GEOLOGIC MAP OF THE RED HILL QUADRANGLE, LA PAZ COUNTY, ARIZONA

By
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1992

Base from U.S. Geological Survey, 1986
Universal Transverse Mercator Projection

SCALE 1:24 000

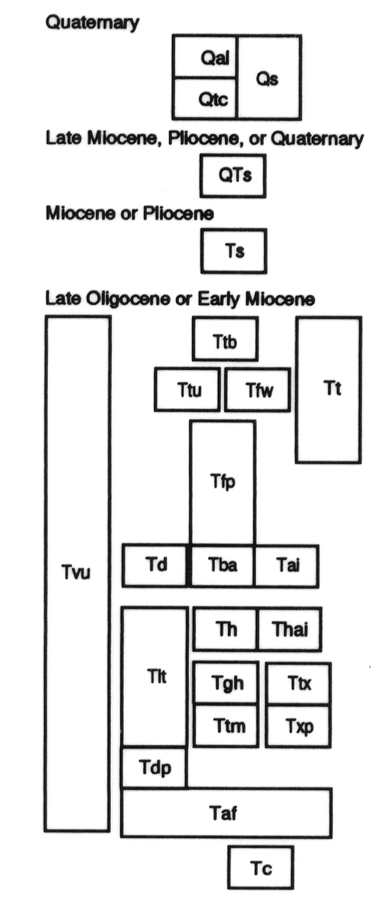
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER

N MN 15°

Based on geologic mapping and interpretation of aerial photography and satellite imagery in 1989-1991

EXPLANATION

CORRELATION OF MAP UNITS



Rocks in the Red Hill 7.5' Quadrangle have been identified and described based on observations along traverses indicated by the distribution of strike and dip data on the map. These observations have been extended using 1:24000 and 1:48000 scale air photographs and processed TM satellite imagery provided by Ron Blom and Bob Crippen of the Jet Propulsion Laboratory at Caltech, Pasadena, CA.

ROCK UNITS

Qs **Undivided alluvium and old alluvium (Quaternary).**

Qal **Alluvium (Quaternary).** Unconsolidated sand and gravel, in modern stream channels. Unconformably overlies all older units.

Qtc **Talus and colluvium (Quaternary).** Unconsolidated talus and colluvium on slopes below cliffs. Consists of locally derived angular cobbles and boulders with sparse sandy matrix.

QTs **Old alluvium (Tertiary or Quaternary)** Moderately indurated polymict conglomerate; clasts up to 30 cm in diameter. Clasts include volcanic and crystalline rocks. Generally weakly to moderately indurated, and very poorly bedded. Generally overlies Tertiary and pre-Tertiary rocks on an angular unconformity. Erosional unconformity separates from younger alluvium. Generally mapped morphologically because of poor outcrop; occurs as deeply dissected old alluvial fans. Old soil horizons with red argillic horizon and thick calcic zones are rarely preserved. Clast size in conglomerate is generally coarser than in younger fans, but as distance from bedrock outcrop increases, this distinction is difficult to make.

Ts **Conglomerate (Miocene or Pliocene).** Volcanic-clast conglomerate, consisting of cobbles to boulders of volcanic rocks generally similar to underlying rocks. Poorly to moderately bedded, with thin to thick beds defined by grain size variations. Clasts sub-angular to sub-round. This conglomerate was probably deposited at the same time as and in a comparable setting to the conglomerate of Bear Canyon [Crowe, 1978] found in the area of Picacho State Park, California. Contacts with overlying alluvium of late Tertiary to early Quaternary age are difficult to locate precisely.

—ı—ı—ı— **Marker bed.** Generally cooling breaks in tuff units and flow tops in sequences of lava flows.

Tvu **Undivided volcanic rocks (Oligocene and Miocene).** Mapped in outcrop areas not visited that were internally too heterogeneous to identify using remote sensing data. Probably includes rocks similar to Tlt, Tba and Td.

Ttu **Poorly welded tuff (Miocene).** Non-descript, white to very light grey massive tuff. Locally contains abundant slightly flattened tan pumice or abundant 1-3 cm angular black obsidian fragments. Depositionally overlies tuff of Felipe Pass. Includes upper poorly indurated Tfp or Tfw.

