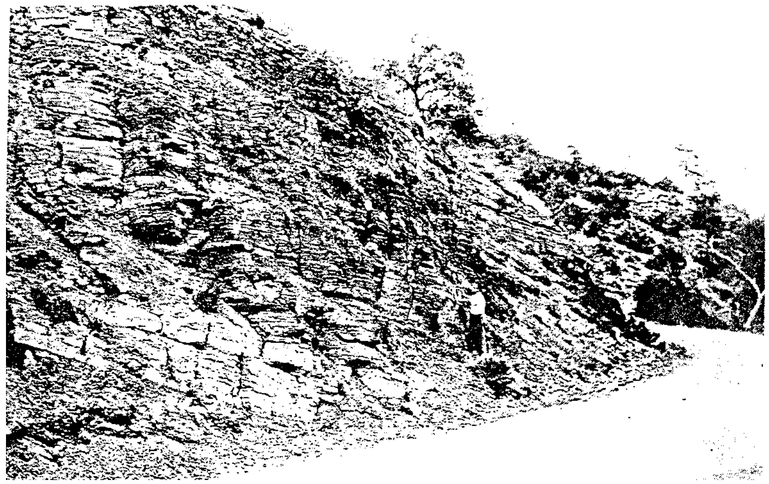
75.5 Highway begins climb over Palo Flechado Pass.
Shale, limestone, sandstone, and conglomerate (cemented gravels) of Pennsylvanian age are exposed in the roadcuts for the next 18 miles.

78.2 Palo Flechado (Spanish, arrows stuck in tree; elevation 9,107 ft). The pass is named for the old Taos Indian custom of shooting the remaining arrows into a large tree after buffalo hunts. Such a tree was found on the pass.

86.9 Miracle Ranch on left.

87.1 STOP G. Park OFF road on left, in middle of curve opposite large roadcut on right side of road. Let's examine the rocks in the roadcut.

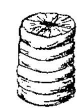
There are two types of rock, thicker more massive layers of sandstone, and thinner, crumbly layers of shale. The sandstone



Shale and sandstone of Pennsylvanian age at Stop G. The man is standing where fossils are most abundant.

(cemented sand) is made up of visible-sized groins, whereas the shale (hardened mud) grains are too small to see. Shale and sandstone are *sedimentary* rocks (rock deposited by water or wind).

Marine (sea) fossils are scattered through these rocks, particularly in the shales. Many different types of animals are buried in this "graveyard." The series of disks are the stems of cup-shaped *crinoids* (sea lilies); the shells with ridges are *brachiopods* of several kinds; the small cones are cup corals. These particular fossils are the remains of animals that lived during Pennsylvanian time. Thus, the fossils indicate that these rocks were deposited in a sea which covered this area during Pennsylvanian time (about 250,000,000 years ago).



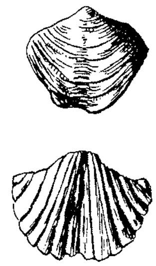
crinoid stem

cup coral

These rocks were deposited in the ocean as horizontal layers, but here we see the beds dipping at an angle. Why? Pressures within the earth acting over millions of years have folded and bent the beds into their present positions.

87.1 Leave Stop G.

88.4 La Sombra campground. Picnic tables, fireplaces, toilet facilities. Many cottonwood trees (crooked, branching trunks, with irregularly ribbed bark).



brachiopods

93.7 Leave mountains. We're back on the Taos Plain.

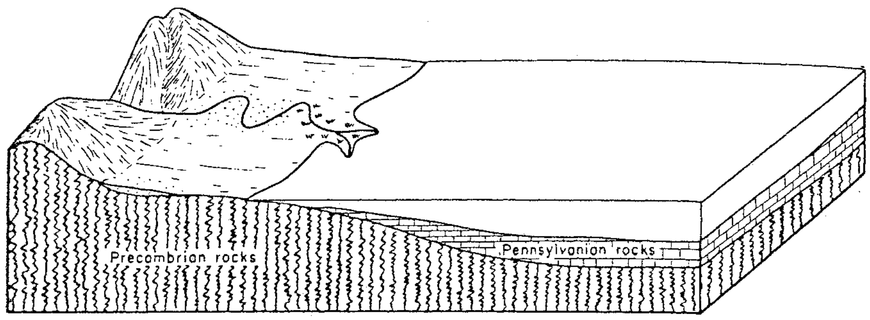
94.0 Entering Taos.

