Geologic Map of the Wickenburg, southern Buckhorn, and northwestern Hieroglyphic Mountains, central Arizona

by
James A. Stimac, Joan E. Fryxell, Stephen J. Reynolds,
Stephen M. Richard, Michael J. Grubenskv, and Elizabeth A. Scott

Arizona Geological Survey
Open-File Report 87-9

October, 1987

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

INTRODUCTION

This report describes the geology of the Red Picacho quadrangle and parts of the Wickenburg, Garfias Mountain, and Wittmann quadrangles (Fig. 1). Geologic mapping was completed between January and April of 1987, and was jointly funded by the U.S. Geological Survey and the Arizona Bureau of Geology and Mineral Technology as part of the cost-sharing COGEOMAP program. Mapping was done on 1:24,000-scale topographic maps and on 1:24,000-scale color aerial photographs provided by Raymond A. Brady of the U.S. Bureau of Land Management.

GEOLOGIC OVERVIEW

The map area includes the Wickenburg Mountains and contiguous parts of the Buckhorn and Hieroglyphic Mountains (Fig. 1). Adjacent parts of the Vulture Mountains were mapped by Grubensky and others (1987) and adjacent parts of the Hieroglyphic Mountains were mapped by Capps and others (1986). The overall geologic history of the area is complex, but the regional stratigraphy developed in these reports carries well from range to range.

The map area is composed of a metamorphic-plutonic basement unconformably overlain by Tertiary volcanic and sedimentary rocks. The oldest rocks, assigned to the Proterozoic (1.8-1.7 b.y.) Yavapai Supergroup, consist of amphibolite, schist, and gneiss, intruded by granite, leucogranite, and pegmatite. Protoliths for the amphibolite, schist, and gneiss include both volcanic and sedimentary rocks.

Proterozoic rocks are intruded by Late Cretaceous granodiorite, granite, pegmatite, and aplite. Basement rocks are cut by numerous felsic and mafic dikes and sills related to Tertiary volcanism. In places, these dikes account for more than half of the outcrop area.

Crystalline basement rocks are unconformably overlain by Tertiary clastic sedimentary and volcanic rocks. Basal Tertiary deposits usually include a sequence of conglomerate, arkosic sandstone, and thin tuffs. The sedimentary rocks probably represent stream deposits formed shortly before and during early volcanism. Locally, deposition of clastic sedimentary rocks composed almost exclusively of basement lithologies persisted throughout early volcanism, which indicates topographic relief on basement rocks.

Tertiary volcanic and sedimentary rocks of the area can be divided into several temporal-compositional packages of regional extent. Volcanism was strongly bimodal throughout its duration, with basaltic and rhyolitic to dacitic lava flows and related tuffs accounting for at least 90 percent of the eruptive volume of the system. Extensive ash flow tuffs are conspicuously absent in the map area, as they are in the Big Horn Mountains (Capps and others, 1985), northeastern Hieroglyphic Mountains (Capps and others, 1986), and northeastern Vulture Mountains (Grubensky and others, 1987). Rare andesite flows occur interbedded with basaltic sequences.

Early volcanism was dominated by basalt flows, but rhyolitic flows and related tuffs are locally present. Early basalts are overlain by the San

Domingo volcanics, a sequence of phenocryst-poor rhyolite flows and related lithic tuffs. This package is in turn overlain by the Hells Gate volcanics, a thick sequence of porphyritic dacite and rhyodacite flows and related tuffs. The volcanic section is cut by numerous silicic and mafic dikes that served as feeders to the extrusive rocks. Dikes are more abundant in the early erupted basalt and rhyolite flows and tuffs than in the overlying dacite flows and tuffs.

The uppermost dacite flows in the Hells Gate volcanics are interbedded with and overlain by debris flows with clasts derived mainly from the dacite. Many, if not all, of the early debris flows are eruption related. Later debris flows tend to be heterolithologic, and probably formed in response to fault-related tilting and seismic activity.

Debris flows overlying the dacite package are interbedded with olivine-bearing basalts, megabreccia blocks of lower stratigraphic units, and immature fluvial clastic rocks. This complex package is synvolcanic, but grades upward into conglomerate and sandstone typical of post-volcanic sedimentary sequences in nearby ranges. The entire package was deposited in irregular-shaped half grabens that formed during the main episode of extensional faulting.

Structure

Volcanism was accompanied and followed by low- to moderate-angle normal faulting produced by northeast-southwest-oriented regional crustal extension. Major north- to northwest-trending moderate-angle faults, which dip 30 to 50 degrees to the southwest, cut and tilt Tertiary rocks and crystalline basement rocks, producing domino-style repetition of section. The largest of these faults have displacements of several kilometers and produce north to northwest-trending ridges that are usually capped by resistant rhyolite and dacite flows. They cut another set of low-angle faults that dip 5 to 15 degrees to the southwest, and that are common to the eastern Hieroglyphic, Wickenburg, and Vulture Mountains. Northeast- to east-trending complex fault zones probably functioned as boundaries for domains of differential extension and tilting during displacement on both moderate- and low-angle fault sets.

The low-angle faults have fairly irregular surfaces, probably in part due to original corrugations in the faults. They are interpreted as normal faults because they commonly carry tilted Tertiary rocks in their hanging walls, and, where they juxtapose pre-Tertiary crystalline rocks, the intrusive margin of the Cretaceous granite is progressively displaced westward (see cross section B-B').

The change from northwest-striking to north-northeast-striking ridges in the west central Wickenburg quadrangle probably formed as the result of drag on a major low-angle structure that separates basement lithologies from the overlying, steeply tilted Tertiary section. This fault probably has on the order of 5 km of displacement (see cross section C-C').

