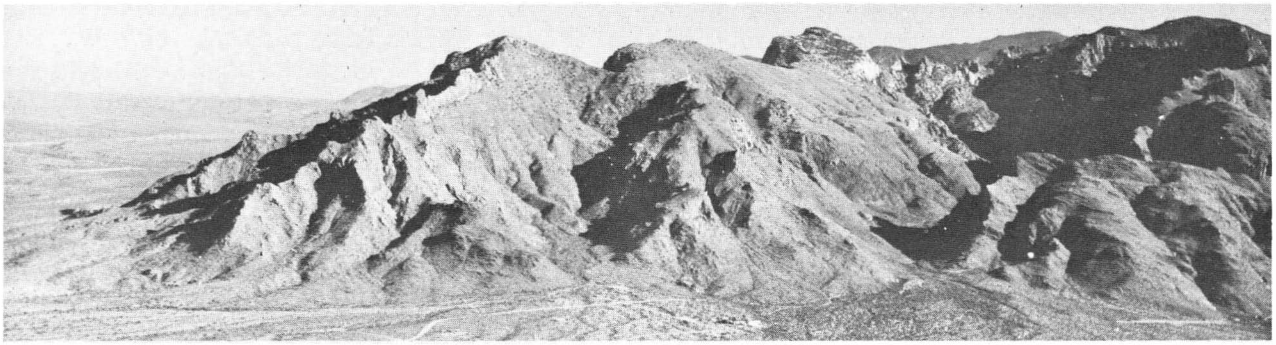
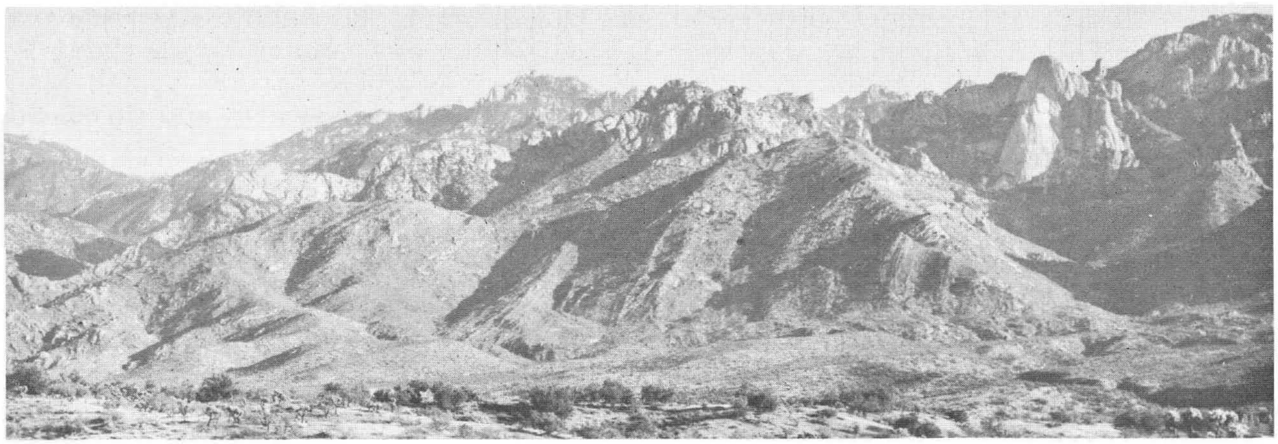


A. View looking northeast up Pima Canyon and showing exposures of gneiss along Pusch Ridge, at the southwest end of the Santa Catalina Mountains.



B. View of northwest side of Santa Catalina Mountains showing overturned asymmetrical anticline in gneiss. Cathedral Rock is high peak on left center skyline.

C. View of northeast side of Oracle Ridge; Alder Canyon in center; Marble Peak is to right of the Alder Canyon gap; Rice Peak on far right. Late Cenozoic alluvial deposits in foreground; Oracle Ridge composed of older sedimentary and crystalline rocks.

FIGURE 18. Aerial view of the Santa Catalina Mountains, Pima County, Arizona. Photos by R. L. DuBois.

GEOLOGY OF THE SANTA CATALINA MOUNTAINS

Robert L. DuBois
University of Arizona

INTRODUCTION

The Santa Catalina Mountains, immediately north of Tucson, Arizona, are the northern part of a larger group of ranges that includes the Tanque Verde and Rincon Mountains to the southeast. These mountains are bounded by broad valleys to the northeast and southwest. Mount Lemmon, altitude 9,150 feet, is the highest point in these ranges and is about 6,700 feet higher than Tucson.

