State of Arizona
Bureau of Geology and Mineral Technology

CALICHE
TEMPE QUADRANGLE, MARICOPA COUNTY, ARIZONA

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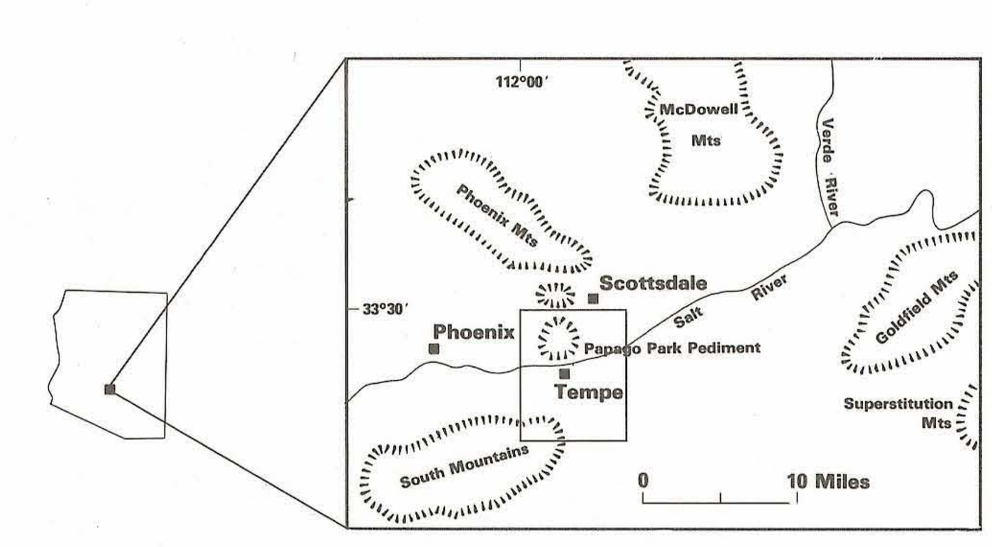
Prepared in cooperation with the cities of Tempe, Scottsdale, and Phoenix, and the Arizona State Land Department



INTRODUCTORY STATEMENT

GENERAL DESCRIPTION

Caliche is a secondary accumulation of calcium carbonate ($CaCO_3$) in the near-surface soil horizons by soil-forming processes in arid and semi-arid lands. Caliche is an important constraint affecting construction because it is perhaps the major cause of excavation difficulties and can greatly increase construction costs in areas where it is strongly developed. Also, it reduces the permeabilities of soils, thus rendering them less suitable for septic tank absorption fields and dry wells. Strongly developed caliche, however, is excellent for foundations and may be equal to some bedrock types in foundation stability.

Caliche forms as rainwater percolates downward into the soil carrying calcium carbonate in solution. *In situ* evaporation of this water results in the precipitation of the $CaCO_3$ in soil or rock voids. Thus, the permeability of the soil or unconsolidated rock and the amount of rainfall influence the depth of descent of the percolating water, and thereby influence the depth of development of caliche. The state of caliche development is time dependent and is greater in soils exposed at the surface for longer periods of time. Climate is a critical factor in caliche development; hot, dry climates are the most favorable, where rainfall occurs during periodic thunderstorms, followed by renewed sunshine and low humidity which promote evaporation. The arid and semi-arid climates of the southwestern U.S., which includes the Tempe Quadrangle, are extremely conducive to the formation of caliche.

Caliche deposits are generally sheet-like and form roughly parallel to the ground surface, undulating with the topography and varying laterally in depth and thickness. Lateral variations in thickness are the result of several factors, including differences in soil permeability, topography, and the nature of the medium which is calichified. For these reasons, this map is necessarily generalized, and is based on the limited exposures found in stream cuts, and records of excavation and drill holes in the area.

This map basically describes the caliche conditions which may be encountered in the upper layers of surface material.

TYPES OF CALICHE

Caliche may develop in two different forms, depending upon the size of particles making up the parent material. One type forms in material consisting of pebbles or larger rocks, and the other type forms in finer parent material such as clay, silt, or fine sand. The variations in development and hardness with depth are very similar for both types of caliche.

