THE GEOLOGY OF THE CABEZA PRIETA GAME RANGE

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ABSTRACT

The Cabeza Prieta Game Range is of geologic and physiographic interest as a representative part of the Sonoran Region of the Basin and Range Province. Located in southern Yuma and Pima Counties, Arizona, the area remains a relatively undisturbed desert wilderness. The area encompasses nearly 1400 square miles of low, generally northwest-trending mountain ranges separated by wide alluvial valleys, with elevations varying from 600 to 3323 feet above sea level. The mountains are of two types: sierra type mountains composed of metamorphic or granitic rocks and mesa type mountains composed primarily of volcanics. Several ranges are skirted by pediments. The valleys are drained by ephemeral streams which finally drain into the Gulf of California, with the exception of two areas which drain into enclosed playas.

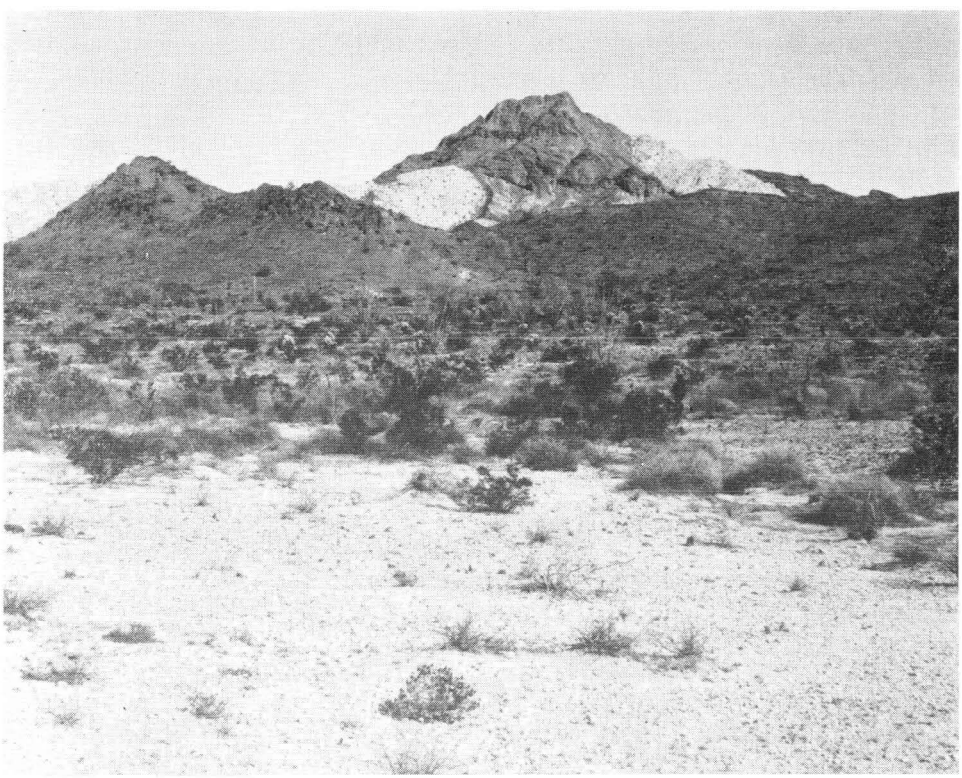

FIGURE 1. Cabeza Prieta Peak.

INTRODUCTION

The Cabeza Prieta Game Range, in southwestern Arizona, is interesting geologically and as part of a unique desert region (Fig. 1). The area has been relatively inaccessible to the general public since it was withdrawn from public domain for use as a wildlife refuge in 1939 and a military aerial gunnery range in 1942. Up to now, no geological study has been made of this area as a unit. This report is a compilation of data from the literature, from interviews, and from personal observations.