The core of the Santa Catalina Mountains is a granitic-gneissic complex (fig. 18A), bounded on the north by a series of sedimentary rocks, part of which has been metamorphosed. The Oracle granite is exposed north of the sedimentary rock outcrops. Younger Precambrian, Paleozoic, and Cretaceous(?) sedimentary rocks are exposed along the east flank. Metasedimentary rocks crop out locally along the western and southwestern flanks. The ages of these gneissic and metasedimentary rocks and their relationships to rocks of known ages have been long a matter of discussion in southern Arizona. This paper summarizes the results of recent investigations regarding the structure and ages of the rocks in the Santa Catalina Mountains.

In one of the earliest references to the metamorphic rocks of the Santa Catalina Mountains, Blake (1908) states that "the croppings appear like ordinary stratified sandstones and shales" when viewed from a distance. He proposed the name "Arizonian" for the gneissic and schistose rocks which he considered to be Precambrian. Ransome (1916) reports that "the central feature of the range as worked out by Mr. C. F. Tolman, is a great post-Carboniferous intrusive mass of siliceous muscovite granite modified to a gneissic rock near its margins, surrounded by a zone of intense contact metamorphism in which rocks of widely different kinds have been conspicuously affected."

Rocks of the Apache group along the eastern flanks of the mountains were reported by Bruhn (1927). Davis (1931) made a physiographic study of the late structural history of the Catalinas and interpreted them as part of the basin-and-range structure. Studies of the pegmatites by Hernon (1932) included data on the "injection" gneiss and other metamorphic and sedimentary rocks of the area. A study of the geology of the Tucson quadrangle was started by Moore and others (1949) but was not completed. Darton (1925) described briefly a number of small areas in the Catalinas, and Stoyanow (1936) discussed the Paleozoic section in Peppersauce Canyon, south of Oracle.

Bromfield (1950) and Ludden (1950) mapped a part of the area between the Oracle granite and Peppersauce Canyon. In the Mineta Ridge area near Redington, Chew (1952) mapped a group of narrow, north-trending fault blocks of Tertiary sediments in contact with metamorphic rocks on the west and Tertiary-Quaternary beds on the east. Data on the Santa Catalina Mountains available up to 1952 were summarized by Bromfield (1952). Recent work in four areas covers a north-south strip through the range (fig. 46). Banerjee (1957) described the structure and petrography of the Oracle granite north of the Mogul fault. Wallace (1954) made a structural study of the sedimentary and metasedimentary rocks south of the Mogul fault. Peirce (1958) studied the structure and petrography of the sedimentary, metamorphic, and igneous rocks in the Summerhaven area. The petrography and structure of the core of the range are discussed by DuBois (20).

GEOLOGIC SETTING

The oldest metasedimentary rock mapped in the Santa Catalina Mountains is the older Precambrian Pinal schist (fig. 46). Unconformably overlying this unit are rocks of the younger Precambrian Apache group, and the Apache group is unconformably overlain by the Paleozoic section. Cretaceous(?) conglomerate, siltstone, sandstone, and limestone unconformably overlie the Paleozoic strata and are in turn unconformably overlain by, or faulted against, middle Tertiary rocks. Tertiary and Quaternary detrital deposits occupy the marginal valleys.

The Precambrian and Paleozoic sedimentary rocks are metamorphosed in the vicinity of Mount Lemmon and Marble Peak (figs. 18C, 46). To the north and east of this area the degree of metamorphism generally decreases, and essentially unmetamorphosed Apache and Paleozoic strata are exposed a few miles south of Oracle and northwest of Redington. Locally, small exposures of intensely metamorphosed rocks lie within the less metamorphosed areas.

Gneissic rocks form the core of the range from its southern end to the vicinity of Mount Lemmon. Granitoid rocks are well represented in the Oracle granite, Samaniego granite, Leatherwood quartz diorite, and Catalina granite. Diabase, quartz latite, latite, and other intrusive rocks also crop out in several areas. Pegmatites are abundant south and east of Mount Lemmon.

Rock units similar to those in the Santa Catalina Mountains extend southeastward into the adjoining Tanque Verde and Rincon Mountains.