Caliche formed in a medium of pebbles or boulders may exhibit a sequence of progressive development with time, as illustrated below (see fig. 1). Beginning as a calcium carbonate coating on the underside of rocks (weakly developed), caliche then builds up and fills the spaces between pebbles as the coatings merge and coalesce (moderately developed), and eventually all inter-pebble spaces become filled. This profile is now plugged, forming a concrete-like impermeable layer (strongly developed). Because the water can percolate no deeper, the profile becomes capped with layers of pure laminated $CaCO_3$ (very strongly developed). Thus, in general, the longer the caliche has been forming, the harder and more strongly developed it will become.

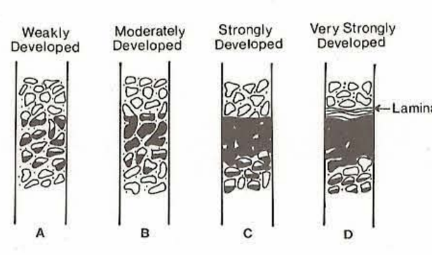


Figure 1. Stages of caliche development in pebbles or boulders (after Gile, 1975).

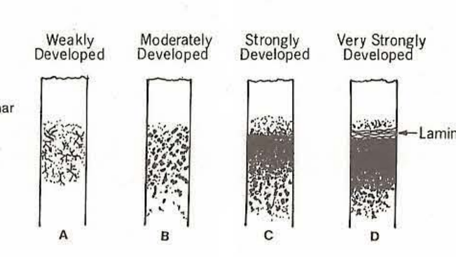


Figure 2. Stages of caliche development in fine sand, silt or clay (after Gile, 1975)

In a parent material of finer particles, caliche may occur as soft, discontinuous filaments and films of carbonate formed on or between the very small individual grains of sand, silt or clay (weakly developed, see fig. 2). Then discrete nodules form, usually 2 to 8 mm in diameter, as calcium carbonate surrounds and engulfs many grains of the fine parent material (moderately developed). Later, the parent material becomes entirely engulfed in caliche, and very few particles or grains of the parent material can be distinguished (strongly developed). This condition renders the material impermeable, and layers of pure $CaCO_3$ will cap the deposit (very strongly developed).

One may encounter repeated layers of either type of caliche in a single drill hole, or along the banks of a wash. These layers are separated by deposits of weakly to non-calichified sediments. The cyclic nature of the caliche layers indicates that interruptions in the formation of caliche had occurred, permitting the deposition of the separating sediments. Very probably the sediments were deposited at a rate too great for caliche to develop.

Caliche is widespread in the Tempe Quadrangle and varies from some weakly developed caliche in the deposits of the Lehi Terrace near the Salt River, to being very strongly developed capping layers on the higher terrace deposits, alluvial fans, and the colluvial deposits. Caliche in most alluvial fan material is very thick and strongly developed. Observable thicknesses in some washes are greater than 15 feet (4.5 m), with thicknesses of 30 feet (9 m) occurring in some drill holes. The caliche has formed to relatively great thicknesses because it has been developing as the fan surface has been aggrading or building up. However, the aggradation has not been so rapid that it precluded formation of caliche beneath the gradually raising fan surface. The result is a uniformily calichified body of alluvium. Aggradation is no longer occurring on some alluvial fans or parts of the pediment cover, therefore very strongly developed layers of caliche have formed near the surface of those landforms. Aggradation is still occurring near the toes of the alluvial fans and on the basin floor. The material in these areas is accumulating at such a high rate that strongly developed caliche does not form.

Surface and subsurface field observations and a study of the landforms were used to delineate caliche boundaries on this map. Older landforms such as buried pediment, inactive alluvial fans, and colluvial slopes generally display strongly developed caliche. Less well developed caliche horizons form in areas of modern depositional activity (aggradation) as described above.

The sands and gravels of the present Salt River bed are not calichified. The gravels forming the Lehi Terrace are generally not calichified, but locally there may be a thin film of caliche developed on the individual pebble surfaces. Commonly the film is no more than 1 mm thick, and quite probably it formed only on the lower side of the pebble (see fig. 1, column A). Gravels of the Mesa and Sawik Terraces have been tightly cemented with $CaCO_3$ and the caliche is strongly to very strongly developed. The colluvium-alluvium of the slopes and the pediment cover are very strongly calichified, and laminar caliche is generally abundant at or near the surface.