Evidence that faulting occurred during volcanism includes (1) generally steeper dips on the early volcanic section than on stratigraphically higher units, and (2) fault zones intruded by Tertiary dikes and sills, with local brecciation of dike rocks due to subsequent movement on those faults.

Pre-Tertiary structures in the map area include isoclinal folds within the foliation of the Proterozoic rocks and megascopic open to tight folds that fold the Proterozoic foliation. The foliation-related isoclinal folds are certainly Proterozoic in age, and the megascopic folds are probably also of Proterozoic age.

Mineralization

Precious- and base-metal prospects occur in both the Tertiary volcanic and sedimentary rocks and the crystalline basement. Many of the prospects are localized along low- to moderate-angle faults characterized by intense brecciation and quartz, calcite, and iron-oxide veining. Such mineralization is middle Tertiary in age. Placer gold occurrences are common in several major drainages and their tributaries. The most productive deposits are in the San Domingo, Little San Domingo, and Ox Wash areas. Proterozoic metachert and metacarbonate lenses, interpreted as exhalites, are also potential prospecting targets for gold. Proterozoic Li-bearing pegmatites occur in the upper San Domingo Wash area.

QUATERNARY AND UPPER TERTIARY UNITS

Qs: Younger alluvium
Unconsolidated sand and gravel in modern channels or on adjacent low-lying terraces to these channels.

Qso: Mid-Level alluvium
Unconsolidated gravel-poor sand and sandy gravel deposits in flood plains elevated 0.5 to 2 m above modern channels. Deposits typically host mature mesquite trees.

QTs: Older alluvium
Unconsolidated to semi-consolidated and caliche-cemented sand and gravel deposits that commonly underlie dissected terraces elevated 2 m or more above modern drainages. The deposits are being incised by the present drainages and host palo verde trees, saguaro, and other cacti.

MIDDLE TERTIARY VOLCANIC AND SEDIMENTARY ROCKS

Tertiary rocks of the area overlie crystalline basement and consist of clastic sedimentary rocks, volcanic rocks, debris flows, and fanglomerate and related megabreccia. The volcanic rocks probably range in age from latest Oligocene to early Miocene. The youngest Tertiary rocks are fanglomerates and related megabreccia that accumulated during extensional faulting. Fanglomerate grades downward into a complex sequence of synvolcanic debris flows, megabreccia, clastic sedimentary rocks, thin tuffs, and olivine-bearing basalts. These units are underlain by a series of dacitic to rhyodacitic flows and tuffs, correlative with the Hells Gate volcanics of the northeastern Hieroglyphic Mountains (Ward, 1977; Capps and others, 1986). The Hells Gate volcanics also make up most of the Buckhorn Mountains in the adjacent Garfias Mountain and Copperopolis quadrangles. The Hells Gate volcanics are underlain by the San Domingo volcanics, a series of rhyolite flows and related tuffs.

The San Domingo volcanics are interbedded with, and underlain by a series of basalt flows and conglomeratic to arkosic sandstone lenses. The average thickness of the volcanic pile is roughly 1-2 km.

The volcanic stratigraphy has been subdivided into the following informal units (from youngest to oldest):

1) debris flows, deposited during and after the Hells Gate volcanics;

2) upper basalt flows, deposited during and after the Hells Gate volcanics;

3) upper tuffs, deposited after the Hells Gate volcanics;

4) Hells Gate volcanics, composed of dacite and rhyodacite flows, tuffs, and debris flows;

5) San Domingo volcanics, composed of rhyolite flows and tuffs;

6) lower basalt, basaltic andesite, and andesite flows; and

7) clastic sedimentary rocks, deposited prior to, during, and after volcanism.

A general stratigraphic section is shown in Figure 2. More detailed stratigraphic sections of the San Domingo Peak area and the Red Picacho area are shown in Figures 3 and 4, respectively.

Tf: Fanglomerate

Brown- to buff-colored consolidated to semi-consolidated conglomerate, sandstone, and siltstone with a discontinuous thin cover of QTs. Fanglomerate grades downward into tilted sheet-flood deposits and debris flows with interbedded basalts and thin upper tuffs.

Fanglomerate usually forms low hills with little or no outcrop, but steep cliffs 5 to 20 m occur along major washes in the Wickenburg quadrangle. The deposits are flat lying to moderately tilted.

Tbx: Megabreccia and sedimentary breccia; protolith of breccia indicated in parentheses where known

Shattered landslide blocks (megabreccia derived from various older rock units). Megabreccia blocks are locally associated with debris flows and fanglomerate.

Tut: Upper tuffs

Purplish-brown to lavender poorly to moderately welded lithic-rich ash flow tuffs. Phenocrysts includes 5 to 15 percent biotite and hornblende (1-4 mm) and 1 to 5 percent plagioclase (1-4 mm). The tuffs contain 25 to 40 percent lithic fragments, mainly consisting of Hells Gate volcanics and upper basalt. They reach maximum thicknesses of 10-20 m in the upper San Domingo Wash area, forming moderately steep ledges and slopes. The tuffs are interbedded with upper basalts and debris flows.