A well-developed northeasterly lineation is present throughout most of the gneissic complex. Although in detail the pattern of folding of the foliation is intricate, broad gentle anticlines and synclines are present, and west of Mount Lemmon there are large overturned asymmetric structures (fig. 18B). There are many faults in the north part of the range and among the more prominent are the east-west-trending Mogul and the north-south-trending Pirate faults. Most faults are high-angle normal faults, but thrust faults are also present.

SEDIMENTARY ROCKS AND THEIR METASEDIMENTARY DERIVATIVES

Pinal Schist

The Pinal schist in the Santa Catalina Mountains crops out as a wide band extending southeastward from the vicinity of the Copper Hill mine, in small exposures along the Mogul fault, near Gold Mill, and north of the Palisades Ranger Station (fig. 46). The exposures of Pinal schist north of the Mogul fault grade into the Oracle granite over distances of several thousand feet. The gradational zone is characterized by increasing numbers of plagioclase porphyroblasts in the Pinal schist as the granite is approached. The contact of the Pinal schist with the Samaniego granite is sharp, steep, and irregular, and the contact zone contains abundant aplite (Wallace, 1954).

The Pinal schist consists of phyllite and quartz-sericite schist, derived by metamorphism of quartz-rich sediments that included both argillaceous and arenaceous bands. The schists are generally made up of abundant sericite and quartz with local muscovite, biotite, and chlorite. Sericite pseudomorphs after andalusite have been reported from zones near contacts with Oracle granite or diabase (Banerjee, 1957).

Feldspar occurs as porphyroblasts, mainly in the gradational zone near the Oracle granite.

The metamorphism of the Pinal schist has been generally low grade and belongs to the green-schist facies (Fyfe and others, 1958). In the vicinity of Summerhaven, higher metamorphic grades, associated with the development of the Catalina gneiss, have been superposed on the green-schist facies. The northward extent of these polymetamorphic effects is not known. Near Oracle, the Pinal schist contains relict biotite, microcline, and oligoclase (Banerjee, 1957). These minerals suggest to me that, in this area, an earlier green-schist facies of the Pinal schist may have been locally remetamorphosed during the formation of the Oracle granite; and that a second, more widespread, period of metamorphism, associated with Catalina gneiss development, formed the present green-schist facies assemblage. The mineral assemblage associated with the superposed metamorphism in the northern area is isograde with the earlier green-schist assemblage.

Apache Group

The Precambrian Apache group generally overlies unconformably the Pinal schist, although in the central part of the area the Apache group locally rests on Precambrian granite (Peirce, 1958). Individual units of the Apache occur in the north and central parts of the Santa Catalina Mountains, and their distribution has been mapped in detail by Wallace (1954) and Peirce (1958). Some of the formations of the Apache group occur near Redington.

The Scanlan conglomerate ranges in thickness from 10 to 50 feet and is composed at some places of quartzite pebbles 1/2 inch to 6 inches in diameter, set in a sandy matrix; elsewhere the formation is a coarse sandstone. Metamorphism of the Scanlan in the vicinity of Mount Lemmon has produced oriented sericite and muscovite, recrystallized quartz, and elongated pebbles.

The Scanlan conglomerate grades into the overlying Pioneer shale which is an arenaceous mudstone with interbedded sandstone, about 250 feet thick. The northernmost exposures are apparently unmetamorphosed, but southward metamorphism has formed muscovite schists with various amounts of quartz.

The Barnes conglomerate overlies the Pioneer shale and ranges in thickness from 25 to 75 feet. This formation is distinctive because it contains easily recognized, well-rounded quartzite and jasper pebbles as much as 8 inches in diameter. The matrix, generally sericite and quartz, is commonly stained reddish-brown by hematite. Near the crest of the Santa Catalina Mountains and near Redington, metamorphism has transformed these rocks into mica schists with locally preserved ellipsoidal pebbles. In some areas the pebbles have been elongated and transformed into narrow quartzose stringers or bands. Minerals in the metamorphosed Barnes include muscovite, biotite, garnet, epidote, sphene, and feldspar.

The Dripping Spring quartzite lies above the Barnes conglomerate and includes about 350 feet of gray sandstone and siltstone, with sandstone more predominant near the base (Peirce, 1958). Metamorphic equivalents near Summerhaven include quartzite in the lower part and quartz-muscovite schist in the upper part.