The Cabeza Prieta Game Range was set aside by Presidential Order as a sanctuary for desert bighorn sheep, Sonoran pronghorn antelope, and other wildlife native to the region. The distribution of flora and fauna is noticeably influenced by rock and soil types and topography. Botanically, the area is a part of the Sonoran Desert Region of the Southwestern Deserts, which is sometimes called an arboreal desert because it contains a high percentage of trees and large shrubs. Plant associations include agave associations on the eroding mountain slopes, palo verde-saguaro cactus associations on the upper bajadas, creosote bush associations on the lower bajadas, and mesquite associations on the bottom lands. Faunal distribution is related to types of terrain also. Desert bighorn sheep and foxes usually prefer the bare rock slopes. The peccary stays in the upper bajadas and washes. The deer and antelope usually stay in the lower valleys and bajadas as do most of the carnivores — coyote and bobcat — and the hares and rabbit, their methods of locomotion being better adapted to the more level ground.*

GEOGRAPHICAL DESCRIPTION

The area consists of nearly 1400 square miles in Yuma and Pima Counties in southwestern Arizona, along the Arizona-Sonora border (Fig. 2). It is characterized by a series of low, elongated, mostly northwest-trending mountain ranges separated by wide desert plains. Elevations vary from about 600 feet above sea level in the San Cristobal Valley to 3323 feet in the Growler Mountains, a difference of 2723 feet.

The eastern end of the game range may be contrasted to the western end by its higher elevation (1458 feet above sea level at Ajo, 1045 feet in the Lechuguilla Desert), greater average precipitation (9 inches per year at Ajo, 3½ inches at Yuma), and lower average yearly temperatures (71½ degrees at Ajo, 74½ degrees at Yuma) (U. S. Weather Bureau, 1962). Daily and seasonal temperature extremes play an important part in the production of desert land forms. Official temperature extremes over several decades have ranged from records of 17 degrees to 120 degrees F. (Institute of Atmospheric Physics, 1960).

The extreme climatic conditions produce a desert topography of bare-

*For detailed discussions of the flora and fauna as related to the geology of the Cabeza Prieta Game Range, see Simmons, 1965.