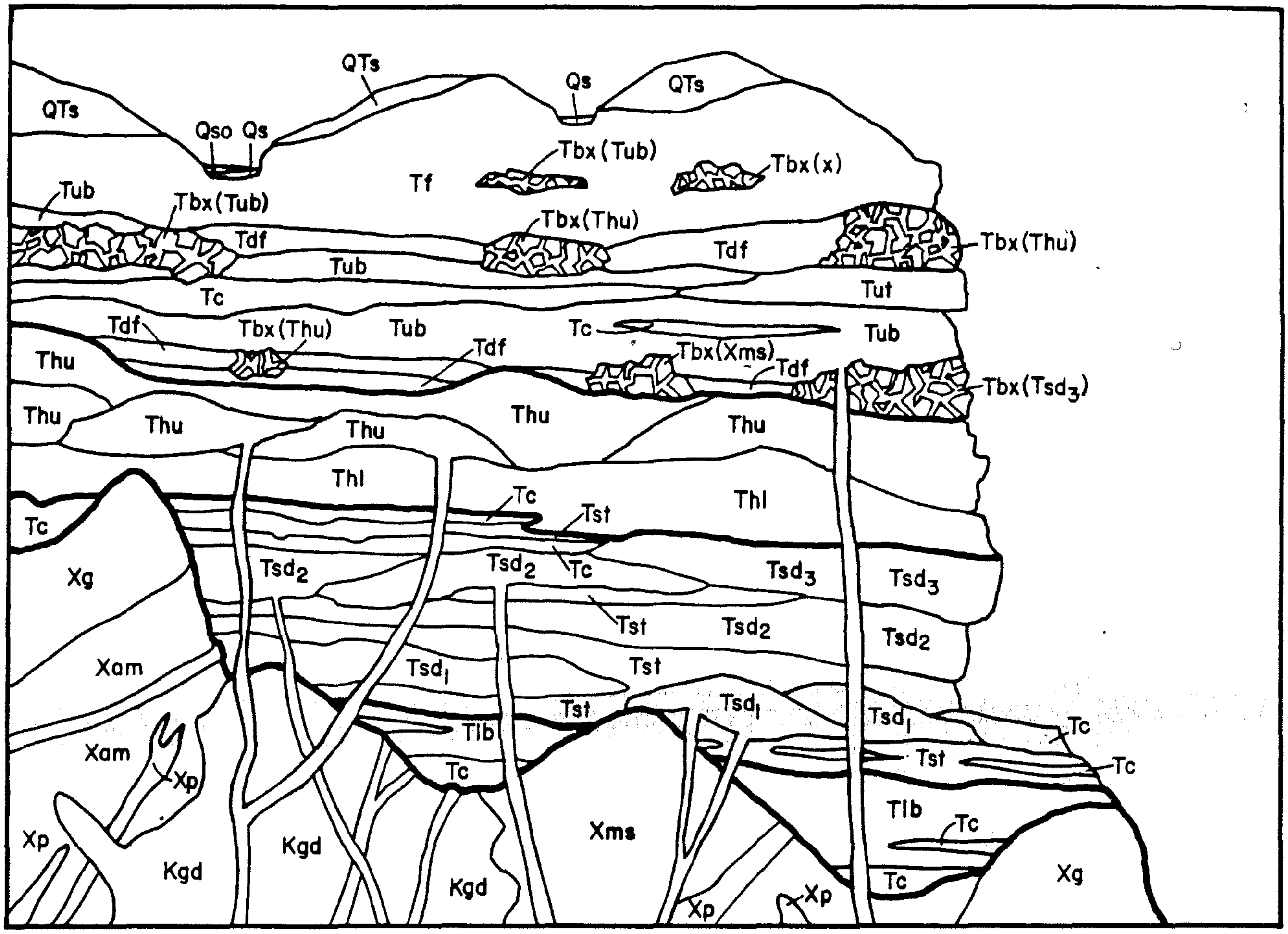

Figure 2. General schematic stratigraphic section for the Wickenburg, southern Buckhorn, and northwestern Hieroglyphic Mountains.