96.0 Taos Plaza--end of trip. Hope you've enjoyed it!

GEOLOGIC HISTORY SUMMARIZED

On our drive we saw a lot of geology and learned about many happenings in the dim geologic past. Let us summarize the geologic history of the area we covered.

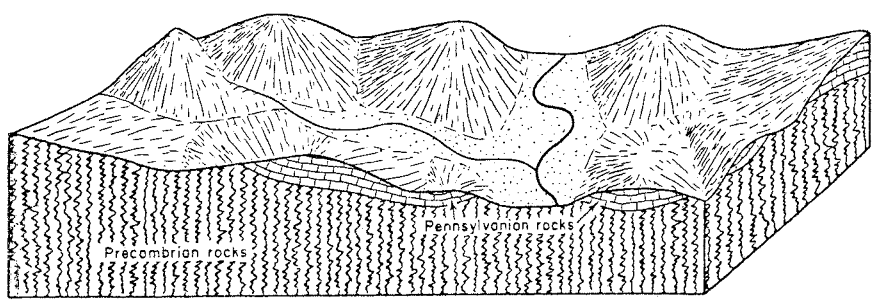
Precambrian rocks were deposited and metamorphosed (changed by heat, pressure, and chemical action). During Cambrian to Devonian time this area



...Pennsylvanian time
sea and coastal plain...

was part of a landmass. Geologists infer this because rocks of these ages are not encountered until central New Mexico is reached.

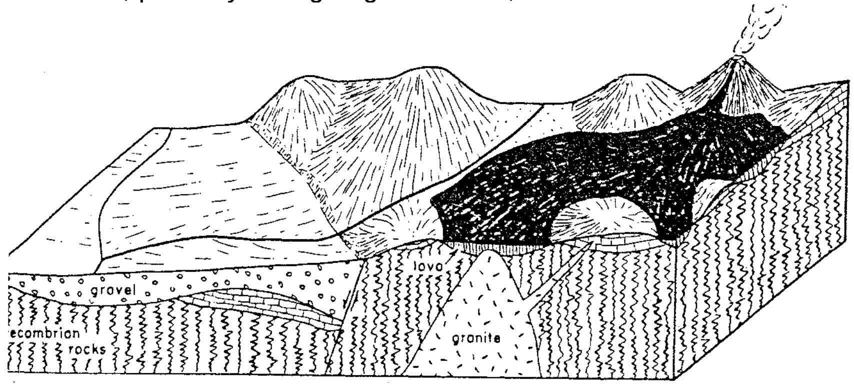
During Pennsylvanian time a sea covered this area. Mud, sand, and gravel were eroded from a mountainous landmass to the west and carried into



...Early Tertiary time
mountains eroded to rolling hills...

the sea by streams, forming shale, sandstone, conglomerate, and limestone. Northern New Mexico must have looked much like North Carolina does today, with its flat coastal plain, swamp forests, and higher mountains to the west. Till late Cretaceous time this area was alternately land and sea, as the shoreline shifted back and forth. Sand and gravel were deposited along streams on the flat coastal plain, and coal beds were formed in the numerous swamps. Dinosaurs roamed the plain, eating the lush plants in the swamps, other animals, or each other! Shale, sandstone, and limestones were deposited in the sea. Although we saw no rocks of these ages, they are exposed In Moreno Valley.