Very fine and extremely fine surface material (usually silt) in the northern part of Indian Bend Wash have local layers of very strongly developed caliche, 3 to 8 feet (.9 to 2.4 m) thick, which occur at varying depths to about 20 feet (6 m). No such layers have yet been found in the southern end of the wash. Elsewhere within the Tempe Quadrangle, surface material of very fine or extremely fine alluvium which is calichified generally exhibits a gradual increase in development of caliche to a depth of 15 to 21 feet (4.5 to 6.3 m).

This map involves a general evaluation on a broad scale and does not preclude the necessity of an on-site investigation.

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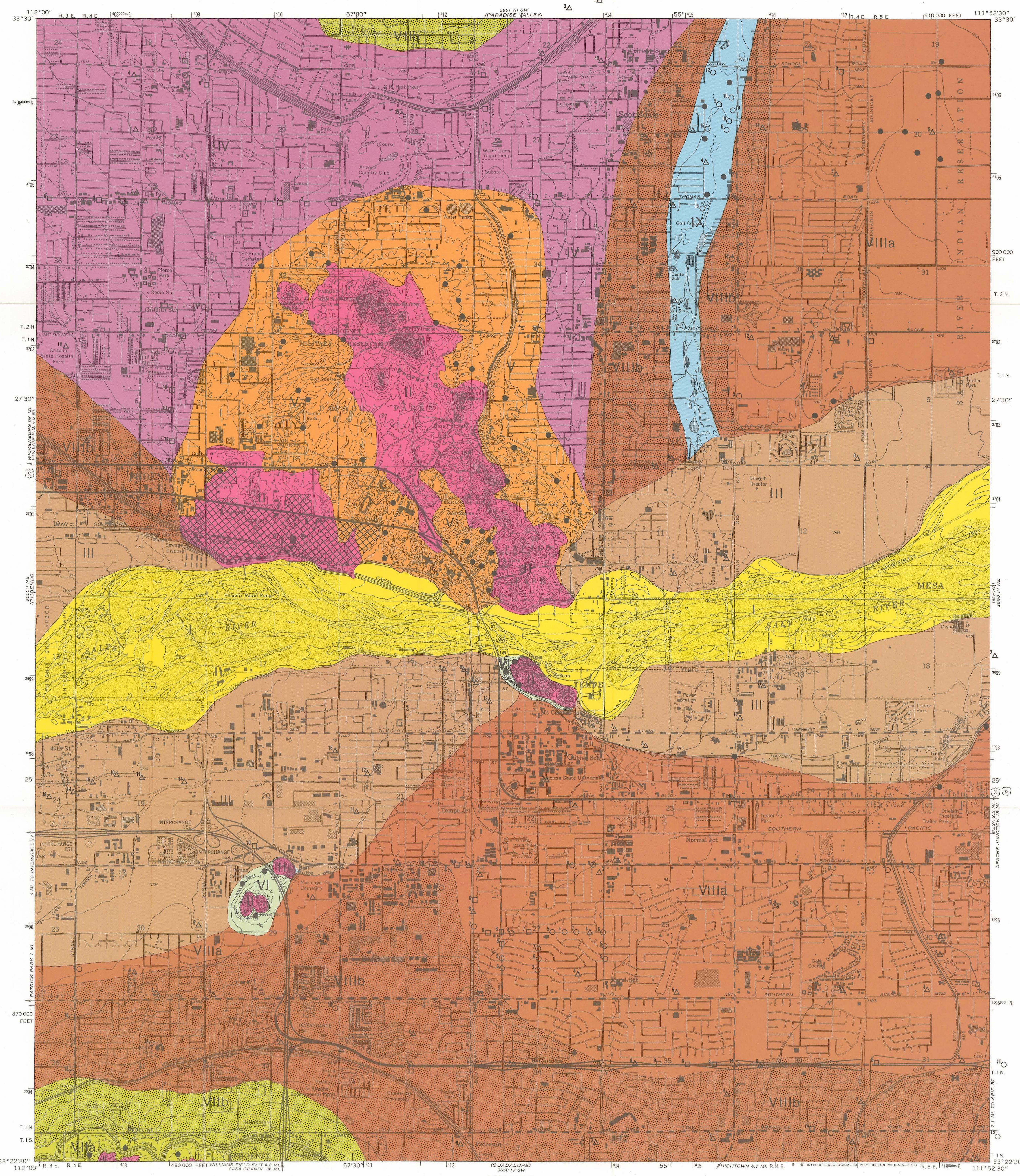
MAP SYMBOLS

- ● Strongly indurated caliche at the surface.
- 4 ○ Strongly indurated caliche; depth of occurrence indicated in feet.
- 7 □ Moderately indurated caliche; depth of occurrence indicated in feet.
- 6 △ Weakly indurated caliche; depth of occurrence indicated in feet. Pebbles or grains may have weak caliche coating. Nodules of caliche soft, if present.
- ⊠ Hatched pattern indicates areas where calichified colluvium had been removed for commercial purposes.