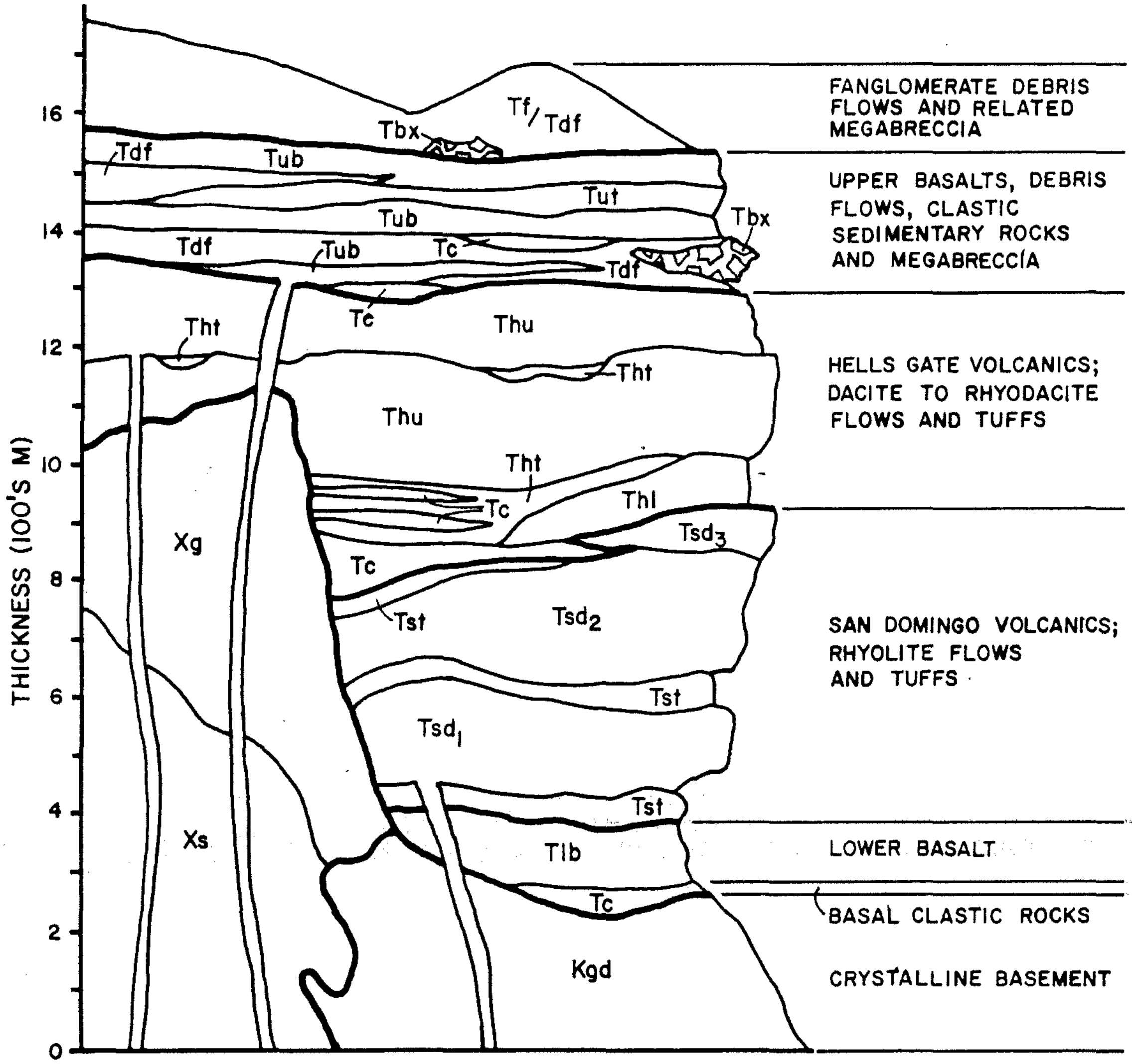

Figure 3. Schematic stratigraphic section for the San Domingo Peak area.

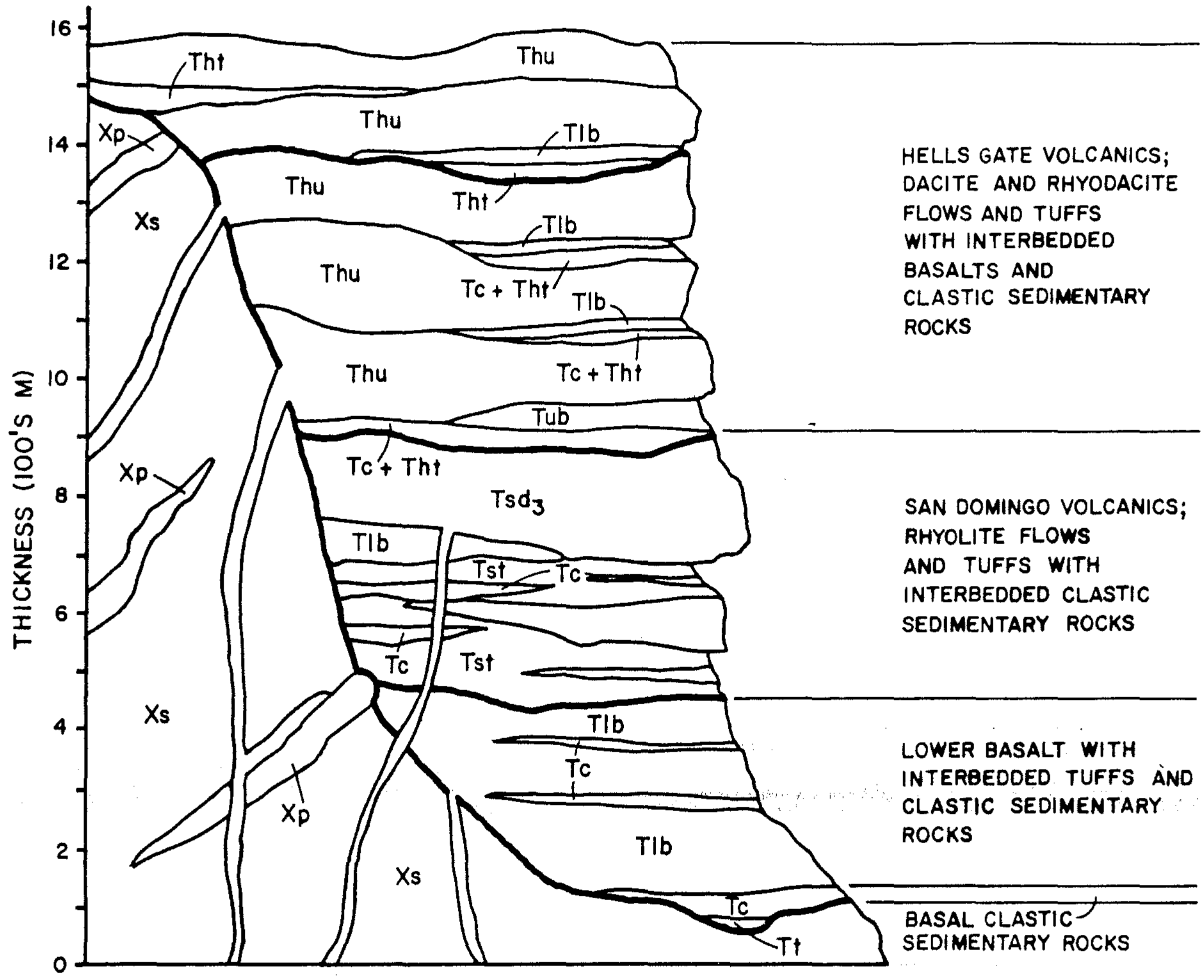

Figure 4. Schematic stratigraphic section for the Red Picacho and White Picacho area.

