Mesozoic Formations in the Vekol Mountains Papago Indian Reservation Arizona

By L. A. HEINDL

CONTRIBUTIONS TO STRATIGRAPHY

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By L. A. HEINDL

ABSTRACT

Mesozoic deposits in the Vekol Mountains include the following: The Phonodoree Formation consisting mostly of quartzitic rocks; the Vekol Formation consisting largely of gray-green arkoses, graywackes and pebble conglomerates, and a local basal angular conglomerate member composed mainly of volcanic material; and the Chiapuk Rhyolite, a welded ash flow. The formations are of probable late Mesozoic, possibly Cretaceous, age.

INTRODUCTION

This paper describes and defines some of the Mesozoic rocks that crop out on the Papago Indian Reservation between Tucson and Ajo, Ariz. (fig. 1). The work on which this report is based was done in cooperation with the U.S. Bureau of Indian Affairs.

The Papago Indian Reservation includes about 4,300 square miles in south-central Arizona in the Basin and Range physiographic province. The Mesozoic rocks are exposed mostly in the eastern two-thirds; the Vekol Mountains are in the north-central part of the reservation. The nearest described Mesozoic rocks, east and west of the reservation, are in the vicinity of Tucson (Brown, 1939; Kinnison, 1958) and in the vicinity of Ajo (Gilluly, 1946), about 100 miles apart. Some of the deposits in the Tucson Mountains are of probable Early and Late Cretaceous age (Kinnison, 1959) and the rocks near Ajo are of possible Cretaceous age. Similar sequences of rocks crop out on the reservation, where, however, they are only a part of a thicker and more diverse sequence.

In general, the Mesozoic sequence is defined as comprising the deposits that lie between surfaces cut on Paleozoic and older rocks and a surface underlying Tertiary rocks. Until recently, the topmost units of the Mesozoic section of this report—mostly rhyolitic rocks—were believed to span the Cretaceous-Tertiary boundary (Heindl,