Ttb **Breccia (Miocene).** Monolithologic breccia consisting of angular blocks of welded tuff lithologically identical Tfw. Lithic and crystal poor tuff with 1-2% crystals of hornblende, oxidized biotite, sanidine, plagioclase and sparse quartz. Breccia is matrix poor; matrix consists of unwelded tuff or comminuted tuff identical to that forming blocks. Some fragments form jigsaw mosaic, but mostly fragments have been rotated relative to each other. Tuff breccia or rock avalanche deposit.

Tfw **Ferguson Wash tuff** member of volcanic rocks of Ferguson Wash. Light grey, buff and light brown welded rhyodacite(?) tuff with prominent light tan fiamme and about 1 to 2% of crystals. Crystals <1 mm diameter, include biotite, hornblende, quartz, plagioclase and sanidine. Sparse lithic fragments are mostly red-brown felsite. Biotite is commonly copper colored. Overlies Felipe Pass tuff; overlain by sedimentary(?) or tuff breccia consisting of clasts of Ferguson Wash tuff, by Bear Canyon Conglomerate, or by alluvium and old alluvium. Correlation of this unit with Ferguson Wash tuff in Ferguson Wash area is based on lithological similarity, and similar $^{40}Ar/^{39}Ar$ date of 22. 4 Ma from hornblende [Richard, in prep.].

Tfp **Tuff of Felipe Pass (Miocene)** [Sherrod and others, 1990] is a pink-brown, generally strongly welded dacite or rhyodacite crystal ash-flow tuff. It contains 1 to 2 percent blocky plagioclase and biotite phenocrysts; accessory augite is diagnostic. Sparse plagioclase-phyric felsite lithic fragments are present. Thick compound sections comprise a basal zone consisting of several 5-15 m-thick units with basal vitrophyres, overlain by a thick zone of massive, densely welded lithophysal ash-flow tuff. Welding decreases gradually up section. An upper unit of rhyolite tuff typically caps the section above a second prominent vitrophyre or strongly welded zone (Tfpr, described below). The tuff of Felipe Pass has been dated at 22.2±.6 Ma (K-Ar plagioclase) [Bagby and others, 1987] in the Livingston Hills. The tuff of Felipe Pass bears a strong resemblance to the dacite tuff unit (unit Tt_4, or Middle Mountains tuff member) in the volcanic rocks of Ferguson Wash [Richard, in press, column 3-G; Richard, 1992], and geochronologic data reported in Richard [in prep.] suggest that these units are correlative. The tuff of Felipe Fass thins slightly to the south within the map area. The thick section in the central part of the map area was not mapped in detail and may include some Ferguson Wash tuff.

Tfpr Crystal poor, stony rhyolite tuff at top of tuff of Felipe Pass, only locally differentiated. Contains about 1 percent sanidine and quartz crystals and a trace of biotite; commonly the base of this unit is strongly welded and forms a break in slope. Differentiated only locally in the area north of Red Hill.

Tt **Tuff (Miocene or Oligocene).** Poorly to moderately welded buff-colored tuff. Sequence with several cooling breaks, or one cooling break repeated by numerous minor normal faults. Crops out only at the eastern edge of the map area.

Ttx **Crystal poor tuff (Miocene or Oligocene).** Poorly welded white tuff with crystal content similar to Txp. Probably a tuff apron related to Txp.

Txp **Felsite (Miocene or Oligocene).** Crystal poor, strongly flow banded felsite with very sparse quartz and feldspar phenocrysts. Light buff and pink bands 1-2 mm thick; in center of thick flows grades to massive white felsite. May be rheomorphic tuff or high temperature lava.

Td **Dacite (Miocene or Oligocene).** Red brown, purple-grey and grey andesite or dacite lava or hypabyssal intrusive rock; commonly with glassy matrix and spherulitic weathering. 3-7% crystals of 2-4 mm plagioclase, and hornblende or pyroxene (not in same flows). When present, pyroxene commonly occurs in 3-5 glomerophyric masses with plagioclase.

Tai **Intrusive andesitic rocks (Miocene or Oligocene).** Massive andesite to basalt identified as intrusive by cross cutting contacts, chilled margins, or homogeneous character over 100's of meters. Lithologically identical to Tba.

