DESCRIPTION AND ORIGIN OF CALICHE IN THE GLEN-SAN JUAN CANYON REGION, UTAH AND ARIZONA

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Calcium carbonate and other substances precipitated by the evaporation of water, here referred to as caliche (Erickson and Marranzino, 1960, p. B98), have a widespread distribution on the Colorado Plateaus. In the Glen Canyon region caliche has formed on gravel-capped terraces, on alluvial slopes, and on planate erosion surfaces which are cut on sedimentary rocks.

This study was part of a comprehensive geologic investigation of the area to be inundated by Lake Powell, the reservoir formed behind Glen Canyon Dam. The investigation was made by the Museum of Northern Arizona in cooperation with the National Park Service. The author thanks Mr. E. S. Davidson for his critical review of this paper, and Mr. A. P. Marranzino for discussions concerning the emplacement of caliche.

Caliche is present in varying amounts on all terraces in the canyon region. These terraces form six distinct levels, ranging in altitude from 30 to 2,000 feet above the Colorado and San Juan Rivers. These levels have been mapped throughout the area. The development of caliche is most pronounced on the higher terraces which are more than 400 feet above the present river beds. The character of caliche in the several terraces is tabulated on Figure 1. In most places the caliche layers form a resistant cap on the terrace deposits. Weathering on the top of the cap generally produces a thin mantle of residual sandy and silty material and some lag gravel. On many terraces the lag gravel forms a desert pavement and is stained by desert varnish. Differential weathering of the caliche gives the deposit a very ragged appearance.

DESCRIPTION

Variation of the caliche can be observed on all the terraces in the canyons, but with local exceptions, the amount of "calcification" is proportionate to the age of the terrace which it caps. Thus, layered and massive caliche is found on the older terraces more than 400 feet above river level and limy nodules and nodular caliche beds are found on the younger terraces less than 400 feet (Fig. 1). This stratigraphic control of the types of caliche is best observed along the San Juan River at Clay Hills Crossing and along the Colorado River at Halls Crossing.

Generally, the best exposures of caliche are on terraces which are between 1,500 and 2,000 feet above the canyon floors. Caliche forms almost all of these terrace deposits and usually contains only a small amount of clastic material. However, the lithology ranges from almost pure limy layers to beds composed of sandy and gravelly sediments in which the coarse material forms a substantial part of the deposit. The caliche is light colored, usually in hues of moderate orange pink, very pale orange, pinkish gray, or, rarely,

Location	Thickness	Type of deposit	Description of deposit
Recent alluvium	-	-	Limy streaks in deposits; thin film on grains and pebbles; few limy nodules.
Pleistocene gravel-capped terraces			
30- 100 feet	-	Nodular	Calcareous deposit around pebbles; no caliche layers.
100- 200 feet	2-3	Nodular	Calcareous and siliceous deposits around pebbles; some limy nodules in matrix and in finer grained units; caliche is partly layered; forms rough cap on terrace.
200- 300 feet	2-5	Nodular and poorly formed layers	Calcareous and siliceous deposits around pebbles; massive caliche and layers formed in upper part of deposit; bedding of the gravel partly destroyed; some caliche layers.
400- 500 feet	2-10	Poorly to well-formed layer	Hard massive and irregular caliche layer capping terrace that grades downward into zone of weakly developed caliche; some irregular siliceous layering; bedding of the gravel destroyed.
800-1,200 feet	3-20	Well-formed layer	Hard, firm, relatively pure, massive and layered caliche; some siliceous layering; most of deposit shows some degree of calcification; bedding of the gravel destroyed.

Location	Thickness	Type of deposit	Description of deposit
Late Pliocene(?) terraces			
1,500-2,000 feet	5-30	Well-formed layer	Thick, hard, pure to relatively pure massive and layered caliche; considerable siliceous material; forms few very thin irregular layers; makes up most of deposit.

Figure 1. --Description of caliche and the variation of the deposits on the several terraces in Glen and San Juan Canyons and adjoining region. Altitudes of terraces are above the Colorado and San Juan Rivers.