Tub: Upper basalts

Black to gray basalt flows. These flows contain up to 25 percent phenocrysts including 5 to 20 percent olivine (1-6 mm), trace to 10 percent clinopyroxene (1-8 mm), trace to 10 percent plagioclase (2-6 mm), and 1 to 5 percent opaque oxide minerals (1-5 mm).

Individual flows are usually thin (2-5 m) with well-developed agglomerate horizons at flow contacts. They are stratigraphically equivalent with the upper aphyric basalts in the Bighorn Mountains, dated at 16.1 Ma (Capps and others, 1985) and upper basalts in the northeastern Hieroglyphics, dated at 16.2 Ma (Capps and others, 1986).

Tdf: Debris flows and avalanche deposits

Tan, pinkish, and white massively bedded, unsorted, matrix-supported debris flow and avalanche deposits. They contain clasts of volcanic and crystalline basement rocks, but are usually dominated by a specific lithology, especially Hells Gate dacites and upper olivine-bearing basalts.

The debris flows are interbedded with upper basalts and clastic sedimentary rocks. They form low hills with sporadic outcrop. Good exposures occur along washes and in roadcuts. Individual flows rarely exceed 20 m, but very thick debris flow sequences occur in the Buckhorn, northern Hieroglyphic, and northeastern Wickenburg Mountains. The debris flow sequence grades upward into less consolidated, finer-grained conglomerate, sandstone, and siltstone.

In the San Domingo Peak area, debris flows composed mainly of fragments of Hells Gate dacite are interbedded with megabreccias of first-erupted Hells Gate dacite and older lithologies. These megabreccias show internal shattering and are interpreted as landslide-avalanche deposits related to tilting during faulting.

In the southern Buckhorn Mountains, large (up to several hundred meters) blocks of dacite flow rock is surrounded by massive, unsorted matrix. Blocks do not show internal shattering characteristic of megabreccias associated with faulting and are interpreted either as interbedded dacite flows or rockslide-avalanche deposits intimately associated with eruptions of dacite lavas.

Th: Hells Gate volcanics

Pink, gray, purple-gray, and reddish-brown phenocryst-rich dacite and rhyodacite flows and related tuffs and debris flows. The unit name is carried over from mapping by Capps and others (1986) in the northeastern Hieroglyphic Mountains. The unit has yielded dates of 17.98 Ma in the northern Buckhorn Mountains (Shafiqullah and others, 1980) and 17.4 and 16.1 Ma in the northeastern Hieroglyphic Mountains (Capps and others, 1986; Kortemeier and others, 1986). The Hells Gate volcanics are divided into two informal members based on phenocryst size and abundance. The lower Hells Gate flows are finer grained and less phenocryst-rich than the upper Hells Gate flows.

Thl: Lower Hells Gate flows

Pink, orangish-brown, and reddish-brown porphyritic rhyodacite flows. Phenocrysts include 5 to 10 percent plagioclase (1-3 mm), 10 to 15 percent hornblende (1-2 mm), less than 5 percent biotite (1-3 mm), trace clinopyroxene (1-2 mm), and less than 2 percent opaque oxide minerals (0.5-1 mm).

Hornblende and biotite phenocrysts are strongly oriented along flow foliation.

These flows appear to be transitional in mineralogy between the rhyolites of the San Domingo volcanics and the upper Hells Gate dacites. They mark the first major appearance of hornblende and biotite (greater than 2 percent), and signal an increase in both the crystallinity and size of phenocrysts in the eruptive sequence.

Thu: Upper Hells Gate dacite and rhyodacite flows

These flows contain from 20 to 45 percent phenocrysts with younger flows generally being most phenocryst rich. Phenocryst assemblages usually include 10 to 20 percent plagioclase (2 mm-1.5 cm), 5 to 15 percent biotite and hornblende (2-8 mm), trace to 3 percent clinopyroxene (1- 3 mm and in cumulophyric clumps with plagioclase), 1 to 3 percent opaque oxide minerals (1-3 mm), and trace to 2 percent quartz (2-5 mm). Quenched mafic inclusions are common in the early dacites, especially in the Red Picacho area.

Tht: Hells Gate tuffs

White, pinkish, and buff-colored lithic-rich tuffs. Phenocrysts include 10 to 25 percent feldspar and 10 to 20 percent biotite and hornblende. Lithic fragments are mainly of Hells Gate flows and olivine-bearing basalts. Most of the tuffs are thin, but thicknesses up to 40 m occur in a paleovalley at the extreme northwestern corner of the Garfias Mountain quadrangle.

The Hells Gate volcanics form major ridges and cliffs in the Red and White Picacho area, and throughout the Buckhorn Mountains. The average thickness of the unit is approximately 200 to 500 m.

Tsd: San Domingo volcanics

Brown, purplish-brown, reddish-brown, pink, and gray aphyric and phenocryst-poor rhyolite flows. These flows are characterized by flow brecciated bases with very poorly preserved vitrophyre, and flow-banded bodies that grade upward into lithophysae-rich tops. The flow rhyolites form prominent ridges and cliffs throughout the map area. The total thickness of the package averages several hundred meters.

The San Domingo volcanics are stratigraphically equivalent to the Morgan City rhyolite of Capps and others (1986). Rhyolite flows and tuffs are mainly aphyric or crystal poor. Most of the flows in this package are K-metasomatized and are unsuitable for either chemical analysis or K-Ar age dating.