Tba **Andesite and basalt lavas (Miocene or Oligocene).** Generally red brown to dark grey highly fractured, vesicular to massive andesite(?) lava that contains 1 to 3% of 2 to 3 mm augite(?) phenocrysts set in a very fine-grained, microlitic groundmass. Mafic phenocrysts are typically altered to hematite and clay, making mineral identification tenuous. Locally includes massive dark brown to dark purple brown dacite(?) with 5-10% 2-4 mm blocky plagioclase phenocrysts. Numerous, 10 to 70 m thick, massive lava flows and probable hypabyssal intrusive rocks are present; flow contacts are locally visible as red-stained, highly vesicular zones. The source of the lava flows was probably in the central Chocolate Mountains of Arizona, where a series of lithologically similar andesitic dikes and sills intrude the underlying units; some of these dikes are continuous with nearby lava flows. In some areas the unit is massive and lacks features to identify flow tops or distinguish intrusive and extrusive rocks.

Th **Hornblende andesite (Miocene or Oligocene).** Lithologically identical to hornblende andesite intrusions but occurs as lava flows(?) with associated volcaniclastic breccia consisting of angular cobbles to boulders in a comminuted matrix of identical rock. May be partly intrusive. These two units are probably part of a dome complex.

Thai **Hornblende andesite intrusions (Miocene or Oligocene).** Light grey very fine grained andesite(?) with 5-10% acicular hornblende crystals 3-5 mm long. Intrudes tuff of Ten Ewe Mountain in the southern part of the quadrangle.

Tlt **Rhyolite lithic tuffs (Miocene and Oligocene).** A sequence of emplacement units composed of buff to tan, lithic lapilli to block tuff with 2 to 4% crystals of quartz, sanidine, biotite, and plagioclase, ±hornblende. The sequence thickens towards the north by addition of emplacement units and thickening of individual units. Vitrophyres separate several of the units present in this area indicating that individual cooling units are present. Red brown, feldspar-phyric felsite lithic fragments are most abundant in the lower units, but medium-grained equigranular granodiorite, with subordinate quartzo-feldspathic gneiss and hornblende schist lithic fragments become abundant in the upper units. The rhyolite lithic tuff unit probably correlates with or includes the tuff of Crazy Woman Wash [Sherrod and Tosdal, 1991]. Because the rhyolite lithic tuff consists of several emplacement units, possibly derived from unrelated sources (for example, tuff of Ten Ewe Mountain), the stratigraphic relationship with the tuff of Crazy Woman Wash is uncertain. ^{40}Ar-^{39}Ar analysis of sanidine from a vitrophyre near the base of the section yields a date of 24.09±.07 Ma [Richard, in prep.].

At the northern edge of the Red Hill Quadrangle, in the northern Chocolate Mountains, these lithic tuffs overlie and appears to interfinger northward with dacitic fragmental rocks that underlie Mojave Peak (Tdp). To the south they overlie andesite or basalt lava flows similar to the Quechan volcanic rocks [Crowe, 1978]. The lithic tuffs are overlain by and interfinger locally with basalt or andesite flows that separate the rhyolite lithic tuff from the tuff of Felipe Pass.

JJJJJJJJ Winterhaven-clast marker bed. Distinctive cooling unit in lithic tuff sequence that contains abundant clasts of dark grey Winterhaven Formation(?) argillite, locally mapped near the top of the sequence.

Tgh **Glassy fragmental rhyolite (Miocene or Oligocene).** Very light grey glassy rhyolite clasts in a dense matrix of lithologically identical rock. Flattening of fragments locally defines a eutaxitic foliation. Phenocrysts of hornblende, biotite, quartz, sanidine and plagioclase make up about 5% of the rock. A thin bedded pyroclastic unit is present at the base. Nature of the contact along strike into lithic tuff unit is not known; rhyolite overlies tuff of Ten Ewe Mountain depositionally. North of Red Hill this unit consists of interbedded glassy fragmental rhyolite or rhyodacite, and a brown hornblende-quartz-plagioclase- tuff that resembles units in the lithic tuff unit (Tlt).