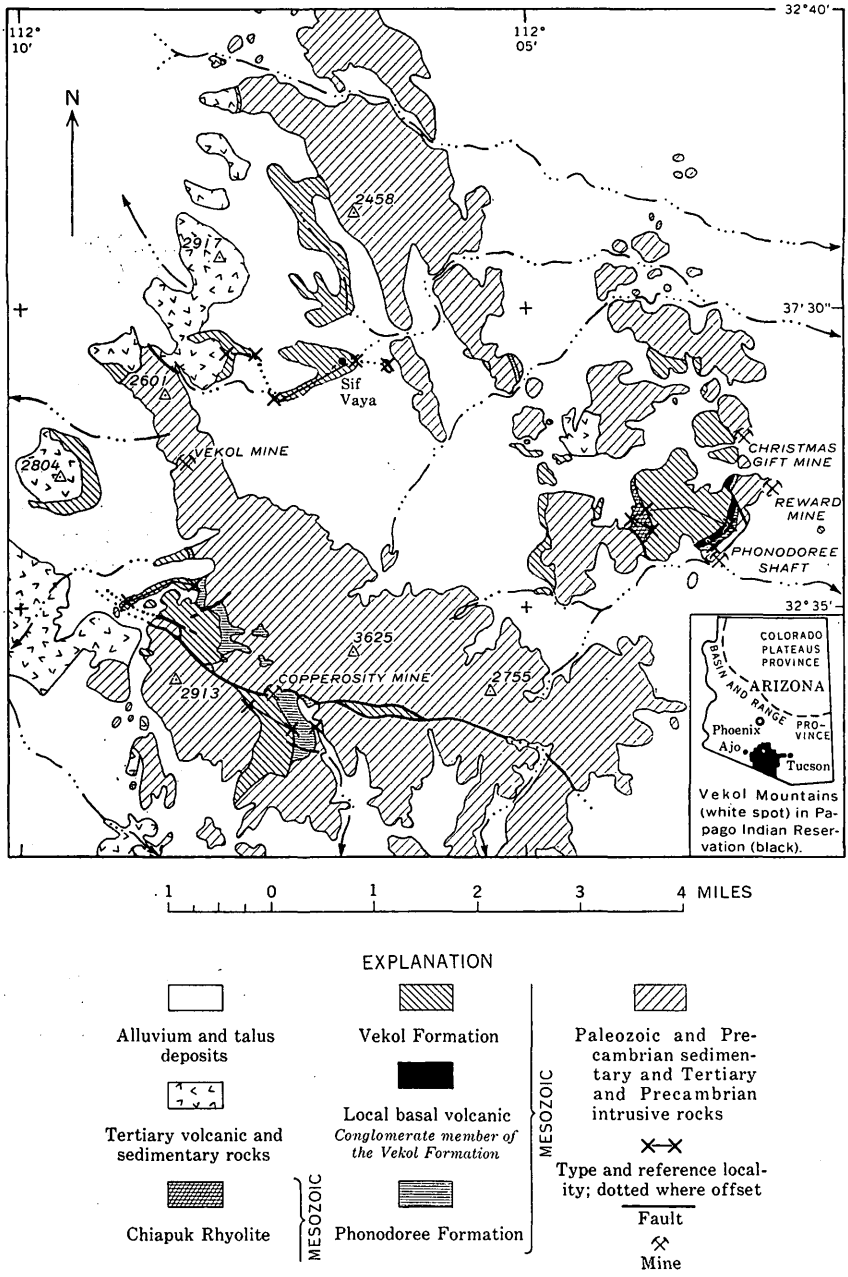

FIGURE 1.—Mesozoic formations and other rocks in the Vekol Mountains, Papago Indian Reservation, Ariz. Base from U.S. Geological Survey, Vekol Mountains, 15-minute quadrangle (1942). Geology by L. A. Heindl, 1954–56; in part after Hadley (1944) and Carpenter (1947).

1960), but recent radiometric dates indicate that these rocks are Late Cretaceous.

Generally, the Mesozoic sequences on the reservation comprise volcanic and sedimentary materials, and most of the sedimentary material is derived from volcanic rocks. In most places, the sections have been truncated and sliced by faults, intruded and altered by dikes, sills, and stocks, and locally metamorphosed. The sections vary from area to area, and deposits in one sequence may be represented by unconformities in another. Some of the Mesozoic rocks in the Vekol Mountains have been described briefly by Hadley (1944) and Carpenter (1947). Hadley's work was summarized by Denton and Haury (1946).

The Mesozoic section in the Vekol Mountains includes, in ascending order, the following: the Phonodoree Formation; the Vekol Formation, which includes a distinctive local basal volcanic conglomerate member; and the Chiapuk Rhyolite (fig. 1). The four units are separated by slight angular unconformities. The Phonodoree is a quartzitic clastic unit that is free of volcanic fragments; the local basal volcanic conglomerate member of the Vekol Formation is composed predominantly of porphyritic andesite from an unknown source; the Vekol Formation is a sedimentary unit which contains a preponderance of felsitic volcanic clasts; and the Chiapuk Rhyolite is a welded tuff. Dikes of monozonite porphyry and felsite cut all units but are not shown on figure 1.

PHONODOREE FORMATION

The Phonodoree Formation, named for the Phonodoree shaft, comprises quartzitic deposits—mostly sandstone, mudstone, and conglomerate—that crop out in widely separated patches in the Vekol Mountains. The Phonodoree is the lower red sandstone unit of Hadley (1944) in the Reward mine area and the lower part of the Cretaceous red beds of Carpenter (1947) southeast of the Copperosity mine. These two areas constitute type and reference localities. The Phonodoree Formation forms steep rubbly steplike slopes and small jagged and ribbed ridges. The mudstone beds are fissile and weather to splinters and small plates; the sandstone and conglomerate beds fracture into small blocks and pebble fragments.

The Phonodoree Formation rests with angular unconformity on the Martin Formation of Devonian age near the Phonodoree shaft, on the Escabrosa Limestone of Mississippian age 2 miles west of the shaft, and on the Horquilla Limestone of Pennsylvanian age near the Copperosity mine. Near the Reward mine, the formation is overlain nearly conformably by the basal volcanic conglomerate member of

the Vekol Formation; elsewhere, it is overlain—with small angular unconformity—by the Vekol Formation. Where the Phonodoree pinches out or has been eroded away, the younger Mesozoic units rest directly on Paleozoic rocks.