San Domingo volcanics are composed of many coalescing flows and domes, with pyroclastic aprons. At least three informal members can be distinguished locally based on mineralogy:

Tsd_1: Aphyric rhyolite flows.

Tsd_2: Phenocryst-poor rhyolite flows with 5 to 10 percent feldspar (dominantly sanidine 1-4 mm in length) and trace to 2 percent biotite and hornblende (1-3 mm) phenocrysts.

Tsd_3: Quartz-bearing rhyolite flows with 5 to 15 percent feldspar (dominantly sanidine 1-4 mm in length) and 5-10 percent quartz (1-3 mm).

These flows form major ridges and cap hills east of Trilby Wash. They reach maximum thicknesses of 50 to 150 m in the Red Picacho area, and are present locally as far west as the San Domingo Peak area.

Tst: Lithic tuffs and related sedimentary rocks

White, pink, and buff-colored aphyric to phenocryst-poor lithic ash-flow, surge, and air fall tuffs, and clastic sedimentary rocks derived mainly from volcanic rocks. The tuffs occur in packages and separate individual flow rhyolites. They form poor outcrops compared to the rhyolite flows, making up moderate to steep slopes generally covered by talus of the overlying rhyolite flows. The tuff sequence reaches thicknesses of 40 to 100 m in the San Domingo Peak and upper Trilby Wash areas and includes at least two moderately welded lithic-rich ash flow tuffs. These tuffs form prominent 3 to 10 m ledges in the San Domingo Peak area. One of these tuffs also forms 5 to 15 m ledges underlying Tsd_3 in the upper Trilby Wash area.

Tlb: Lower basalt, basaltic andesite, and andesite flows

Black, gray, brown, and reddish-brown vesicular to massive basaltic to andesitic flows and agglomerate. The phenocryst assemblage and thin, tabular nature of these flows indicate that the vast majority are basaltic in composition, but, rare basaltic andesite and andesite flows are also present. In the map area, the lower basalt sequence reaches a maximum thickness of 200-400 m in the upper Trilby Wash area, near the Maricopa-Yavapai County line.

The mafic flows contain 5 to 30 percent phenocrysts, including 2 to 10 percent olivine (1-4 mm), 2 to 20 percent clinopyroxene (1-6 mm), 2 to 10 percent plagioclase (1-8 mm), and 1 to 5 percent opaque oxide minerals (1-4 mm). Rare flows contain up to 20 percent orthopyroxene megacrysts (5-15 mm).

The mafic flows are interbedded with the first erupted rhyolitic flows and tuffs of the San Domingo volcanics and with clastic sedimentary rocks composed mainly of clasts of basement lithologies. The basalts form slopes with sporadic outcrop and are commonly covered by talus of more resistant overlying rhyolite flows.

The basaltic sequence appears to be part of a regional episode of dominantly basaltic volcanism that preceded and overlapped with silicic volcanism. It is stratigraphically equivalent to the Deadhorse Wash basalt of the Big Horn Mountains and undifferentiated lower basalts of the Hieroglyphic Mountains. The age of this sequence remains poorly constrained, but it is older than 21 Ma in the Big Horn Mountains (Capps and others, 1985), and older than 18.7 Ma in the Hieroglyphic Mountains (Kortemeier and others, 1986).

Ta: Andesite flow

Gray biotite- and hornblende-bearing flow foliated andesite. This distinctive flow occurs in the Red Picacho area, where it reaches a maximum thickness of 30 to 40 m.

Tc: Clastic sedimentary rocks

Reddish-brown, brown, tan, greenish-gray, and white conglomerate, coarse sandstone, and sandstone. Clasts are mainly of Proterozoic and Cretaceous rocks, but clasts of volcanic units are locally abundant, especially in lenses interbedded with the volcanic section. These deposits unconformably overlie basement rocks and occur interbedded with and overlying the volcanic section. They form moderately resistant ledges and steep slopes. The thickest deposits (20-50 m) occur in the lower Trilby Wash area. Basal deposits rarely exceed 15 m, but clastic lenses from 1 to 10 m occur intercalated with lower basalts, San Domingo volcanics, and debris flows and upper basalts throughout much of the Red Picacho quadrangle.

TERTIARY ALTERATION ZONES

Tqz: Intensely silicified rocks

White to gray intensely silicified rocks composed of fine-grained quartz and chalcedony. These deposits probably represent near-surface levels of fossil hot-spring systems.

Stippled pattern: Hydrothermal alteration

The stippled pattern denotes areas of local and regional hydrothermal alteration characterized by silicification, and argillic or propylitic alteration. Regional hydrothermal alteration has affected much of the northwestern Hieroglyphic Mountains and the adjacent southern Buckhorn Mountains. This alteration is restricted mainly to the lower part of the section and is probably related to emplacement of upper Hells Gate dacite flows. Some of the alteration in crystalline basement rocks may be pre-Tertiary in age.

PRE-TERTIARY ROCK UNITS AND STRUCTURES

Cretaceous intrusive rocks

Granodiorite, granite, aplite, and pegmatite of Late Cretaceous age occurs throughout the map area as well as in adjacent ranges. This intrusive sequence is equivalent with the Wickenburg granodiorite (Rehrig and others, 1980) and granitic rocks in the Big Horn Mountains (Capps and others, 1985). The suite rarely forms good outcrops, weathering to low, grus-covered hills in most areas. However, good outcrops occur in the southeastern corner of the Red Picacho quadrangle. In some areas, mafic minerals have been completely replaced by chlorite and epidote.

The suite includes small aplite and pegmatite bodies that are similar to those found in the Precambrian rocks of the area, but they usually contain less muscovite and little or no tourmaline.