Ttm **Tuff of Ten Ewe Mountain (Miocene).** Tan, crystal-rich welded ash-flow tuff containing 4 to 7 percent crystals of hornblende, biotite, and plagioclase. Forms a thick emplacement unit in the Red Hill area. The tuff contains 10 to 20 percent lithic fragments of hornblende- and/or plagioclase-phyric andesite, and sparse but ubiquitous equigranular, medium-grained hornblende-biotite granodiorite fragments. Overlies andesite flows near the southern limit of its outcrop SW of Red Hill, dacitic pyroclastic rocks (Tdp) on Red Hill, and lithic tuff (Tlt) in the northern part of the Red Hill quadrangle. Correlation with the tuff of Ten Ewe Mountain [Grubensky and Bagby, 1990] is based on lithologic similarity with ash-flow tuff exposed in the cliffs east of Stone Cabin on Arizona highway 95. In the Kofa Mountains the tuff of Ten Ewe Mountain has yielded a biotite K-Ar date of 22.1±.3 Ma [Bagby and others, 1987]. The tuff of Ten Ewe Mountain disappears abruptly across an east-trending fault 3 km south of Red Hill (south-central edge of map area); this may represent a collapse structure related to the eruption of the tuff. The tuff of Ten Ewe Mountain is interbedded in the rhyolite tuff sequence just below the Winterhaven-clast tuff marker (JJJJJ on map, see above), and thins rapidly to the north in the central Arizona Chocolate Mountains where it pinches out within the rhyolite lithic tuff unit (Tlt).

Tdp **Dacitic pyroclastic rocks (Miocene or Oligocene).** Dark grey or purple grey block tuff(?) consisting of angular clasts in a dense matrix of very similar rock. Rock is very fine grained, with 2-3% 2-4 mm plagioclase and altered mafic (hornblende or biotite) phenocrysts and sparse angular shards of quartz. Scattered zoned plagioclase crystals up to 1 cm in diameter are present. Blocks are 2-100 cm in diameter. Strongly indurated, fractures across blocks to form relatively smooth surfaces; the fragmental character is not evident from a distance.

Taf **Andesite, dacite, and basalt (Oligocene).** Includes brown dacite(?) or andesite lava flows and domes with phenocrysts of plagioclase, hornblende(?), and rare quartz; dark-grey basalt lava with olivine, pyroxene and plagioclase phenocrysts; and andesite lava with about 5 percent 1 to 2 mm long plagioclase phenocrysts and sparse altered mafic phenocrysts. Large volumes of homogeneous, massive, intrusive(?) andesite are present in the southwest part of the quadrangle (mapped as Tai where field relations indicate intrusive origin). The mafic phenocrysts are typically altered to hematite and clay, making mineral identification tenuous. Flow contacts in the basaltic rocks are visible as red-stained, highly vesicular or fragmental zones, but flow margins in the andesitic to dacitic rocks tend to be more cryptic, thuse intrusive rocks are difficult to distinguish from extrusive rocks. A poorly bracketed lower age limit may be as old as 32 Ma, based on correlation with similar rocks included in the Quechan volcanic rocks of Crowe [1978]. Unit is lithologically very similary to Tba, and

Tc **Conglomerate (Paleogene).** Brown, well bedded conglomerate and conglomeratic sandstone, interbedded with sparse thin sandstone beds. Conglomerate is medium to thick bedded. Clasts include quartz-feldspar-biotite gneiss, schistose metavolcanic tectonite, and foliated metavolcanic rocks (Jurassic volcanic rocks?), medium-grained granodiorite similar to Jurassic granitoid, and red-brown felsite. Conglomerate is generally fine-grained sandstone matrix supported, and poorly organized. Contact with overlying Taf unit has thin andesite-lithic sandstone overlain by basal flow breccia; along strike to north andesite cuts down section across Tc, probably in intrusive contact. The age is bracketed by the Late Cretaceous and Early Tertiary biotite K-Ar cooling ages of crystalline rocks that underlie similar sediments in the Trigo Mountains [Weaver, 1982], and the Late Oligocene(?) age of the overlying intermediate volcanic rocks (Taf) correlated with the Quechan volcanic rocks of Crowe [1978].

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Symbols

■ Geochronology sample location and sample ID

FAULT; dip direction and dip; trend and plunge of slickenside striae

CONTACT; dashed where approximate, dotted where concealed

wavy strike line indicates irregular foliation

broken strike line indicates approximate measurement

Primary foliation

upright vertical BEDDING; strike and dip

APPARENT DIP of bedding; trend and plunge

FLOW FOLIATION in igneous rocks