The formation consists of red, brick-red and light-brown mudstone, red feldspathic sandstone, white to gray quartzite, and white, gray, and orangish-brown pebble conglomerate. A bluish-gray basal quartzitic conglomerate, which contains smooth chert and quartzite pebbles rarely more than 1 inch long, is generally only a few inches to a few feet thick. Where it fills channels in the underlying Paleozoic rocks, however, the conglomerate is as much as 20 feet thick. The finer beds range from siltstone to sandy mudstone. The sand grains, both those in the mudstone and in the quartzite beds, are predominantly well-rounded quartz; most quartzite beds are fairly pure but a few are arkosic. The conglomerate beds contain smooth almost ellipsoidal pebbles as much as 4 inches long; most of the pebbles are chert and quartzite, but some are limestone. Some of the limestone pebbles contain Paleozoic fossil fragments. Conglomerate beds above the basal conglomerate differ in color and have a higher proportion of pebbles to matrix. All beds are siliceous but the amount of cement differs; some conglomerate beds fracture across pebbles. The coarse beds commonly grade upward into the finer materials, and the finer beds are separated from overlying coarser deposits by well-defined bedding planes. Individual beds range from about 2 to 10 feet thick.

Near the Phonodoree shaft, the formation is about 150 feet thick and consists mainly of quartzitic conglomerate, quartzite, and feldspathic quartzite; the basal conglomerate is thin or absent. Southeast of the Copperosity mine, the formation is as much as 300 feet thick and consists mostly of siliceous mudstone. The quartzite and conglomerate beds, although a minor part of the section, are the most conspicuous because they weather into rugged ribs or ledges. The Phonodoree thins northward from the Copperosity mine towards the Vekol mine. About a mile south of the Vekol mine, the formation is only about 50 feet thick; 1½ miles north of the mine, it is preserved mostly in channels cut into Paleozoic rocks; and nearly 4 miles north of the mine, it is absent.

The Phonodoree Formation probably represents deposition on a flood plain. The excellent rounding of the grains and pebbles and the lack of silt and clay in the sandy beds suggest a near-shore environment. If the deposits are marine, they may represent westward extensions of either Lower or Late Cretaceous seas—the only post-Paleozoic marine encroachments known in this part of southern Arizona. (See Ferguson, 1959.) The siliceous red mudstone beds

are superficially similar to the much thicker Recreation Red Beds of Brown (1939) in the Tucson Mountains, and the general sequence and type of material are similar to those of the basal part of deposits of probable Late Cretaceous age in southeastern Arizona; however, no age designation or correlation is implied by such comparisons. The Phonodoree Formation is definitely younger than Paleozoic and older than Tertiary, and for the time being its age can only be given certainly as Mesozoic. The formation is probably late Mesozoic because of the general absence of Triassic and Jurassic sedimentary rocks in southern Arizona and as suggested by the lithologic comparisons just mentioned. Probably, the Cretaceous age suggested by Hadley (1944) and Carpenter (1947) will some day be proved.

VEKOL FORMATION

A thick series of gray-green sedimentary rocks is here named the Vekol Formation for its widespread exposures in the Vekol Mountains. The best exposures are immediately west of the Reward mine and 1 to 2 miles south of the Vekol mine. (See fig. 1.) The Vekol Formation generally is weakly resistant to weathering, and for the most part it crops out in low hillocks and in walls of arroyos; however, beds of cobble to boulder conglomerate in the lower part of the formation form conspicuous ridges north of the Phonodoree shaft and southeast of the Copperosity mine.

The Vekol Formation overlaps the Phonodoree and lies unconformably on older rocks. West of the Reward Mine, the Vekol is overlain unconformably by the Chiapuk Rhyolite, but elsewhere the Vekol is exposed below a cover of Tertiary volcanic rocks and Tertiary and Quaternary alluvium. The basal beds of the Vekol Formation contain large water-worn fragments of materials similar to those of the underlying Phonodoree and of andesitic rocks from undefined sources. Similar pre-Tertiary andesitic rocks are exposed in the Brownell, Quijotoa, and North and South Comobabi Mountains, but these mountains are 30 or more miles to the south, and the large fragments suggest a closer source at the time of deposition. Whatever the source, these cobbles and boulders indicate an interval of uplift, vulcanism, and erosion between the deposition of the Phonodoree Formation and the Vekol Formation.

