GEOLOGIC MAP OF THE VULTURE MINE AREA, VULTURE MOUNTAINS, WEST-CENTRAL ARIZONA

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INTRODUCTION

The Vulture Mountains, located directly southwest of Wickenburg in central Arizona, contain one of Arizona's premier historic gold deposits, the Vulture Mine. This mine yielded about 340,000 ounces of gold and 260,000 ounces of silver, with average grades of 0.35 oz/ton gold and 0.27 oz/ton silver. In spite of this significant production, the mine has received relatively little geologic study until recently (White, 1988). In order to better characterize the geologic setting of this historically important gold deposit, we mapped the geology of approximately 10 square kilometers centered on the mine. This mapping was partially supported by the U.S. Geological Survey and Arizona Geological Survey Cooperative Geologic Mapping (COGEOMAP) Program.

GEOLOGIC SETTING

The Vulture Mountains are in the Basin and Range Province, a region that underwent crustal extension during Tertiary time. Tertiary crustal extension was severe within the Vulture Mountains region and resulted in a series of steeply tilted fault blocks bounded by low- to moderate-angle normal faults (Rehrig and others, 1980; Grubensky and others, 1987). The oldest rocks exposed within the fault blocks are Lower Proterozoic metamorphic and granitoid rocks. These have been intruded by a large pluton of Cretaceous granodiorite, smaller plutons of Cretaceous granite, and numerous middle Tertiary dikes and sills. The crystalline basement is overlain by a sequence of middle Tertiary volcanic and minor sedimentary rocks that is at least 1 km thick. The Tertiary units generally strike north to north-northwest and dip steeply to the east; they are locally overturned into steep westward dips in the most highly rotated fault blocks. The tilted Tertiary and pre-Tertiary rocks are locally overlain unconformably by mid-Miocene basalt flows and Quaternary to Upper Tertiary surficial deposits.

PRE-TERTIARY ROCKS, STRUCTURE, AND MINERALIZATION

The oldest rocks near the Vulture Mine are Proterozoic metaigneous and metasedimentary rocks that partially host mineral deposits at the Vulture mine and that form low, rounded outcrops to the north, east, and south of the mine. These include the following rock types:

> (1) quartz-feldspar-sericite-chlorite schist and phyllite derived from fine-grained, clastic sedimentary rocks. These include light-gray to tan quartz-sericite schist, greenish chloritic schist, locally with actinolite, medium- to dark-gray sericitic phyllite, and dark-brown, hematite-stained metasandstone and schist. This unit is variably compositionally banded or laminated, with layers ranging from 2 to 20 mm thick. Some units probably include metamorphosed volcaniclastic rocks;
> (2) dark-colored, fine-grained amphibolite derived from mafic igneous rocks; and
> (3) medium- to fine-grained, variably foliated granite and granodiorite.

Lithologic layering is generally parallel to foliation and schistosity, which strike west to northwest and dip moderately to steeply to the north and northeast. This fabric is interpreted to be Proterozoic in age because of its style and orientation, and its absence in the Cretaceous plutons.

Intruding the Proterozoic rocks is a Cretaceous granitic pluton that crops out over 1 square kilometer west of the Vulture Mine and extends as a north-dipping sill-like apophysis eastward into the mine workings (White, 1988). The main pluton is composed of two phases and their sericitically altered equivalents. The oldest phase is a medium-grained biotite granite to granodiorite that is equigranular or rarely porphyritic with feldspar phenocrysts as large as 1 cm. This phase is cut by northeast-striking, steeply dipping dikes and more irregular apophyses of lighter colored granite, which typically contains medium-grained muscovite, in part of secondary origin, and conspicuous quartz eyes as large as 1 cm in diameter. The abundance of muscovite increases with the degree of alteration, and some outcrops of altered granite contain more than 20 percent muscovite. Alteration has resulted in the destruction of plagioclase and mafic minerals, converting them into fine-grained sericite, hematite, and clay minerals. Many dikes of granite are flanked by muscovite-rich alteration selvages. The granite is most highly altered in the sill near the Vulture mine, where it has been converted into a muscovitic quartz-porphyry due to preferential preservation of the quartz eyes. The granite is interpreted to be Late Cretaceous based on an 85 ± 3 Ma Rb-Sr muscovite-whole-rock age (White, 1988).

Gold mineralization at the Vulture Mine is concentrated within quartz veins and silicified rocks within the granitic sill and its Proterozoic wall rocks. Gold is present as native metal and electrum associated with pyrite, argentiferous galena, and minor chalcopyrite and sphalerite. There is a good correspondence between the abundances of silica, sulfides, and gold (White, 1988).