The Mescal limestone, which elsewhere overlies the Dripping Spring quartzite, is generally missing in the northernmost Santa Catalina Mountains (Wallace, 1954). Peirce (1958) suggested that in the Summerhaven area, marble composed of calcite, tremolite, quartz, and diopside may be metamorphosed Mescal limestone because the marble is associated with metamorphosed Dripping Spring quartzite.

Paleozoic Rocks

The Middle and Upper Cambrian strata in the northern Santa Catalina Mountains include the Troy quartzite, Santa Catalina formation, Southern Belle quartzite, and Abrigo formation (Stoyanow, 1936; Dickinson, 6). The latter three units are shown as undifferentiated Abrigo formation on figure 46.

Weakly metamorphosed to unmetamorphosed Troy quartzite consists locally of 310 feet of white to brownish-red quartzite, composed mostly of interlocking quartz grains with minor amounts of sericite (Peirce, 1958). The metamorphosed equivalent of the Troy in the Summerhaven area is a massive gray to white quartzite that contains oriented quartz, muscovite, and biotite. Minor amounts of microcline, tourmaline, magnetite, and sphene are locally present. A predominance of quartz in the Troy readily distinguishes it from other nearby metamorphosed formations.

The Santa Catalina formation rests on the Troy quartzite and consists of mudstone near the base, calcareous mudstone in the middle, and sandstone near the top. The Santa Catalina formation is 300 feet thick. Metamorphism has formed tremolite, epidote, clinozoisite, and diopside in the more calcareous members. Staurolite, muscovite, and biotite occur in the metamorphosed rocks derived from the more aluminous parts of the formation. The mineral assemblages in the aluminous rocks of the Santa Catalina formation demonstrate the gradational nature of metamorphic effects from the vicinity of Mount Lemmon northward. Near Mount Lemmon, the Santa Catalina equivalents are assigned to the staurolite-quartz subfacies of the almandine-amphibolite facies (Fyfe and others, 1958). Northward the equivalent rocks are metamorphosed to the green-schist facies.

A 30-foot section of Southern Belle quartzite overlies the Santa Catalina formation and underlies the Abrigo formation. The Abrigo is about 350 feet thick and consists of brown limestone with interbedded sandstone. Where the Abrigo is metamorphosed, it ranges from hornfels to marble composed of calcite, quartz, tremolite, and clinozoisite. Dolomite is locally present in both the metamorphosed and unmetamorphosed sections.

Metamorphic equivalents of Devonian and younger Paleozoic formations have not been recognized in the more metamorphosed terrains, although west of Mount Lemmon there are rather pure marbles which probably are upper Paleozoic. In areas of relatively weak metamorphism, Peirce (1958) has mapped 185 feet of Martin limestone, an unmeasured thickness of Escabrosa limestone, a section of the Horquilla formation about 1,000 feet thick, and approximately 200 feet of the lower part of the Andrada formation. These units are not differentiated on figure 46. These formations probably are all present in the weakly metamorphosed, undifferentiated section of Marble Peak, and most have been metamorphosed locally by contact with the Leatherwood quartz diorite.

IGNEOUS AND METAMORPHIC GRANITOID ROCKS

Catalina Gneiss

The term Catalina gneiss describes the gneissic rocks that make up the core of the Santa Catalina Mountains and extend southeastward from Mount Lemmon into the

Tanque Verde and Rincon Mountains. The contacts between the gneiss and the surrounding rocks have not been studied in detail. Peirce (1958) infers that in the Summerhaven area the contact between the metasedimentary rocks and the gneiss was originally a depositional contact between younger Precambrian sedimentary and older rocks. Locally, the contacts between the gneiss and the sedimentary and metasedimentary rocks are probably faulted.

The gneissic rocks may be divided into three general types (DuBois, 20) --banded augen gneiss (fig. 21), augen gneiss (fig. 22A, C), and granitic gneiss-gneissic granite (fig. 21B). The banded augen gneiss crops out mainly in the southern part; the augen gneiss, in the central part, and the granitic gneiss-gneissic granite, in the northern part of the exposures of Catalina gneiss. All possible gradations occur between these types, and it is impracticable to depict contacts between them on the scale of figure 46. The three types of gneiss have similar mineral compositions --large feldspar crystals set in a matrix of quartz, feldspar, and biotite. In the banded augen gneiss, the large crystals are porphyroclasts set in a sheared matrix (fig. 21B, C). Light and dark bands alternate as an expression of relative difference in biotite content. The occurrence of porphyroclasts as single crystals, or as strings or bands of several crystals, is a striking feature of these rocks. The augen gneiss is similar in cataclastic and other general features to the light-colored zones in the banded gneiss. The granitic gneiss-gneissic granite is similar to the augen gneiss but has undergone less extensive cataclastic deformation.