Kgd: Granodiorite

White to gray porphyritic to equigranular granodiorite. The mineral assemblage includes 10 to 25 percent plagioclase, 10 to 25 percent potassium feldspar (either microcline or orthoclase), 5 to 15 percent quartz, 10 to 20 percent biotite, 5 to 20 percent hornblende, 5 percent opaque oxides, and trace sphene and zircon.

Kg: Granite

Gray to white porphyritic to equigranular granite. This unit is similar to the granodiorite, but contains more quartz and less amphibole. Quartz aggregates up to 15 mm in diameter are common in the northern Red Picacho quadrangle.

Kp: Pegmatite

Ka: Aplite

Proterozoic Rocks

Proterozoic rocks in the map area include metavolcanic and metasedimentary rocks, deformed and undeformed granites, and pegmatite dikes and sills. All of these rocks are intruded to varying degrees by Tertiary felsic and mafic dikes. In places, these dikes compose up to about 70 percent of the outcrop area. Even in these highly intruded areas, however, foliation in the Proterozoic rocks remains consistent in orientation.

Xs: Metamorphic Rocks

Metamorphic rocks in the map area are correlative with the Proterozoic Yavapai Supergroup, and appear to be continuations of lithologies found in the southern Bradshaw Mountains. In the most extensive exposures of Proterozoic rocks, in the northern Red Picacho quadrangle, the metamorphic rocks have been divided into two units: a predominantly mafic unit (Xam) and a predominantly pelitic unit (Xms). Both units are heterogeneous, with lithologies interlayered on a scale of tens of meters to a meter or less. This interlayering may be due to original depositional variation or to deformation. In other parts of the map area units Xam and Xms were not mapped seperately, but were mapped as Xs (metamorphic rocks including schist, amphibolite, and gneiss).

Xam: Metavolcanic Rocks

Black, dark-greenish, to gray-green amphibolite, and light gray to tannish well foliated and lineated gneiss.

The most abundant lithologies are biotite-amphibole schist, amphibole-feldspar schist and gneiss, and massive amphibole-epidote gneiss. These rocks are fine to medium grained, well foliated, and usually have a well-developed mineral alignment-lineation in the foliation plane. One amphibolite shows a well-developed lineation, but no foliation.

The amphibolite commonly contains thick layers to small pods of silicic metavolcanic rock, and metacarbonate and metachert that appear to be of exhalative origin. The silicic metavolcanic rocks are very fine grained, well-foliated and lineated gneisses. Thin layers of this lithology can be found within the amphibolite throughout its extent. Good exposures of this lithology are in sections 11, 14, and 15, T7N, R3W, in the Red Picacho quadrangle, where they form east-west-trending bands through the amphibolite.

Xmch: Metacherts

Red, purplish-brown, and black quartzite. These rocks are interpreted as cherts whose grain-size has coarsened through metamorphism. They occur as pods and stringers interlayered with amphibolite and small bodies of carbonate breccia. Quartzites are common in sections 14 and 15, T7N, R3W, in the Red Picacho quadrangle.

Xmc: Metacarbonate

Dark-greenish-brown carbonate. These rocks occur as small bodies of carbonate breccia, commonly with siliceous stringers concentrated around their margins. These rocks occur together with metachert, and both rock types probably originated as exhalites.

Xms: Metasedimentary Rocks

Gray to reddish-gray schist, white, tan, and gray stretched-pebble conglomerate, and light-gray to medium-gray banded paragneiss.

The most common rock type in this unit is muscovite schist that varies in mineralogy from muscovite-garnet-biotite-quartz-feldspar, muscovite-andalusite-biotite-chloritoid(?)-quartz-feldspar, muscovite-cordierite(?)-biotite-quartz-feldspar, and muscovite-quartz-feldspar. These lithologies are fine to coarse grained, and well foliated and lineated. A local crenulation is unique to these metamorphic rocks in the study area. A striking variant to the muscovite schist assemblage contains andalusite porphyroblasts up to 10 cm long.

The stretched-pebble conglomerate contains clasts of felsic igneous rocks, probably volcanic lithologies. The matrix is composed of fine-grained muscovite, chlorite(?), quartz, and feldspar.

The paragneiss in this unit may be a transitional unit between the metasedimentary and the metavolcanic packages; it is certainly transitional in mineralogy, although it usually crops out in association with the metasedimentary rocks. The gneiss is composed of fine-grained amphibole, quartz, feldspar, muscovite, and pyrite. It is well foliated and moderately to well lineated.

Xps: Psammitic Schist

These rocks are derived from a lithic sandstone, are similar to the metaconglomerate, but lack the igneous rock clasts, and usually crop out near the metaconglomerate.

The fabrics developed in this unit include a well-developed foliation and a mineral and stretching lineation in the foliation plane. Pebbles in the metaconglomerate are flattened into the foliation plane and highly elongated in the lineation direction. Pebbles presently range from 1 to 20 cm in length, 1 to 3 cm in width, and 0.5 to 3 cm in height.

Xg: Granitic Rocks

Orangish-brown, tan, and gray- to light-gray, foliated biotite granite, light-gray to white biotite-muscovite granite. This unit includes several granitic lithologies, the most common of which is a fine-grained, foliated and lineated, biotite granite. This granite is commonly interlayered with metamorphic rocks on the scale of a few meters.

The next most abundant lithology is a medium-grained biotite-muscovite granite. This lithology has a deformed border zone with amphibolite in sections 32 and 33, T8N, R3W in the Red Picacho quadrangle. It appears to grade into a porphyritic version with microcline phenocrysts (1-3 cm in length), aligned in the plane of foliation. This lithology rarely shows a lineation, and the foliation is commonly less well developed than in the orangish-brown-weathering biotite granite, or in the other Proterozoic rocks.

