THE GEOLOGY OF THE WESTERN PORTION OF THE SAGUARO NATIONAL MONUMENT

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For the purposes of understanding the geology, the western part of the Saguaro National Monument should be considered as two unequal areas divided by a large northeast-trending fault. This fault, or structural break in the earth, is marked by a change in topography as well as a change in rock type. On the east side of the fault is the Catalina gneiss which forms Tanque Verde Ridge and the bulk of the Rincon Mountain mass. To the west, a pediment, or gently sloping erosion surface cut into bedrock, has been developed in the granite and schist rocks which flank the mountains. Two parallel faults, roughly at right angles to the northeast-trending boundary fault, divide the pediment area into three main fault blocks. Of these, the central block has been elevated relative to those on either side, and subsequent erosion has exposed and dissected the schist and granite bedrock. Pantano formation sediments of Middle Miocene(?) age overlie the pediment surface, except on the central block where they have been eroded away. Vertical movements on the faults which bound these blocks have controlled this erosion.

These faults have also served as channels to localize the intrusion of a series of andesite plugs. Remnants of rhyolite flows which cap hills of Pantano sediments and some of the andesite plugs, suggest that more extensive flows were present at one time. The rhyolite was probably also extruded from along one or more of these faults.

A series of unmetamorphosed sedimentary rocks which probably belong to the Earp formation of Pennsylvanian-Permian age is found straddling the boundary fault between the Catalina gneiss and the rocks of the pediment. These sediments are clearly separated from the underlying rocks by a gently dipping fault. The occurrence and manner of emplacement of these sediments is one of the most remarkable features in the entire area. The sediments occur as three or four great blocks, the largest of which is over a mile in length and a quarter of a mile wide. Since the geologic evidence indicates that these sediments are older than the rocks on which they rest, some mechanism must be used to explain this inversion. Earlier workers in the area believed that these rocks represented the remnants of a thrust fault, and that they had moved eastward from an original position somewhere in the valley. Thrust faulting occurs when compressional horizontal stresses in the earth's crust become strong enough to shear through the rocks and force those above the shear plane up and over those below. The result is both a shortening and thickening of the rocks involved. If these rocks are stratified, some of the older beds will be displaced over younger ones, which is what has been observed in the Saguaro National Monument.

More recent work, however, indicates that an entirely different method of emplacement actually occurred. Detailed study of the internal structure of these blocks suggests that they slid slowly westward down the ridge under the influence of gravity to their present location. This phenomenon, termed gravitational gliding, has been recognized and studied in Europe, North Africa, and elsewhere, but has not previously been noted in this region. The implications of the operation of this mechanism are very important in establishing the geologic history of this area.

THE GRANITE AND THE SCHIST

The granite and the schist units form the bedrock of the pediment. The schist unit is a series of metamorphosed rocks consisting largely of schists, but also includes phyllite, quartzite, and gneiss. Most of the rocks in this unit are green or gray in color, though some are shades of brown or tan. Quartz and sericite are the predominant minerals, but chlorite, feldspars, andalusite, garnet, and tourmaline are found locally.

The granite is a pinkish-gray, coarse-grained rock containing crystals of microcline up to 2 inches in length in a matrix of quartz, feldspars, and biotite. The granite has been generally sheared, but is fairly fresh in appearance. Exposures are scattered, and with few exceptions are small in size. The evidence indicates, however, that they are undoubtedly all part of one large intrusive mass. Granite is found on all sides of the schist unit and definitely intrudes it. This can best be seen on the northwest side of the schist unit where the contact can be traced for over a mile. Although this contact is poorly exposed, its location can usually be determined within a foot or two by careful observation.

All evidence indicates that the granite in the Saguaro National Monument was probably emplaced as a molten intrusion at depths sufficient for a coarsely crystalline texture to develop. It is possible that heat and pressure derived from the intrusion of the granite were responsible for the development of the schists and other metamorphic rocks from sediments which were probably Cretaceous in age.

CATALINA GNEISS

The rocks which compose the Catalina gneiss are gray in color, and are characterized by simple mineralogy. Quartz, feldspars, and micas make up the bulk of this unit, with garnet and epidote occurring locally. Several theories have been proposed attempting to explain the origin of this gneiss complex, but no single theory is as yet generally accepted. Two periods of metamorphism have affected this unit; the second of these periods and the elevation of the Santa Catalina-Rincon Mountain mass occurred during or after Cretaceous time. The chief problem is that of determining the relative importance of the two periods of metamorphism in the different parts of the gneiss. Some geologists believe that the present gneissic structure was a result of the post-Cretaceous period of deformation. While this may still be true, recent work in the Saguaro National Monument has indicated that at least locally the gneiss may be of Precambrian age, since the Paleozoic sediments found on these rocks are unmetamorphosed. In other words, these beds must have been deposited as part of a sedimentary sequence on pre-existing gneisses; otherwise some theory must be developed to account for their preservation while gneisses were forming beneath them.