MIDDLE TERTIARY ROCKS

Middle Tertiary rocks are most widespread east of the mine, where they form a belt of volcanic rocks that strikes north to north-northwest and is vertical to steeply east dipping. The volcanic sequence includes, from bottom to top, (1) mafic flows and associated feldspar-phyric rhyolite, (2) yellowish-weathering tuff and altered rhyolite flows, and (3) phenocryst-poor rhyolite flows. In addition, dikes lithologically equivalent to the mafic flows and feldspar-phyric rhyolite flows intrude the Proterozoic rocks and Cretaceous granite.

The stratigraphically lowest Tertiary unit exposed consists of mafic (basaltic to andesitic) flows that crop out directly to the east of the crystalline block that hosts the Vulture mineralization. Similar mafic flows occur near the base of the Tertiary section throughout the region (Capps and others, 1985, 1986; Grubensky and others, 1987; Stimac and others, 1987). Adjacent to the Vulture Mine, the contact between the mafic flows and the underlying crystalline rocks is not exposed; although it could be a fault, it is probably a slightly faulted(?), steeply dipping depositional contact. Mafic dikes similar in lithology to the flows are present within the Proterozoic and Cretaceous crystalline rocks.

The mafic flows and dikes are locally associated with pinkish-gray rhyolite containing as much as 5 percent phenocrysts of feldspar and minor quartz. The rhyolite consists largely of dikes that occur along the center or margins of the mafic dikes. In some exposures, the rhyolite contains irregularly shaped inclusions of the mafic dike. Assimilation of similar mafic material into the rhyolite has locally produced an intermediate-composition rock (andesite or dacite?). Phenocrysts from the rhyolite are likewise locally incorporated into the mafic dikes. In all, these relations imply that the rhyolitic and mafic magmas were intruded synchronously and interacted while molten. A texturally similar rhyolite with abundant mafic clots occurs as a fault-bounded klippe in the eastern part of the map areas and is probably a flow rather than a dike.

The basaltic to andesitic flows are depositionally overlain by a sequence of yellowish to cream-colored, yellowish-gray-weathering lithic tuff and altered, phenocryst-poor rhyolite and vitrophyre. These rocks are slope forming and probably correlative with the San Domingo rhyolite of the eastern Vulture and Wickenburg Mountains (Grubensky and others, 1987; Grubensky and Reynolds, 1988).

The sequence of yellowish-weathering tuffs and flows is overlain by at least two flow-banded rhyolitic flows, both of which contain less than one percent feldspar phenocrysts. The stratigraphically lowest flow is creamy gray to pinkish gray and somewhat granular in texture, whereas the overlying flow is pinkish-gray to maroonish-brown weathering and contains abundant silica-filled lithophysae. Vitrophyre is commonly preserved along the base of the lower flow.

MIDDLE TERTIARY STRUCTURES AND TILTING: IMPLICATIONS FOR MINERALIZATION

Middle Tertiary normal faulting and tilting has widely affected rocks of the area, including those that host the Vulture mine. The Tertiary volcanic belt has been tilted approximately 90 degrees, so that it now strikes north to north-northwest and is nearly vertical, with the top of the section facing to the east. The volcanic section is cut by several west- to southwest-dipping, low- and high-angle angle normal faults. These faults consistently place stratigraphically higher units westward over lower units. Analogous faults are present within the pre-Tertiary crystalline rocks but are more difficult to follow due to poor exposure and the lack of distinctive marker units. A major, poorly exposed, low-angle(?) normal fault places the volcanic section down against Proterozoic rocks at the south end of the volcanic belt (along Vulture Mine Road near the northern edge of section 31).

Although the contact between the main volcanic sequence and the pre-Tertiary crystalline rocks that host the Vulture mine is not exposed, it is likely that the crystalline rocks, and the gold-bearing quartz veins, have undergone the same 90 degrees of rotation as the volcanic rocks. If so, then the Vulture granitic sill and vein have been tilted onto their side, and the highest preserved levels of the original mineralized system are at the present east end of the deposit. Restoring the volcanic section to its original subhorizontal attitude would bring the presently north-dipping Late Cretaceous granitic sill and veins into a near-vertical, east-northeast-striking orientation, which is typical for Late Cretaceous intrusions and veins in the region.

ACKNOWLEDGMENTS

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MAP UNITS

Qsy -- sand and gravel in active channels (Holocene)

Qso -- surficial deposits (Pleistocene to Holocene)

Tv -- Volcanic rocks, undifferentiated (Early Miocene?)

Tra -- aphyric rhyolite (Early Miocene?)

Tt -- tuff and altered rhyolite (Early Miocene?)

Trp -- feldspar-phyric rhyolite (Early Miocene?); includes mafic rocks in most dikes

Tbl -- lower basaltic and andesitic flows (early Miocene? or late Oligocene?)