Medium- to coarse-grained equigranular to porphyritic biotite or biotite-muscovite granites outcrop in the northeastern corner of the Wickenburg quadrangle and the northwestern corner of the Red Picacho quadrangle. Foliation in these rocks is generally not well developed, and is confined to higher strain zones, with undeformed granite and related pegmatite between these zones. Undeformed portions of these granites can closely resemble the Cretaceous granite. The Proterozoic granites tend to be more resistant, forming large hills and ridges. They are also interlayered with sparse amphibolite and schist stringers, and are more variable in both grain size and mineralogy.

Xal: Leucogranite, pegmatite, and interlayered schist and amphibolite

White to gray, fine-grained, weakly foliated leucogranite and pegmatite. This lithology differs from other granitic rocks in the area in its almost complete lack of mafic minerals. Good exposures occur along the Castle Hot Springs road northeast of Trilby Wash.

Xp: Pegmatite

White, pink, and gray pegmatite. The mineral assemblage normally includes very coarse-grained microcline, quartz, muscovite, and tourmaline. Tourmaline commonly pervades rocks adjacent to the dikes, especially amphibolites and schists.

Pegmatite bodies intruded all Proterozoic units. The pegmatites usually occur in elongate bodies parallel to foliation of the host rock, although some pegmatites also cross-cut foliation. Only a few of the pegmatite bodies show evidence of deformation.

Lithium-bearing pegmatites occur in both the Red Picacho and Wickenburg quadrangles. Lithium-bearing minerals documented from the White Picacho District, the largest group of lithium-bearing pegmatites in the area, include spodumene, lepidolite, lithiophilite, amblygonite, and, eucryptite. Other minerals of interest include beryl, tourmaline, scheelite, columbite-tantalite and garnet (Jahns, 1952; London and Burt, 1978). K-Ar dates (Laughlin, 1969) on pegmatite minerals from the area yielded apparent ages ranging from 750-1580 Ma, with muscovite giving a minimum age of 1270 Ma.

Proterozoic Structures

Proterozoic rocks of the area contain large- and small-scale structures of known or suspected Proterozoic age that include interfolial rootless fold noses with axes parallel to the mineral-alignment lineation in the rocks. The presence of an isoclinal folding event implies that folding may pervade the Proterozoic section, and some (or all) of the lenticular map patterns may in fact reflect isoclinal folds.

A tight fold nose crops out in sections 5 and 6, T7N, R3W of the Red Picacho quadrangle. The axial plane of this fold is subvertical and strikes east-west, the axis dips about 60 degrees west, and the fold closes westward. This structure folds pre-existing foliation, but is not associated with an axial-planar cleavage or crenulation. Just northeast of this fold, in sections 32 and 33 of T8N, R3W, a broad, very open fold gently the foliation in and around the border zone of granite and amphibolite. The axis of this open-fold plunges steeply northwest, with the fold closing southeast. Another such open fold that crops out just to the west, has a nearly vertical axis and closes to the northwest.

REFERENCES CITED

Capps, R. C., Reynolds, S. J., Kortemeier, C. P., Stimac, J. A, Scott, E. A., and Allen, G. B., 1985, Preliminary geologic maps of the eastern Bighorn and Belmont Mountains, west-central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 85-14, 25 p, scale 1:24,000.

Capps, R. C., Reynolds, S. J., Kortemeier, K. C., and Scott, E. A., 1986, Geologic map of the northeastern Hieroglyphic Mountains, central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-10, 16 p., scale 1:24,000.

Grubensky, M. J., Stimac, J. A., Reynolds, S. J., and Richard, S. M., 1987, Geologic map of the northeastern Vulture Mountains and vicinity, central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-10, 8 p., scale 1:24,000.

Jahns, R. H., 1952, Pegmatite deposits of the White Picacho district, Maricopa and Yavapai County, Arizona: Arizona Bureau of Mines Bulletin 162, 105 p.

Kortemeir, C. P., Jorgensen, M., and Sheridan, M. F., 1986, Volcanic geology of the Castle Hot Springs area, in Beatty, Barbara, and Wilkinson, P. A. K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Arizona Geological Society Digest, v. 16, p. 473-477.

Laughlin, A. W., 1969, Excess radiogenic argon in pegmatitic minerals: Journal Geophysical Research, v. 74. p. 6684-6690.

London, D., and Burt, D. M., 1978, Lithium pegmatites of the White Picacho district, Maricopa and Yavapai Counties, Arizona, in Burt, D. M., and Pewe, T. L., eds., Guidebook to the geology of central Arizona: Geological Society of America Cordilleran Section, 74th annual meeting, Arizona Bureau of Geology and Mineral Technology Special Paper 2, p. 61-73.

Rehrig, W. A., Shafiqullah, M., and Damon, P. E., 1980, Geochronology, geology, and listric normal faulting of the Vulture Mountains, Maricopa County, Arizona, in Jenney, J. P., and Stone, Claudia, eds., Studies in western Arizona: Arizona Geological Society Digest, v. 12, p. 89-110.

Shafiqullah, M., Damon, P. E., Lynch, D. J., Reynolds, S. J., Rehrig, W. A., and Raymond, R. H., 1980, K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas, in Jenney, J. P., and Stone, Claudia, eds., Studies in western Arizona: Arizona Geological Society Digest, v. 12, p. 201-260.

Ward, M. B., 1977, The volcanic geology of the Castle Hot Springs area, Yavapai County, Arizona: Tempe, Arizona State University, M.S. Thesis, 74 p.