The gneissic rocks in the southern part of the range were derived from sedimentary and igneous materials (DuBois, 20) and the gneisses in the northern part of the area were derived from granitic rocks (Peirce, 1958; DuBois, 20). Peirce considered the pre-metamorphic material to be older Precambrian Oracle granite or its equivalent that became mobilized during the main period of metamorphism; whereas I suggest that this portion of the gneiss is a polymetamorphosed granitic rock of igneous origin, formed by metamorphism during older Precambrian and post-Cretaceous times. These two apparently different conclusions are in part compatible.

Oracle Granite

The older Precambrian Oracle granite forms the northernmost part of the Santa Catalina Mountains, and areas of granitic rocks in the north-central part of the range were considered to be Oracle granite by Peirce (1958). The Oracle granite is in fault contact with Precambrian and Paleozoic sedimentary rocks, or grades into the Pinal schist. At the north end of the range, it is overlain by Tertiary and Quaternary alluvial rocks.

The Oracle granite is a coarse-grained porphyritic quartz monzonite with local granite to granodiorite phases. The main minerals are quartz, plagioclase (An_{22-34}), microcline, perthite, biotite, and chlorite. Minor minerals include magnetite, ilmenite, epidote, sphene, tourmaline, and zircon. Large crystals of microcline, which appear subhedral to euhedral in the field, have xenomorphic forms in thin section, suggesting crystalloblastic growth, and other main minerals have anhedral forms with crystalloblastic characteristics. Banerjee (1957) considers the biotite to have been derived from an original hornblende.

Banerjee interprets the preferred northeast orientation of biotite and feldspar crystals and of schlieren and inclusions to be a deformational feature related to the Mazatzal orogeny (fig. 19). He also states that the rock was originally a granodiorite and was changed to quartz monzonite by K-metasomatism. Banerjee (1957, p.