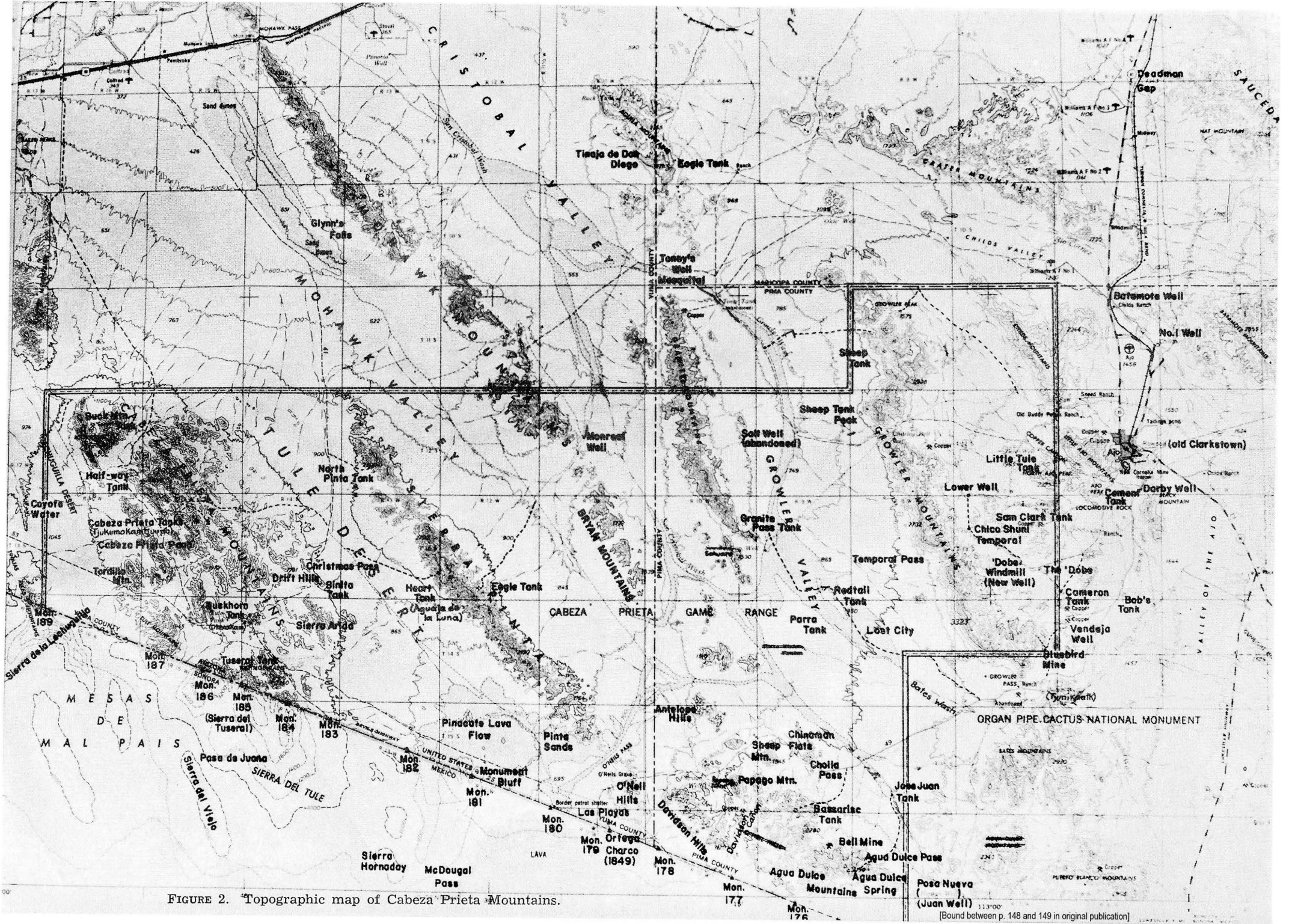

FIGURE 2. Topographic map of Cabeza Prieta Mountains.

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rock mountains of two types: the "sierra" type are jagged, metamorphic or granitic mountain ranges, and the "mesa" type are relatively flat, bedded volcanic mountain masses. Some of the mountains are skirted by pediments, and all are flanked by large bajadas of coalescing alluvial fans. Because of the rapidity of erosion in the desert mountains, soils are found mainly in the valleys. The soils of the area are alkaline and low in organic matter. Much lime is present and occurs as nodules, mottlings, or accumulated layers referred to as "caliche."

All streams within the area are intermittent (Figs. 3 and 4), and most of them drain ultimately to the Gulf of California, though a few drain into playas. Surface water catchments include rock tanks, playas, and man-made charcos. One fracture spring is located in the area. Wells, 30 to over 400 feet deep, produce water in local areas.

GEOLOGIC DESCRIPTIONS OF MOUNTAIN RANGES†

Childs Mountain

Childs Mountain is a nine mile long group of layered volcanic plateaus and ridges at the northeast corner of the area just northwest of Ajo, Arizona. Its bedded lavas rise 1500 feet above the valley west of Childs Mountain. The lavas dip gently toward the east, with a gentle dip slope on the east and a steep fault scarp cutting through them on the western slope. Steep canyons also border the western slope.

Growler Mountains

The Growler Mountains are a 27 mile long, northwest-trending range west of Childs' Mountain. They are primarily a volcanic, mesa type range (Fig. 5). The eastern slope of the main mass of Growler Mountains is relatively smooth and gentle, having the same slope as the east-sloping lava beds which cap the mountains. The west slope is a steep 1500 foot escarpment showing a thick succession of varicolored lava beds, unconformably overlying a crystalline complex.

Outstanding landmarks flank the western slope. The most conspicuous is a conical, pointed peak just northwest of Charlie Bell Pass, called Sheep Tank Peak (Bryan, 1925). This may be an especially resistant Quaternary plug (Wilson, Moore, and O'Haire, 1960) which has been isolated by the headward cutting of a stream (Bryan, 1925). A smaller plug is partly buried by talus on the north side of Temporal Pass. Twelve miles south of Sheep Tank Peak is a one by one-half mile black butte with a steep northeast face and gentle southwest slope, adjacent to the main mountain mass. It is composed of lava beds dipping sharply southeast, in contrast to the gently east-sloping beds of the main mountain pass. It is underlain by the crystalline complex which connects it to the main mountain mass. The

†For geologic maps refer to Wilson, 1960; Wilson, Moore, and O'Haire, 1960.

lava beds of the butte and of the main mass are thought by Bryan to be parts of a once continuous lava field, which has been dislocated by a northwest trending fault between the butte and the mountain front.

At the southeastern end of the Growler Mountains are located outcrops of limestone and quartzite which may be the only Paleozoic rocks exposed in the entire area.