BASE MAP FROM U.S. GEOLOGICAL SURVEY
TOPOGRAPHIC MAP, 1:24,000 SERIES
TEMPE QUADRANGLE (1952, PHOTOREVISED 1967)
Additional revisions compiled by the Geological Survey from aerial photographs taken 1978 and other sources. This information not field checked.
Map edited 1982.

UTM GRID AND 1982 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET
GN MN 0°31′ 9 MILS 13° 231 MILS

SCALE 1:24000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

EXPLANATION

CALICHE UNITS		LANDFORM UNITS	GEOLOGIC UNITS	DESCRIPTION
Non-calichified				
	I	Modern stream channel of the Salt River.	Coarse to fine alluvium.	Material is loose, no caliche development is visible.
	II	Bedrock highlands and exposed pediment.	All bedrock units.	Non-calichified, except in small, local unmapped accumulations of slope debris and colluvial cover, which may have very strongly developed layers of laminar caliche over shallow bedrock. Bedrock fractures may be filled locally with calcium carbonate (particularly in basalt).
Weak				
	III	Lehi Terrace of the Salt River.	Extremely fine alluvium covering rounded river gravel.	Locally weak nodular caliche in the finer grained material, or thin caliche coatings on the gravel. May occur from 4 to 20 ft (1.2 to 6 m).
Moderate				
	IV	Basin floor.	Fine and very fine-grained alluvium.	Moderately developed caliche from 3 to more than 20 ft (0.9 to 6 m) below surface, but generally 6 to 10 ft (1.8 to 3 m). Locally, caliche may vary from non-indurated to strongly developed.
Strong				
	V	Colluvium-alluvium cover-bedrock (pediment).	Coarse to medium-grained colluvium-alluvium.	Strongly developed caliche at or within 3 ft (.9 m) of the surface; laminar caliche widespread. Caliche may extend to depths of 15 ft (4.5 m) (See Geology map, GI-2-A for local areas covered by asphalt, buildups, or other works of man).
	VI	Colluvium-alluvium slopes.	Coarse to medium-grained colluvium-alluvium.	Strongly developed caliche at or within 3 ft (.9 m) of the surface, laminar caliche common. Caliche may extend to depths of at least 12 ft (3.6 m).
	VIIa / VIIb	VIIa & VIIb. Active and inactive alluvial fans.	VIIa & VIIb. Coarse to medium-grained alluvium.	VIIa. Strongly developed caliche at or within 10 ft (3 m) of the surface, laminar caliche common. Caliche may extend to depths of at least 10 ft (3 m). VIIb. Strongly developed caliche more than 10 ft (3 m) below surface. Caliche may extend to depths of at least 30 ft (9 m).
	VIIIa / VIIIb	VIIIa & VIIIb. Mesa and Sawik Terraces of Salt River.	VIIIa & VIIIb. Extremely fine-grained alluvium covering rounded river gravel.	VIIIa. Strongly developed caliche in river gravel at or within 10 ft (3 m) from the surface, laminar caliche locally present. Caliche may extend to depths of 10 ft (3 m) to at least 40 ft (12 m). VIIIb. Strongly developed caliche more than 10 ft (3 m) below surface. Caliche may extend to depths of 20 ft (6 m) to 45 ft (13.5 m).
	IX	Bed of ephemeral wash (Indian Bend Wash).	Extremely fine-grained alluvium.	Strongly developed caliche layers from 3 to 8 ft (.9 to 2.4 m) thick extending laterally from 10 to more than 100 ft (3 to 30 m). Caliche may extend to depths of at least 60 ft (18 m).

Stongly developed "plugged type" caliche in rounded gravel of the Salt River in Mesa Terrace sediments, Higley Road, SE¼, Section 27, T.2N., R.6E., Buckhorn Quadrangle, Arizona (Photograph No. 4717 by T.L. Péwé, March 12, 1983).