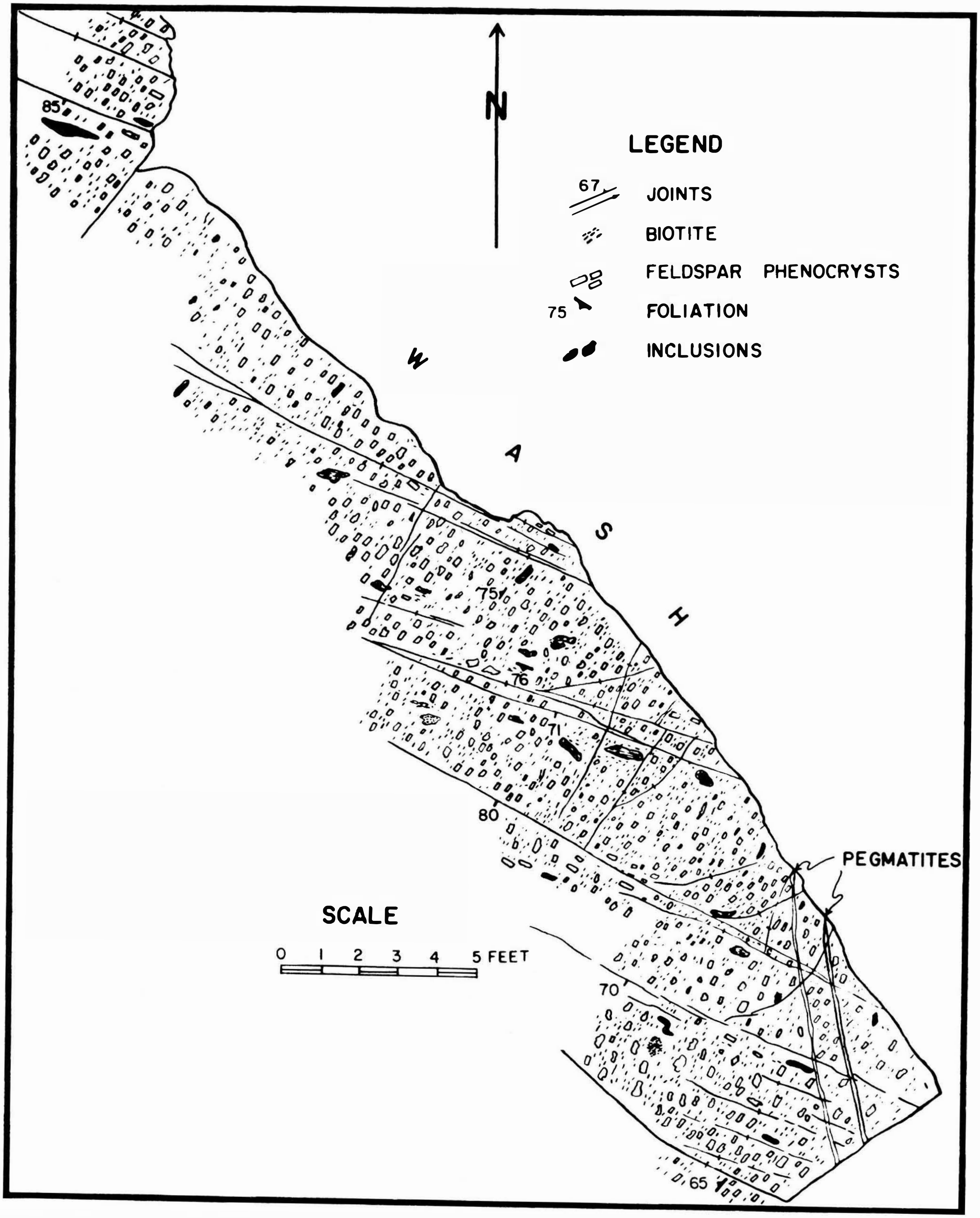


FIGURE 19. Plan view of cross-foliation in Oracle granite (Banerjee, 1957, fig. 5).

98) attributes the presence of inclusions and schlieren to remnants of Pinal schist and says that these and other features "strongly suggest that much schist has become granite by recrystallization and metasomatism." Although petrographic evidence does not preclude the possibility that the granite may have been partly mobile during emplacement, structural features do not support this interpretation (Banerjee, 1957).

Banerjee considers the Oracle granite in its present form to be of Precambrian age (Damon, 5), but suggests the possibility of movements along the Mogul fault during "Laramide" orogency which may have produced local orientations within the granite along the fault.

It is also possible that this granite might have been emplaced into the Pinal schist during Precambrian time as a magma, or as mobilized granitic material, which locally feldspathized the Pinal schist near its margins. Post-Cretaceous metamorphism and metasomatism may have then brought about structural orientation, compositional changes, crystalloblastic textures, and the development of microcline porphyroblasts in the older granite. Such post-Cretaceous changes formed the gneisses of the main mountain mass to the south (DuBois, 20).

This hypothesis of the origin of the Oracle granite is supported by the parallelism of structures in gneisses (DuBois, 20) and in the Oracle granite (Banerjee, 1957) and by petrographic features of the rocks.

The early phase of feldspathization of the Pinal schist by Oracle materials fits well with Banerjee's concept of an early stage of plagioclase porphyroblast formation. The chemistry of this feldspathization would further agree with Banerjee's idea of an original granodiorite. The later metasomatic action is in accord with the supposed microcline porphyroblast development in the Oracle granite and the Pinal schist, and with Banerjee's conclusion of granodiorite changing to quartz monzonite.

Samaniego Granite

Granitic rocks, which Wallace (1954) called the Samaniego granite and considered to be Precambrian, crop out along the western side of the northern Santa Catalina Mountains. This unit is in fault contact with late Cenozoic sediments on the west and with Pinal schist on the east. Wallace (1954, p. 13) states that the eastern contact "is sharp, steep, and irregular, and the contact zone contains abundant aplite" with local inclusions of Pinal schist. In composition, the rock ranges from granodiorite to quartz monzonite and contains large microcline crystals associated with quartz, plagioclase, and hornblende.

Wallace suggests that this "granite" is not the Oracle granite because it contains a more calcic plagioclase, a hornblende instead of biotite as the mafic mineral, and a primary magnetite. The Samaniego granite appears to be similar in composition to the granodiorite postulated by Banerjee (1957) to be the original composition of the Oracle granite.