ANDESITE

The andesite at Twin Hills and the Saguaro National Monument is a distinctive gray-green porphyritic rock which commonly weathers to a purplish-brown color. The most prominent feature of the andesite is the occurrence of large crystals of plagioclase which range from half an inch to over an inch in length. These make up 30 to 40 percent of the rock. The resulting texture is rather conspicuous, and as a consequence this rock has been nicknamed the "Turkey Track" andesite. All of the andesite found is in the granite pediment where it occurs as scattered plugs ranging in size from less than 100 feet to nearly 1,000 feet in diameter. Their location appears to have been controlled by faulting, since all are found along the traces of prominent faults or near fault intersections. The age of the andesite is probably the same as that of the Pantano formation, i.e., middle Miocene(?). Although the only exposed contact between these units in the Saguaro National Monument is probably faulted, this age is in agreement with that of similar occurrences elsewhere in Pima County.

RHYOLITE

Remnants of rhyolite flows are found at Twin Hills, and on a hill half a mile northeast of Observation Hill. At both of these locations the rhyolite occurs as flows up to 30 feet thick, and displays well-developed flow structure. Elsewhere, thick float occurs, marking extensions of the original flow which have been broken up by erosion. This type of occurrence is found at the Loma Verde mine, and at Observation Hill. The relationships between the rhyolite and other units in the area show that flows of at least two different ages have occurred in the Saguaro Monument area. This is suggested by field evidence at Observation Hill, where rhyolite pebbles and cobbles are found throughout a 150- to 175-foot section of the Pantano formation. This implies a source of rhyolitic material separate from the flow remnants which now cap these sediments. The location and extent of these earlier flows are unknown. All of the flow remnants which remain in the area are probably the same age, if not part of the same flow. These flows are at least post-lower Pantano in age, and possibly occurred quite late in Tertiary time.

EARP(?) FORMATION

An account of the structural position of these sediments and their method of emplacement has already been given. The sediments themselves consist of alternating beds of limestone, dolomite, sandstone, shale, and conglomerate. An absolute identification of this unit has not been possible, but the few fossils and the type of sediments suggest that they should be assigned to the Earp formation of Pennsylvanian-Permian age.

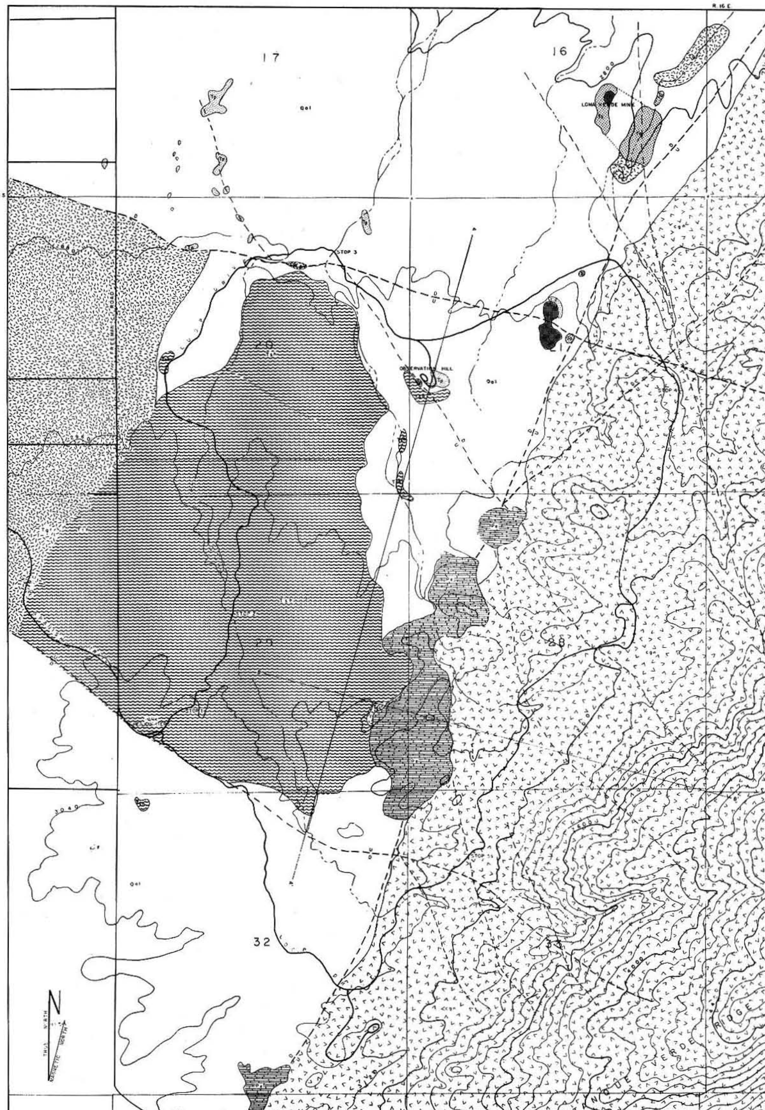
PANTANO FORMATION

The Pantano formation includes sandstone and sandy conglomerates, coarse boulder conglomerates, and interbedded volcanic material. The beds are typical continental deposits, and represent a range of depositional conditions.