Late In Cretaceous time the coastal plain and sea were uplifted into mountains. These mountains were worn away slowly until only rolling hills remained. Later, probably during Oligocene time, what is now the Taos Plain

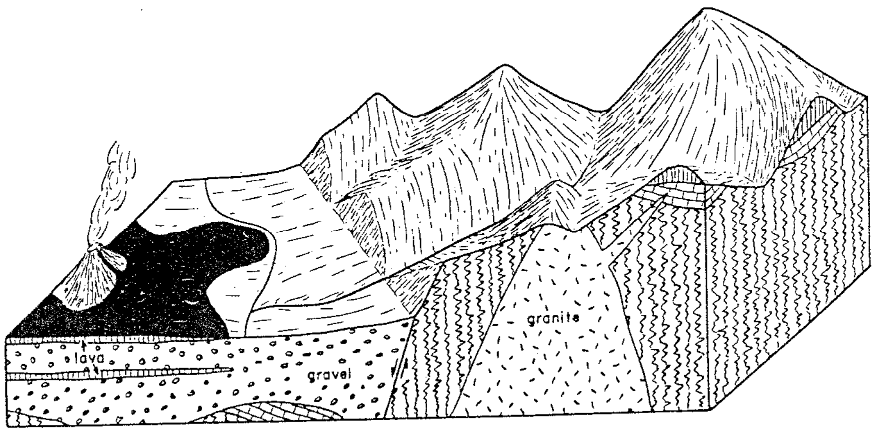


...Miocene time
uplift and settling began,
eruptions in the mountains...

began slowly to settle, while what is now the Sangre de Cristo Mountains began to rise. Faulting (slipping of rocks along a crack) took place at the border between these two areas. Volcanoes erupted in the uplifted area, covering the rolling hills with lava and ash. Hot pasty granite forced its way up into the volcanic rocks and then solidified.

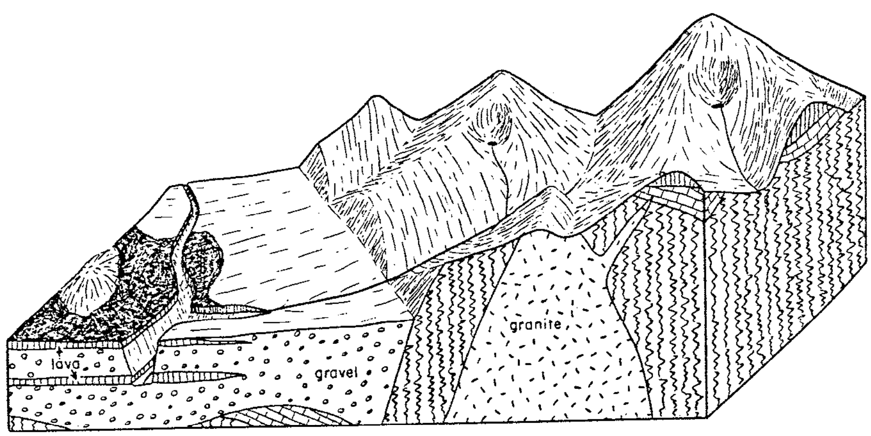
The uplift continued slowly until, by Pleistocene time, the Sangre de Cristo Mountains had been formed and streams were carving the mountains into their present form. During the Ice Age glaciers covered and scoured out depressions (cirques) on the higher peaks. The plains area was still settling slowy, and the streams from the mountains carried gravel into this *structural trough*. From time to time, while the trough was being filled with gravel, volcanoes to the west erupted, pouring lava over the gravel. More recently the Rio Grande cut into the gravels and lava to form the present gorge.

Today the streams are still eroding the mountains and carrying gravel onto the plain. And the uplifting and settling probably still are going on. Rather than a slow but steady movement, the uplift takes place as a series of jerks, each one causing an earthquake. These processes work so slowly that we can see little change during our lifetime. It staggers the imagination to visualize something that took millions of years to form. If, for example, the mountains



...Pleistocene time
continuing uplift and settling,
erosion in the mountains,
gravel and lava cover plain...

had been uplifted only one inch per century, they would have risen almost 5 miles during the 30,000,000 years since uplift began!