The variety of rock types and the abruptness of lateral and vertical changes are characteristic of the Vekol, and both type and reference localities are given in this report. The formation includes thin to thick lenses of conglomerate, gray-green pebbly arkose and graywacke, and green and maroon mudstone, and beds of quartzite, arkosic quartzite, or aphanitic claystone. The unit is moderately to well in-

durated, and some beds are strongly cemented by calcium carbonate or by silica. The degree and type of cementation seem to reflect the nature of the predominant rock fragments. Sandy and coarser grained beds range from about 6 inches to 25 feet in thickness, and the mudstone may be in units several tens of feet thick made up of numerous very thin beds or lamellae. In most places, the basal beds of the Vekol contain well-rounded fragments of feldspathic quartzite or quartzitic sandstone and red mudstone similar to the rocks of the Phonodoree.

The Vekol Formation includes a local basal member which is exposed within a radius of about a mile of the Reward mine. This basal member is a 50- to 200-foot unit of purplish-green volcanic conglomerate; it is the "volcanic breccia" of Hadley (1944, pl. 2). The lithologic characteristics of the local basal member are similar to those of the Silver Bell Formation of Courtright (1958) and also to those of some beds near the top of the Vekol Formation. Most fragments in the local basal member are dark purplish-gray porphyritic andesite, but they are also of granite porphyry, schist, Precambrian and Paleozoic quartzites, and Paleozoic limestones. The unit also contains large fragments of quartzite, feldspathic sandstone, and mudstone similar to the rocks of the immediately underlying Phonodoree Formation. Pebbles and cobbles are subrounded to well-rounded and are set in a matrix composed mostly of angular to subangular sand and granules. Between the Reward mine and the Phonodoree shaft, the unit is locally garnetized.

The Vekol Formation west of the Reward mine constitutes the type locality. Here the lowest part of the formation consists of alternating beds of conglomerate and mudstone (fig. 1). The conglomerate beds are as much as 25 feet thick, are well indurated, and contain mostly quartzite and quartz and a few limestone fragments. The intercalated mudstone beds weather grayish green, but are nearly white on fresh surfaces; they are from about 1 to 3 feet thick and are so dense and fine-grained as to be almost cherty. This sequence is about 300 feet thick and grades upward through a transition zone into the main part of the formation. In this area it is a series of poorly- to well-bedded gray to green pebbly arkose and graywacke characterized by felsitic and andesitic fragments. A thin flow of andesite is near the top of this gray-green sequence. The gray-green beds grade upward into purplish-gray volcanic conglomerate, similar in appearance to the local basal volcanic conglomerate, and the purplish-gray conglomerate is overlain by the Chiapuk Rhyolite.

At a reference locality southeast of the Copperosity mine, the Vekol Formation is a conglomerate made up almost entirely of deeply

weathered, intensely sheared pebbles and cobbles. The clasts are mostly quartzite and sandstone and to a lesser extent limestone, granite, and latitic to andesitic rocks. A few boulders are composed of limestone cobble conglomerate, made up of cobbles of limestone conglomerate, indicating that the Vekol Formation is separated from the deposition of Paleozoic rocks by at least two generations of uplift and erosion. The Vekol in this area is about 1,000 feet thick. The sheared pebbles and cobbles reflect stresses in the adjoining zone of north-northwest strike-slip movement. Sandstone and quartzite cobbles are usually sliced into ½- to 2-inch rounds which are offset en echelon, but the volcanic and granitic fragments seem to be stretched rather than sliced. Locally, phenocrysts in volcanic cobbles seem to have been realined roughly parallel to the direction of stress.

Between the Copperosity and Vekol mines, in a second reference locality, the Vekol Formation is predominantly limestone conglomerate. In this vicinity, the limestone pebbles weather out of the limy matrix and roll freely underfoot, particularly on moderate slopes. The third reference locality is in the vicinity of the village of Sif Vaya. East of the village, the Vekol is a series of pebble conglomerate beds that overlie the Phonodoree and older rocks; the conglomerates grade upward (westward) into a thick sequence of maroon mudstone and sandy mudstone beds. West of Sif Vaya, the sequence is partly covered by alluvium, but the maroon beds are seemingly covered by greenish-gray volcanic conglomerate and angular conglomerate beds.