Leatherwood Quartz Diorite

The Leatherwood quartz diorite is a stock on the northeastern slope of the Santa Catalina Mountains (Peirce, 1958) that intrudes Cretaceous rocks (Bromfield, 1952). Peirce noted that its western contact is locally concordant where it intrudes Precambrian and Paleozoic rocks at Marble Peak, and elsewhere the western contact is discordant. The eastern contact is exposed only where the stock intrudes the lower part of the Andrada formation. A few feet of contact-metamorphic lime-silicates were formed where the stock intruded limestone.

The Leatherwood quartz diorite ranges from massive to gneissic in texture and the Leatherwood is generally composed of biotite, quartz, oligoclase, and epidote. Minor minerals include hornblende, sphene, and apatite. An originally hypidiomorphic granular texture is suggested by the mineral arrangements seen in thin sections. A superposed crystalloblastic texture has been formed under conditions of metamorphism which have changed the plagioclase to a more sodic composition and formed epidote from the released calcium. Locally, hornblende was the primary mafic mineral. Some of the biotite may be igneous, but a large part of it was formed from the hornblende during metamorphism.

The inclusions and mineral orientations in the Leatherwood quartz diorite are parallel to each other and both are parallel to the planar structure of the nearby gneisses. Peirce (1958) considers this parallelism of structures within the Leatherwood and between the Leatherwood and the gneiss to indicate that the intrusion of the Leatherwood is contemporaneous with some of the early kinematic phases of the metamorphism.

Catalina Granite

Peirce (1958) has mapped a body of granite north of Mount Lemmon which Moore and others (1949) named "Catalina granite". Dikes and apophyses from this rock intrude the post-Cretaceous Leatherwood quartz diorite. Chilled contacts in this northern area clearly suggest a hot mobile intrusive origin. The contact with the metasediments on the south has not been observed, but near the area of contact, about one mile north of Mount Lemmon, there are numerous large inclusions of metasediments with an orientation parallel to a foliation locally present in the granite in this area.

Two different facies characterize the Catalina granite. The northern exposures, according to Peirce, are granodiorite in composition, hypidiomorphic granular in texture, and contain mainly quartz, orthoclase, and oligoclase. Outcrops on the south are of a granite with a crystalloblastic texture, composed of abundant quartz and orthoclase with some plagioclase and biotite.

The Catalina granite appears to have had a complex origin. Features of the southern portions suggest metasomatic replacement of metasediments forming granite, and features of outcrops to the north seem best related to mobilization of granitic materials that may or may not have been completely molten.

Pegmatite

Pegmatite dikes and irregular bodies transect the rocks of the Leatherwood quartz diorite (fig. 22D), the Catalina gneiss (fig. 22C), and the metamorphosed Precambrian sediments. Pegmatite dikes cross each other and were emplaced at different times, probably within a single general period. The pegmatites have irregular widths but are generally less than 2 feet wide. A replacement origin is suggested (Hernon, 1932; Peirce, 1958) by the presence within the pegmatite of books of mica aligned parallel to the structure of the country rock (fig. 22C). Offsets are common where pegmatites cross one another, but some small displacements along fractures may have occurred before the emplacement of the pegmatite. The contacts are generally sharp but locally they are gradational, and in some areas they are paralleled by strings of garnet crystals (fig. 22D). At many places, fragments of the country rock project into a dike and the structures and trends in the country rock on both sides of a dike are continued in fragments of country rock completely surrounded by pegmatite.

Quartz, orthoclase, albite, and muscovite make up most of the pegmatites; minor minerals include biotite, microcline, and garnet. Rare earth minerals have been reported from the pegmatites of the Santa Catalina and Rincon Mountains.

Miscellaneous Igneous Rocks

In the northern end of the Santa Catalina Mountains there is a large exposure of metamorphosed hypabyssal rocks. Moore and others (1949) considered these rocks to be andesite of possible Cretaceous or Tertiary age. Wallace (1954), however, considers them to be Tertiary metadiorite, and Peirce (1958) suggests they are predominantly quartz latite of post-Precambrian age. Rocks of this unit separate the two belts of sedimentary rocks north of Copper Hill mine (fig. 46) and occur as sills in the Apache group near Stratton Canyon and as a small body in Precambrian granite farther south. The original porphyritic texture is evident in most thin sections and has not been completely destroyed by superposed low-grade metamorphism. Quartz and feldspar phenocrysts are partly preserved, but the mafic minerals have been changed to chlorite, tremolite, and epidote.