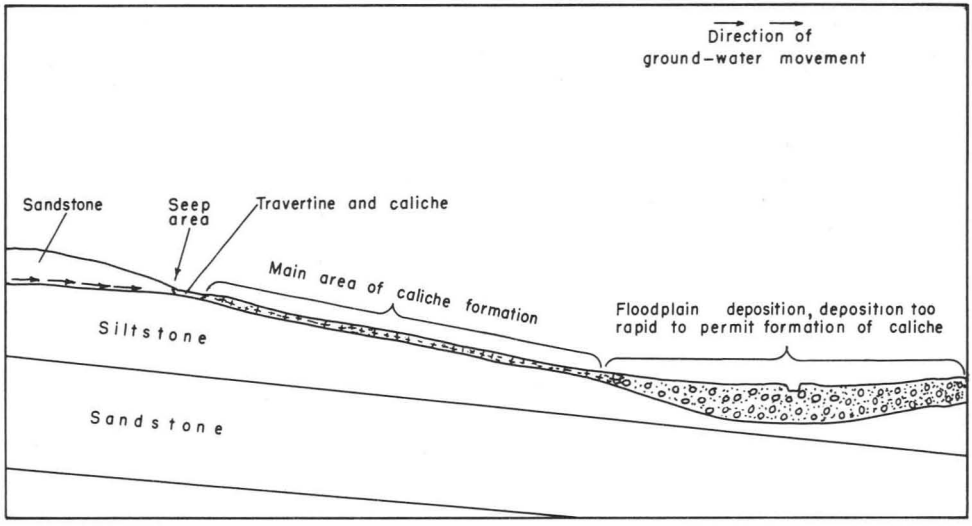

Figure 2. --Diagram showing general relationships of aliche to the physiography, to other deposits, and to ground-water discharge

white; locally, it is light brown and pale reddish brown. The darker colors reflect an increase in the amount of material serived from the nearby red beds of Triassic and Jurassic age. The deposits are irregularly bedded and in poorly defined layers less than 5 feet thick. In some exposures the bedding structures appear to merge into massive zones. Beds containing shrinkage cracks and thin layers composed of silt, sand, and pebbles are scattered throughout the deposit. A few angular fragments weathered from the underlying sedimentary rocks are incorporated within the lower 1-2 feet.

The capping caliche layer is underlain by 10 to more than 50 feet of river-laid gravel in most of the terrace deposits having altitudes between 400 and 1,200 feet above the Colorado and San Juan Rivers. The uppermost beds of the caliche are composed principally of calcium carbonate and contain pebbles and varying amounts of sand. The amount of limy material decreases downward from the top of the deposit, and in many exposures a transition zone can be seen between the capping limy layer and the underlying unaffected gravel. Much of the bedding of the gravel in the transitional zone has been masked or destroyed by the precipitation of the caliche.

Nodular caliche deposits are present on the gravel-capped terraces which are less than 400 feet above the canyon floors (Fig. 1). These deposits consist of limy nodules and thinly laminated limy encrustations on pebbles. The bedding of the gravel composing these terraces has been modified slightly by the formation of the caliche.

Siliceous replacement or contemporaneous formation of silica with the calciferous material is apparent in most of the caliche deposits. However, the siliceous material is more common in the older deposits. The silica occurs in concentric bands around pebbles and in very thin compact layers which resemble chert beds.

ORIGIN

Most caliche of the canyon country is believed to have been formed chiefly as a result of precipitation of soluable materials from ground and soil waters in areas where these waters discharge and evaporate at or near the land surface. Evaporation must exceed discharge or else leaching would take place. The caliche may grade into travertine (spring deposits) because some of the well-developed deposits are associated with seep areas or points of discharge of small amounts of ground water (Fig. 2). An example is the firmly cemented gravels of a terrace 300 feet above the Colorado River about a mile upstream from the White Canyon Store near Hite, Utah. However, if a large amount of ground water is discharged, travertine is deposited.

The more favorable places for caliche development are in areas where little erosion or sedimentation occurs and where residual deposits can accumulate. These areas are mostly along gentle bedrock and alluvial slopes which bordered the flood plains of old through-flowing streams (Fig. 2) and on the top of terraces composed principally of sand and gravel.