Agua Dulce Mountains

The Agua Dulce Mountains lie in the southwestern corner of Pima County near the international boundary. They form an irregular arc about 12 miles long which trends slightly north of west. Non-volcanic crystalline rocks form three sierra-type masses which are surrounded by an extensive pediment. The surrounding plains rise steeply to the foot of the mountain, the highest peak rising about 1000 feet above them. Numerous quartz veins run through the mountains.

Davidson Hills and O'Neill Hills

The hills west of the Agua Dulce Mountains and south of Papago Well, the Davidson Hills, are intricately faulted, sierra type mountains, which rise 300-700 feet above the plains and appear to be part of the same mountain block as the Agua Dulce Mountains. The Davidson Hills are about five miles long and are composed of granite or coarse granite gneiss.

The O'Neill Hills, west of Papago Well, are 150 to 300 feet high and about four miles in extent. These are considered outliers of the Agua Dulce Mountains. Here many small hills are almost buried by the alluvium. Granodiorite forms part of the hills in O'Neill Pass. Two remnants of Quaternary basalt are found among these hills: a mesa five miles south of O'Neill Pass with nearly horizontal beds, and a downfaulted block just south of Papago Well which dips about 20 degrees southwest.

To the north, between the Davidson Hills and Granite Mountains are scattered hills composed mostly of gneiss and granite, with a few remnants of Quaternary basalt.

Granite Mountains

The Granite Mountains are a sierra type range with a north-south trend, lying west of the Growler Mountains and Growler Valley. The range is about 15 miles in length, and the highest peaks rise about 1000 feet above the adjacent valleys. The Granite Mountains have a sawtooth outline and are composed of granite and similar coarse grained crystallines. Outcrops of grey schist as large as a mile in length are to be found within the granite. One such outcrop forms the southeastern tip of the range (N. M. Simmons, personal communication).

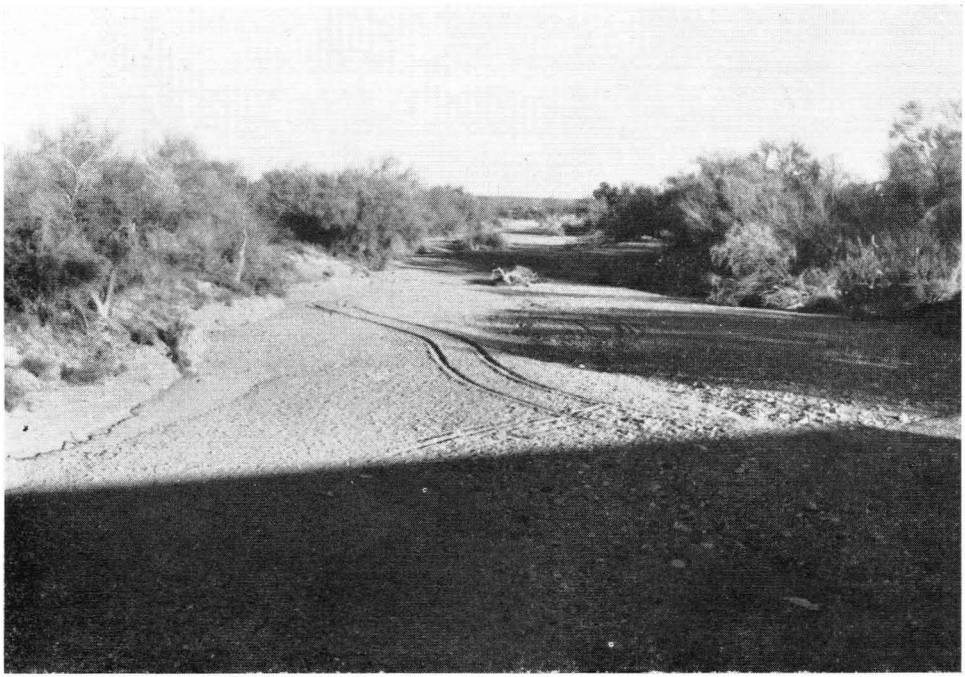

FIGURE 3. Dry stream.

FIGURE 4. Same stream.