Sills and dikes of diabase are intrusive into Precambrian and Paleozoic strata, and Moore and others (1949) mention diabase cutting Cretaceous rocks. In most areas the diabase is aphanitic and in thin section shows partially preserved original igneous textures. In the Summerhaven area diabase has been metamorphosed to hornblende and biotite schists.

Dikes and other small post-metamorphic intrusive bodies transect many rock units in the area and range in composition from lamprophyre to rhyolite. Some of these, composed of andesite, are characterized by the presence of exceptionally large phenocrysts of plagioclase.

STRUCTURAL GEOLOGY

The northwest side of the Santa Catalina Mountains is transected by the north-trending Pirate fault (Wallace, 1954), and the north part of the range is cut by two major east-west faults --the Mogul fault and the Geesman fault (Peirce, 1958). Along the Mogul fault, which dips steeply to the south and is downthrown to the south, Precambrian and Paleozoic rocks are in contact with the Precambrian Oracle granite on the north. Farther south, the Geesman fault, which also dips steeply and is downthrown to the south, has a vertical displacement of 3,000 feet. This fault brings Precambrian and Paleozoic granitoid and metasedimentary rocks into contact with Paleozoic rocks and with Leatherwood quartz diorite. Many small high-angle normal faults offset the sedimentary and metasedimentary units. In some areas, as near Redington, thrust faults have been mapped. Broad anticlinal and synclinal structures exist in most parts of the area, and asymmetrical, overturned anticlines exist in places, especially along the western front. These structures are evident in trends of bedding and foliation. Within the gneissic complex an earlier foliation and lineation with an east-west trend exists, which has superposed upon it a foliation with variable trends and with a N. 50° E. lineation. The superposed lineation is most easily recognized in outcrops of gneiss (DuBois, 20, fig. 20).

The sequence of deformation producing the structures of the rocks in the Santa Catalina Mountains is not entirely understood. Precambrian movements are evident in exposures of Pinal schist, and post-Cretaceous structures have been formed in younger metasedimentary and igneous units. It is possible that the faults and folds established by Precambrian deformation in part controlled the trends of adjustments during post-Cretaceous deformation. Movement along the major faults, such as the Mogul and Geesman, has occurred during both Precambrian and post-Cretaceous times.

Offsets and folding of late Cenozoic beds show that at least some deformation has occurred in late Tertiary or Quaternary time. Metamorphism associated with the post-Cretaceous deformation did not affect middle to late Cenozoic rocks mapped to date (Chew, 1952). This suggests either a separate period of Cenozoic deformation or a continuation of post-Cretaceous deformation after the cessation of metamorphism.

SUMMARY OF METAMORPHISM AND METASOMATIC ACTIVITY

At least two periods of metamorphic activity are recorded in the rocks of the Santa Catalina Mountains. The earlier one metamorphosed sedimentary and possibly volcanic rocks into the Pinal schist during Precambrian time. Deformation developed schistosity more or less parallel to bedding planes and metamorphism was generally low-grade, belonging to the green-schist facies. The later metamorphism, dated as post-Cretaceous because of its effects on the Leatherwood quartz diorite, developed the Catalina gneiss in its present form and also formed schistose rocks near Mount Lemmon. The presence of staurolite-quartz subfacies of the almandine-amphibolite facies near Mount Lemmon and green-schist facies farther north (Fyfe and others, 1958) suggests that the effects of this metamorphism were more intense near Mount Lemmon than to the north. During this period of metamorphism, synkinematic metasomatic feldspathization formed feldspar porphyroblasts as single crystals and as strings of crystals in the gneiss. Continued metasomatism of the gneiss developed synkinematic and post-kinematic quartz-feldspar pegmatitic zones roughly parallel to the linear structure of the gneiss. Post-kinematic, cross-cutting replacement pegmatite dikes were also formed throughout most of the gneiss in the southern part of the Santa Catalina Mountains.

Cataclastic action associated with the post-Cretaceous metamorphism formed porphyroclasts and augen structures in the gneissic rocks. Locally deformation has been sufficiently intense to form mylonites.