The caliche at the top of gravelly deposits may be formed, in part, when the water table within those deposits was near the surface and evaporation of this water caused considerable chemical precipitation of limy materials. After the water table was lowered to a sufficient depth, concentration of

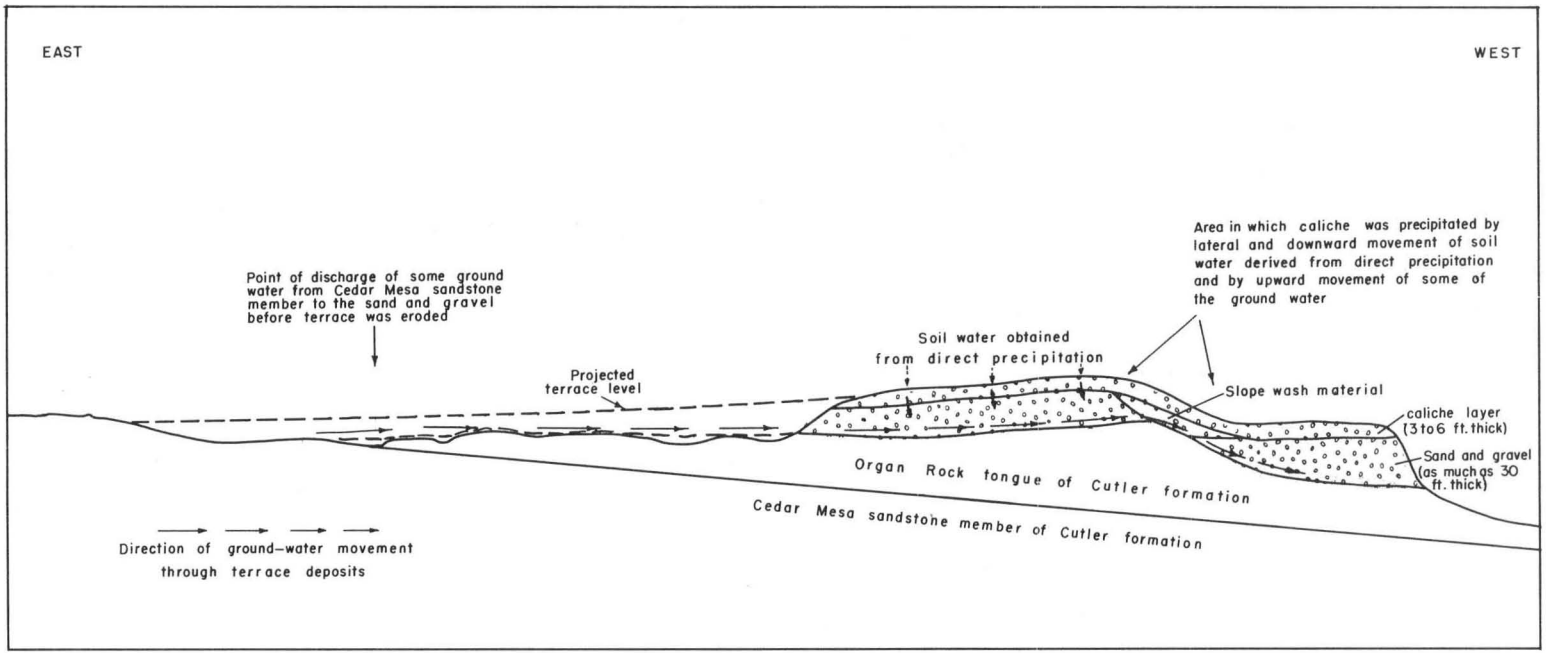

Figure 3.--Diagram showing a caliche layer formed on two gravel capped terraces, 2 miles east of Clay Hills crossing of the San Juan River

material by upward movement of water ceased, but evaporation of soil water (water above the water table) continues to maintain the formation of caliche. Precipitation of caliche was aided by leaching and re-deposition caused by downward movement of water from direct precipitation. The precipitation of caliche by soil water is illustrated at two localities near Clay Hills Crossing of the San Juan River. At one locality, 2 miles east of Clay Hills Crossing, a uniform layer of caliche extends across slope-wash material and connects two terrace levels which are about 450 feet above the San Juan River (Fig. 3). Part of the moisture depositing the calcareous material at this locality may have come from seepage from the Cedar Mesa sandstone member of the Cutler formation which is exposed within 1,000 feet of the terraces and part from direct precipitation.