...today
mountains, plains, and gorge...

SOME ADDITIONAL READING

If you'd like to learn more about geology, the following books will help:

*Geology--Merit Badge Series: Boy Scouts of America, 83 pp., 1953. (An excellent introductory booklet on geology.)

Down to Earth: C. G. Crone is and W. C. Krumbein, University of Chicago Press, 501 pp., 19360 (Readable college text; well illustrated.)

The World We Live In: Lincoln Barnett and the editorial staff of LIFE, Time Inc., 304 pp., 1955. (Excellent colored drawings and photographs illustrating geologic features.)

The Rock Book: C. L. and M. A. Fenton, Doubleday Doran & Co., 1940. (About minerals and rocks.)

Rocks and Minerals: H. S. Zim, P. R. Schaffer, and R. Perlman, Golden Nature Guide, Simon & Schuster, 19570

Minerals of New Mexico: S. Northrup, University of New Mexico Press, 1959. (A book every rockhound interested In New Mexico should have.)

If you'd like to read more about the geology of this area:

*Geology of Costilla and Latir Peak Quadrangles, Taos County, New Mexico: P. F. McKinlay, Bulletin 42; N. Mex. Bureau of Mines, 32 pp., map, 1956. (Technical report on plains and mountains north of Red River Canyon. $1.75 postpaid.)

*Geology of the Questa Molybdenum (Moly) Mine Area, Taos County, New Mexico: J. H. Schilling, Bulletin 51, N. Mex. Bureau of Mines, 86 pp., maps, 1956, (Technical report on Moly mine and area along the Red River. $2.50 postpaid,)

*Guidebook for Southeastern Sangre de Cristo Mountains: New Mexico Geological Society, Seventh Field Conference, 1956. (Third day is from Taos to Eagle Nest and in Moreno Valley; also articles on the area. $7.25 postpaid.)

*Geology of Questa Quadrangle, Taos County, New Mexico: P. F. McKinlay, Bulletin 53, N. Mex. Bureau of Mines, 21 pp., map, 19570 (Technical report on the area of the western half of the Circle Drive. $1.25 postpaid,)

continued next page

*For sale by the New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico.

If you'd like to do some hiking in the mountains:

*Topographic Map of Taos and Vicinity: U. S. Geological Survey. (Covers the entire Circle Drive area. Shows cultural and drainage features, such as houses, roads, trails, towns, streams, and arroyos, and depicts the topography with contours of elevation. $0.30 postpaid.)

If you'd like to know more about mining in New Mexico, including its history:

The Bonanza Trail: M. S. Wolle, Indiana University Press, 1953. (Wonderful sketches of New Mexico and other Western ghost towns, and a text telling their history.)

New Mexico Magazine: G. Fitzpatrick [editor], The Capitol, Santa Fe. (Numerous articles, often with photos, on mining and mining camps.)

*The Metal Resources of New Mexico and Their Economic Features Through 1954: E. C. Anderson, Bulletin 39, N. Mex. Bureau of Mines, 1957, (Excellent reference on New Mexico metal mines and mining districts. $2.50 postpaid.)

*New Mexico's Underground Resources: N. Mex. Bureau of Mines, 1958. (An interesting booklet telling what New Mexico mines produce, and its amount and value. Also shows the importance of the mineral industries to New Mexico. Free copies.)

If you'd like to learn more about New Mexico:

New Mexico--A Guide to the Colorful State: Hastings House, 1953. (Describes history, plants and animals, geology, industry, and geography, and includes excellent logs for most of the main roads.

New Mexico, Land of Enchantment: E. B. Mann and F. E. Harvey, Michigan State University Press, 1955. (Describes government, culture, history, and geography.

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