Sierra Pinta

Just northwest of the O'Neill Hills, lies the Sierra Pinta, another northwest-trending, sierra type range about 25 miles long (Fig. 6). The range is narrow and steep, with sharp peaks rising to 2000 feet above the valleys. Narrow, V-shaped canyons separate razorback spurs along the margins, and small hanging valleys lie about 400 feet above the base.

The Sierra Pinta, composed entirely of coarse grained crystalline rock, is divided by a distinct contact between pinkish-white granite in the northern half and dark grey gneiss and schist in the southern half. Well defined stringers of granite extend into the metamorphics.

Pinacate Lava Flow

The Pinacate Mountains in northern Sonora, Mexico, consist of a great black or reddish-brown mass of lavas and volcanic cinder cones, occupying about 600 square miles. The highest peak rises to an altitude of 4235 feet above sea level.

The part of the Pinacate lava field north of the international boundary is a low mesa rising from 50 to 100 feet above the Tule Desert, about 30 square miles in area and extending to the north for about six miles. Small cinder cones and craters dot the surface.

Cabeza Prieta Mountains

The mountains from which the Cabeza Prieta Game Range takes its name lie west of the Sierra Pinta and north of the Tule Mountains. This range is a sprawling, irregular mass of about 10 by 20 miles, composed of both crystalline complex rocks and overlying lavas and sediments. This varied composition results in both sierra type ridges and peaks as well as dissected mesas and buttes. The trend of the range is generally northwest. The highest point is about 1500 feet above the plains. The name Cabeza Prieta or "Black Head" comes from a prominent, lava capped peak near the center of the range (Fig. 1).

The Cabeza Prieta basal complex is composed of gneiss, schist, and granite. Dikes containing aplite and schist cut both the granite and schist, especially in the north. At the McMillan prospect, which follows fissure zones in these dikes, chrysocolla, malachite, and limonite have been found.

Quaternary basalt is present in flows up to 1000 feet thick and caps many of the peaks. Two small buttes of basalt dip under the Lechuguilla Desert to the west of the Cabeza Prieta Mountains (Darton, 1925). A thick layer of poorly sorted volcanic breccia which has phenocrysts from one millimeter to six feet in diameter have been found in the Cabeza Prieta Tanks area. Many caves as well as the tanks themselves have been formed from the weathering out of large boulders and fragments. In some locations, layers of agglomerate and conglomerate up to a hundred or more feet in thickness underlie the volcanics.

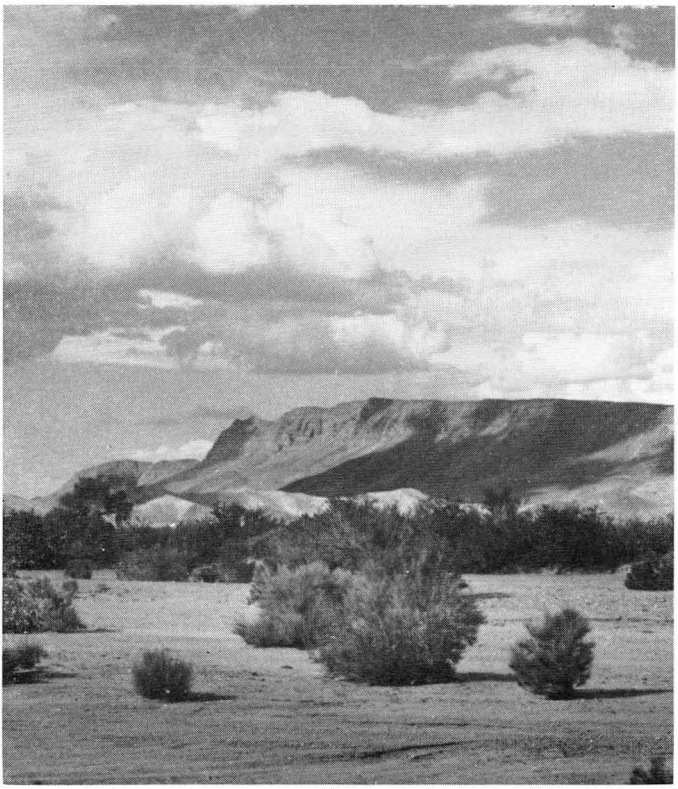

FIGURE 5. Growlers.