With the exception of Observation Hill where nearly 150 feet of Pantano sediments are exposed, only a few feet of section can be seen at any single outcropping. The Pantano formation appears to form a depositional blanket over the granite pediment north of the Loop road. At Observation Hill, a portion of the pediment has been raised and tilted, exposing the Pantano sediments which have been preserved from erosion by a protecting cap of resistant rhyolite. On the fault block south of Observation Hill they have been entirely stripped away.

GEOLOGIC HISTORY

With the possible exception of the Catalina gneiss, no definite occurrence of rocks older than Upper Pennsylvanian is known in this area. Paleozoic rocks older than Pennsylvanian probably were deposited, but except for quartzite and limestone pebbles found in the Pantano sediments no traces of them are left. Sometime during Pennsylvanian-Permian time were deposited the thin-bedded clastic and limy sediments which are preserved as the fault blocks overlying the gneiss-granite contact. The next rocks of which we have record are Cretaceous siltstones, sandstones, and arkoses. During Laramide time these sediments were metamorphosed to schists, phyllites, quartzite, and gneiss. This metamorphism may have been caused or assisted by the intrusion of the granite into these rocks. This activity probably occurred contemporaneously with the second period of metamorphism of the Catalina gneiss. This was followed by a period of mountain building with the formation, or reactivation, of the northeast-trending faults. Accompanying the uplift of this mountain block was deep erosion which by Miocene time had exposed the granite and the schist, and formed the pediment on which the Pantano sediments were laid. By middle Miocene(?) time, a new phase of mountain building caused doming of the Catalina gneiss which formed the core of Tanque Verde Ridge. The Pantano formation began to be deposited on the erosion surface of the schist and granite, drawing sedimentary material from the Paleozoic cover on Tanque Verde Ridge, and from other units, such as the Rincon Valley granite, farther south. Local volcanic activity produced rhyolite flows and quantities of tuff at this time, and material from these sources was incorporated as well. Northwest-trending faults were developed as the ridge continued to rise, extending from the gneiss out into the pediment. These faults mark zones of weakness along which a series of andesite plugs were intruded. Further volcanic activity then occurred in the form of new rhyolite flows which capped the andesite and the Pantano beds. Erosion finally penetrated to the gneissic core of Tanque Verde Ridge, and later Pantano sediments include conglomerates with increasing quantities of Catalina gneiss. The next important event (Pliocene?) was the faulting and tilting of the rocks forming the pediment. As a result of this faulting, the Pantano sediments were stripped from the raised block to the south, exposed and tilted to the southwest in the central block at Observation Hill, and remained undisturbed on the downthrown northern block. The emplacement of the Permian(?) sediments by gliding occurred after they were placed in an unstable structural position, either as a result of undercutting by erosion, or by further tilting of the underlying gneissic rock. Once started, the downhill movement of the blocks continued until stopped by jamming of the blocks against the schist at the base of the ridge. Absence of Pantano sediments beneath the Permian(?) rocks suggests that they had been removed from the schist unit by erosion before the latter sediments moved to their present position. Recent alluvium, derived largely from the Catalina gneiss, now covers a large part of the pediment. This material is coarse and thick near the base of the ridge, and thins and becomes finer as it extends toward the valley. At present, erosion is leveling the dissected remains of the uplifted pediment blocks, and, of course, the main mountain mass.



GEOLOGIC MAP OF THE WESTERN PORTION OF THE SAGUARO NATIONAL MONUMENT

PIMA COUNTY, ARIZONA

EXPLANATION

- Observed contacts
- Concealed contacts
- Attitude of bedding
- Faults
- Cross sections
- Roads

Topography by the U. S. Geological Survey
Rincon Valley Quadrangle 1957

SCALE IN MILES

0 — 1/8 — 1/4 — 1/2 — 3/4 — 1

QUATERNARY	Qal	Alluvium
TERTIARY	Tr	Rhyolite
	Ta	Andesite
	Tp	Pantano formation
	Tgr	Granite
PERMIAN(?)	Tsh	Schist
	Pe	Earp formation(?)
	cgn	Catalina gneiss