"Caliche stalactites" were found in a terrace deposit at another locality 2 miles south of Clay Hills Crossing and 200 feet above the San Juan River. These unique forms are composed of limy material that was precipitated as stalactite-like shapes underneath quartzite, granite, and chert pebbles (Fig. 4). All calcareous material apparently was leached from the deposit on the top of the pebbles which now protrude slightly above the ground. These caliche stalactites apparently were formed by downward movement of water derived from direct precipitation through the sand and gravel.

At present, within the canyon region, leaching and re-deposition within the caliche are actually "lowering" the caliche layer and the top of the terrace. When leaching has removed the limy binding material, sand and silt-size particles are removed by water and wind action leaving the gravel scattered on the surface as lag deposits. If this process combined with erosion has sufficient time, a caliche deposit may be completely removed. This is believed to be the case where lag gravel consisting of fragments of caliche and pebbles lie on broad stripped surfaces cut on sandstone units.

In summary, caliche in the Glen-San Juan Canyon region has been formed by (1) leaching and re-deposition caused by downward percolation of water derived from direct precipitation, (2) precipitation of material near discharge points of ground water from sedimentary rocks, and (3) concentration of material from upward movement and evaporation of soil and ground water. In each locality the local physiographic and hydrologic conditions control the mode of origin of the caliche.

LITERATURE CITED

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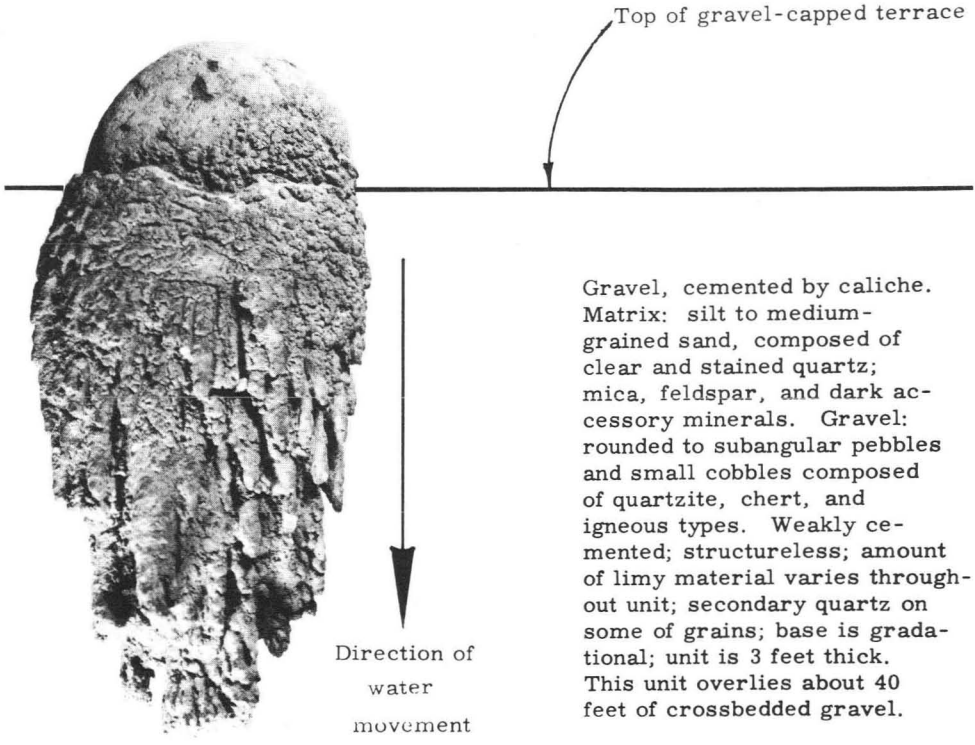

Photograph by C. T. Pynchon

Figure 4.--"Caliche stalactite" embedded in a gravel-capped terrace 2 miles south of Clay Hills Crossing of the San Juan River, Clay Hills quadrangle, Utah.