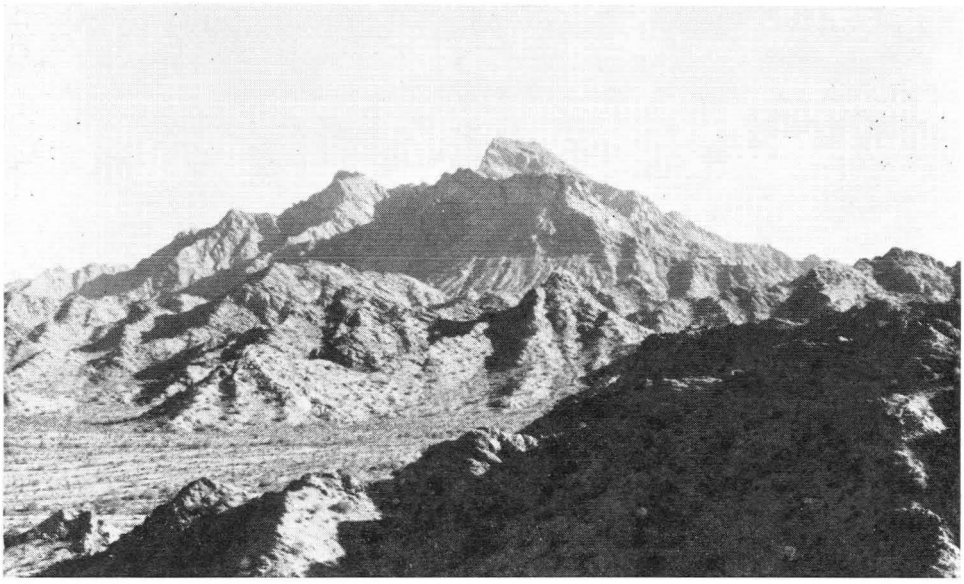

FIGURE 6. Sierra Pinta.

Tuseral Mountains

The Tuseral Mountains, south of the Cabeza Prieta Mountains, present both sierra and mesa type topography. They extend about four miles into the game range, but the larger part of the range extends into Sonora, Mexico. The ridges rise to 1200 feet above the plains in Arizona, and even higher in Mexico.

The mountains consist of schist, gneiss, and granite, intruded by dikes of aplite and pegmatite, overlain by west-dipping Quaternary basalt in the north, up to 500 feet in thickness. Conglomerates found in the north are composed of lava and arkosic fragments (Bryan, 1925). As in the Cabeza Prieta Mountains, postvolcanic faulting is evidenced.

PHYSIOGRAPHY

Mountains

Many of the mountain ranges in the area appear to have been formed by normal faulting. Clear evidence of faulting has been found in the Childs, Cabeza Prieta, and Tule Mountains, and the Davidson Hills; the west slope of the Growler Mountains (Fig. 5) is an excellent example of an uplifted fault block.

The shapes of the mountains in this area fall into two groups: sierras and mesas (Bryan, 1925). The sierra type presents a jagged appearance. Composed largely or entirely of crystalline granite and metamorphic rock, the sierra type mountains are sharply crested and serrated, maturely dissected, and usually have a high peak near the center. The mesa type mountain is composed primarily of bedded volcanics, appearing as gently inclined or relatively flat, massive blocks cut by young canyons.

The mountain slopes range from 15 to 90 degrees, while the plains slope from 1 to 6 degrees. The change from plain to mountain is usually abrupt, with no transition zone of foothill areas. Bryan cites Lawson's theory that the angle of slope of the mountain is directly controlled by the size of the joint blocks which break off. "The hard-rock slopes of desert ranges which shed large spalls are steep, while those which shed small fragments have a low angle." (Bryan, 1925.)

Minor erosional features include niches formed in coarse granite and isolated pillars or monuments, called "peñascos," formed by dissection of lava flows.

Pediments

An important feature of the Sonoran topography is the mountain pediment. This is a planed off section of bedrock at the foot of many desert mountains, sloping down to the level of the upper bajada or alluvium. Such a pediment is clearly exposed in the deeper stream channels flanking the Agua Dulce Mountains.