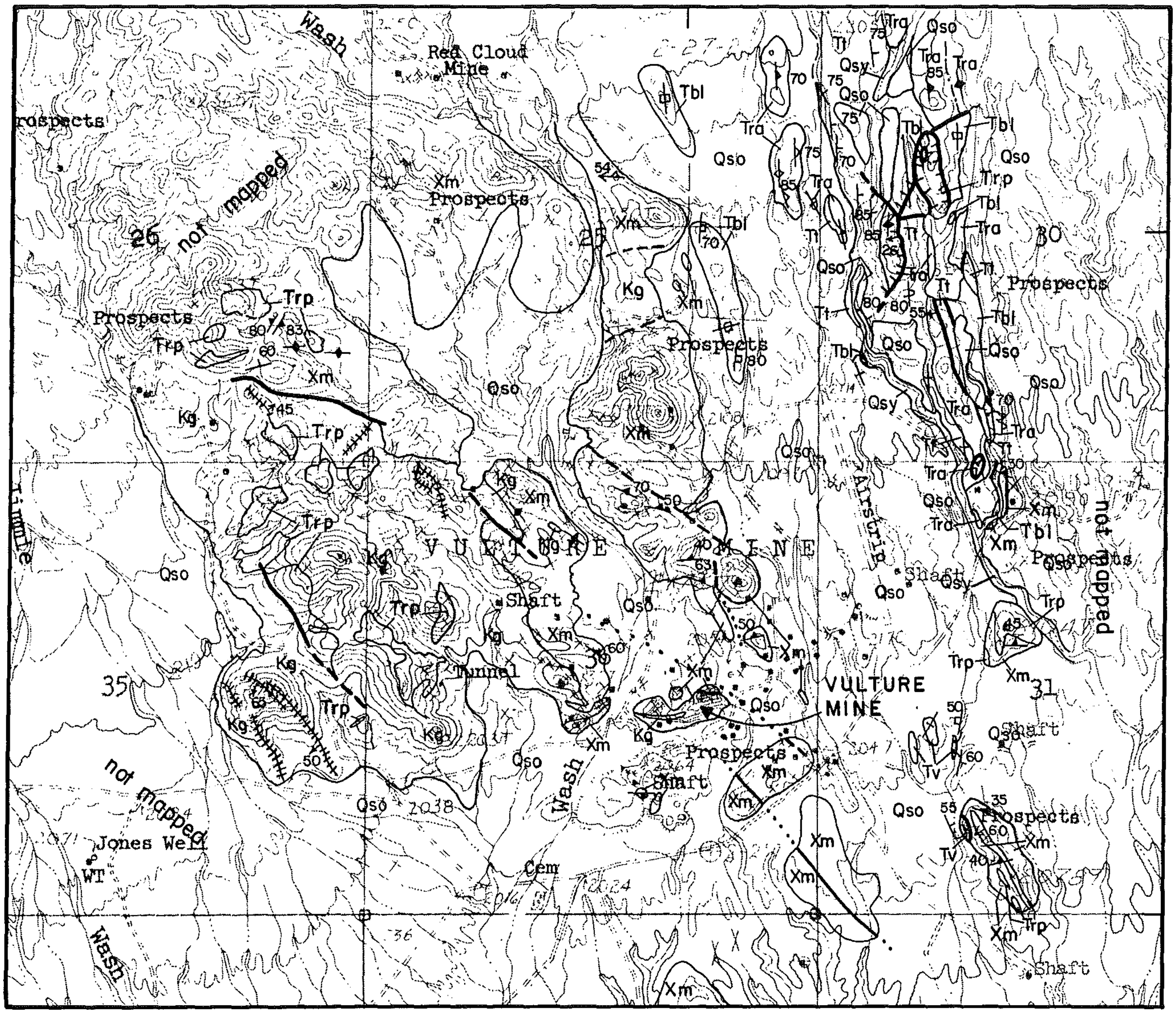
Kg -- granite (Late Cretaceous)

Xm -- metamorphic rocks (Early Proterozoic)

MAP SYMBOLS

	contact; dashed where approximately located
	fault; dashed where approximately located; dotted where covered
	low-angle normal fault; dashed where approximately located; dotted where covered
	marker unit
50	dike; showing dip
35	bedding
	vertical bedding
75	overturned bedding
25	foliation with lineation
	vertical foliation
70	overturned flow foliation
80	joints in unit Tbl; probably parallel to flow layering
	vertical joints in unit Tbl; probably parallel to flow layering

ARIZONA GEOLOGICAL SURVEY
OFR 88-10



BASE FROM WICKENBURG 2SE., ARIZONA, U.S. GEOLOGICAL SURVEY, 1961

Scale 1:24,000

0 0.5 1.0 mile

0 0.5 1.0 km

CONTOUR INTERVAL 20 FT.
DATUM IS MEAN SEA LEVEL

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