Except for the section southeast of the Copperosity mine, the thickness of the Vekol is between 2,000 and 3,000 feet.

These four sections are broadly similar, but they do not match in detail. The differences may be partly due to faulting, but this explanation is not entirely satisfactory because the broad sequences of rock types are not repeated. A more plausible explanation is that the sediments of each section were deposited in separate valleys or in separate fans from different source areas. Also, the individual sections may include unrecognized unconformities, and they may be less similar than they seem. Certainly, the changes through the section of the size, angularity, and composition of the fragments of latite, dacite, and andesite suggest a succession of volcanic eruptions and intervals of uplift. Furthermore, the general alternation of channeled lenses of conglomerate and beds of mudstone suggests deposition under continental conditions. These conjugate lines of evidence indicate that the Vekol Formation was derived from source areas that were undergoing uplift and vulcanism and that the Vekol was laid down in several adjacent valleys or in otherwise locally distinct environments.

The maroon mudstone, like the red beds of the Phonodoree, is superficially similar to the Recreation Red Beds of Brown (1939) and other sequences of fine-grained red deposits of Cretaceous age in southeastern Arizona. The gray-green and purplish-gray volcanic conglomerate beds are similar to, and in the same stratigraphic sequences as, the Claflin Ranch and Silver Bell Formations of Richard and Courtright (1960). No actual correlations, however, are implied.

The only fossils reported from the Mesozoic deposits in the Vekol Mountains were fragments of a log found by R. T. Webb of the Bureau of Land Management Mineral Survey. These fragments were identified as *Cupressinoxylon*, resembling modern members of the cypress family, by R. A. Scott (written commun., June 14, 1960), who reports: "Since wood of this type is known from Jurassic time onward, this specimen is not definitive in resolving the * * * age problem."

CHIAPUK RHYOLITE

The Chiapuk Rhyolite, named for the nearby village of Chiapuk, is a welded ash flow that crops out about 2 miles west of the Reward mine. The southern part of this area of exposure is the type locality. Where the basal contact is exposed, the welded tuff seems to lie conformably on the Vekol; however, over a longer reach, the contact cuts obliquely across the strike of the Vekol, and the Chiapuk is probably separated from the Vekol by an erosional surface of low relief. The top of the unit either is cut off by faults which abut the tuff against the Escabrosa Limestone or is covered by alluvium.

The Chiapuk Rhyolite includes welded tuff and tuff-agglomerate, which are probably textural variants of the same ash flow. The tuff is a dense to porous creamy to grayish-pink rock whose groundmass contains many angular fragments of dense pink porphyritic rhyolite and a gray porous pumice. The fragments may be as much as 8 inches long. The groundmass is generally cryptocrystalline and shows banding suggestive of plastic flow, particularly around the pink rhyolite fragments; commonly the groundmass contains small fragments of the rhyolite and pumice and of broken feldspar crystals. The truncated section of welded tuff is about 200 feet thick and is much thinner than similar sections of rhyolitic ash flows and associated rocks elsewhere on the reservation.

The Chiapuk Rhyolite is similar lithologically, stratigraphically, and structurally to the Cat Mountain Rhyolite of Brown (1939) in the Tucson Mountains and to rhyolitic deposits in several intervening areas. The Chiapuk is also cut by dikes of monzonite porphyry, which are analogous to some of the quartz monzonite dikes that cut the Cat Mountain. Rocks similar to the Cat Mountain also crop

out in the Silver Bell Mountains (Richard and Courtright, 1960), about half way between the Tucson and Vekol Mountains, and in the Roskruge Mountains, about 25 miles west of the Tucsons. The two units probably correlate with each other, but the evidence is still insufficient to conclude that they are actually one formation. The Cat Mountain Rhyolite has been dated at 70.3±2.2 million years and some of the rhyolite deposits at Bell Mountain, south of the Roskruges, at 74.1±2.2 million years (Damon, 1963, p. 8). The Chiapuk Rhyolite is sufficiently similar to these deposits to be considered contemporaneous and, like them, is probably also of Late Cretaceous age.

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