Valleys

The mountains are flanked by bajadas made of coalescing alluvial fans which slope into the axes of the valleys. These are formed by intermittent, fast moving streams which flow down from the mountain in radial or parallel patterns, but which sometimes have a braided or meandering pattern in the valleys. Most valleys are drained by only one main stream. The stream valleys are well integrated, with higher streams feeding into lower ones as in an area of permanent streams. Near the mountains the channels are commonly well defined, but downslope the streams divide into smaller, shallower channels or spread into large sheets. Sheet floods produce adobe flats from 30 to 40 feet wide up to several square miles in area.

Figure 2 shows the drainage patterns of the valleys within the area. Most of the valleys drain ultimately to the Gulf of California; however, there are two areas of enclosed sinks. The valley east of the Growler Mountains, Growler Valley, San Cristobal Valley, the northern Mohawk Valley, the northern Tule Desert, and the northern Lechuguilla Desert all drain northward into the Gila River, thence westward to the Colorado River and southward to the gulf. The southern part of the Lechuguilla Desert, a small plain between the Cabeza Prieta and Tuseral Mountains, and an area south of the Davidson Hills drain directly south into Mexico and thence into the gulf. The southern Tule Desert drains into two large playas or temporary lakes, Las Playas and Pinta Playa. Las Playas is a mesquite-bordered flat of mud-cracked clay about two miles in diameter which holds water for a few days after a rain. Pinta Playa is about a mile in length. A small part of the southern Mohawk Valley drains into two small sinks called Dos Playas.

The southern Tule Desert contains a large, fairly stable dune area, the Pinta Sands, which may have blown eastward up against the Sierra Pinta from the Gulf of California. Some of the sands have entered the mouths of streambeds, somewhat impeding erosion.

GEOLOGIC HISTORY

The geologic history of the area described herein is difficult to reconstruct due to the lack of fossils, and correlation between the isolated mountain ranges. Probably the earliest geologic occurrence for which clear evidence is found was the metamorphism of most of the rocks which form the gneisses and schists present in nearly all the mountain ranges of the area. These metamorphics were apparently later intruded by igneous material which is exposed as the light colored granites in most of the ranges.

Only a few small outcrops of limestone and quartzite at the southern tip of the Growler Mountains appear similar to Paleozoic deposits which are located in great thicknesses in northern Arizona and Nevada (Wilson, Moore, and O'Haire, 1960; Wilson, 1965).

A few sediments which appear to be derived from earlier granitic rocks are located in the Agua Dulce Mountains (Wilson, Moore, and O'Haire, 1960).

Following the intrusion of the metamorphics by the granitic masses, much volcanism, intrusion of dikes and veins, and faulting occurred. This activity was possibly associated with the late Mesozoic and early Cenozoic Laramide mountain-making movements (Dunbar, 1952). Perhaps at this time some of the mountains were formed by normal faulting. Volcanic activity modified and in some cases augmented their shapes. The subsequent erosion of these uplands produced alluvial deposits in the valleys and pediments flanking some of the mountains.

Probably during the Quaternary period, most of the extensive basalts were deposited over the older metamorphics, intrusives, and lavas. Great thicknesses of these younger basalts are located in the Growler and Cabeza Prieta Mountains. Remnants found in other locations indicate that perhaps a large part of the region was once covered by Quaternary basalts which have by now been eroded away (Bryan, 1925; Wilson, 1960; Wilson, Moore, and O'Haire, 1960).

The Pinacate lavas, the most spectacular and recent lavas in the area, erupted repeatedly during Quaternary times also, producing the cones, craters, mesas, and extensive flows of this large lava field found in Sonora and Arizona (Galbaith, 1959; Ives, 1964).

Erosion of the mountains has continued to the present. Concurrently, alluvial fans and bajadas of silt, sand, gravel, and conglomerate have been deposited; pediments have been cut; and stream systems have attained their present stage of integration.

ACKNOWLEDGMENTS

I am most indebted to my husband, Norman Simmons, for inspiration, encouragement, criticism, important data, and guided tours of the Cabeza Prieta Game Range. He is also responsible for the illustrations. I am grateful to the late Dr. Eldred Wilson of the Arizona Bureau of Mines for advice, references, and for reading the manuscript for correction; to Mr. Don Dixon of Phelps Dodge Corporation for information and valuable criticism of the manuscripts; and to the U. S. Fish and Wildlife Service for the use of photographs and maps and for the opportunity to tour the game range area.

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