GEOLOGIC MAP OF THE GERALD HILLS AREA, GLOBE-MIAMI AREA, GILA COUNTY, ARIZONA

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INTRODUCTION

The purpose of this study is to provide detailed geologic information about part of the Gerald Hills, north of Globe, to facilitate the relocation of a section of State Highway 88. The map area includes parts of the following 1:24,000 scale USGS 7.5' topographic quadrangles: Globe, Inspiration, Salt River Peak, and Rockinstraw Mountain. Field work was done during July, 1995.

PREVIOUS INVESTIGATIONS

Ransome (1903 and 1904) created a geologic map of the Globe 15' Quadrangle at 1:62,500 scale and a 1:12,000 scale map of the Globe copper district. Peterson (1954) published a 1:24,000 scale map of the Globe 7.5' Quadrangle and, later, a 1:12,000 scale map of the Globe-Miami District (Peterson, 1962) and a 1:24,000 scale map of the Pinal Ranch Quadrangle. Reconnaissance geologic work was included in the Geologic Map of Arizona (Wilson and others, 1969), and in the most recent Geologic map of Arizona (Reynolds, 1988).

Wrucke (1989), though not specifically mentioning this study area, described in detail the rocks of the Apache Group which are exposed in the area. Silver and others (1980) determined a uranium-lead date from zircons from the Ruin Granite.

Several theses and studies have been written about the ground water and geohydrology of the Globe-Miami area and Pinal Creek. Those pertinent to this study were by Rause (1981), Gellenbeck and Hunter (1994), and Neaville and Brown (1994).

GEOLOGIC SETTING

The Ruin Granite is the oldest rock in the study area and has been dated by the U-Pb method at 1440 ± 20 Ma (Silver, 1980). Nonconformably overlying the granite are rocks of the Late Proterozoic Apache Group, including, from bottom to top; Scanlan Conglomerate, Pioneer Shale, Barnes Conglomerate, Dripping Spring Quartzite, and Mescal Limestone. All units have been intruded by diabase, dated at between about 1040 Ma and 1150 Ma (Wrucke, 1989), which commonly intrudes near the base of the Dripping Spring Quartzite.

Exposures of the Apache Group in this area are notable because both the Pioneer Shale and the Dripping Spring Quartzite contain interbedded conglomerates. The conglomerate within the Pioneer Shale merges with a conglomerate at the base of the Pioneer. The conglomerate is 1 to 5 meters thick and, though generally slightly lighter grey in color than the Barnes and Scanlan conglomerates, contains well rounded clasts of quartz, quartzite, and jasper--much the same as the other units--and is lithologically indistinguishable from them. The conglomerate within the Dripping Spring Quartzite is up to 3 meters thick and is also lithologically indistinguishable from the Barnes and Scanlan Conglomerates. The conglomerate, where visible, appears to lie above a fine-grained pink argillaceous quartzite and below a slightly coarser-grained white quartzite.

Mescal Limestone is exposed only in the northern part of the map area. Farther south Paleozoic limestones rest directly on Dripping Spring Quartzite (probably Escabrosa/Redwall Limestone and possibly Martin Formation). Bolsa Quartzite appears to be absent from the area. In most areas the Proterozoic and Paleozoic limestones can be distinguished by the abundance of fossils in the Paleozoic rocks. Also, the Mescal Limestone is locally more strongly fractured and contains abundant dark-colored chert.

The Apache Leap Tuff unconformably overlies Dripping Spring Quartzite, diabase, Mescal Limestone, and Paleozoic limestones, and is overlain by tan-colored, poorly sorted, coarse sandstone and fanglomerate (Gila Conglomerate of Peterson, 1962). These clastic rocks are tilted on the west side of Pinal Creek and are probably older than flat-lying, otherwise similar strata on the east side.

STRUCTURE

The region is dominated by northwest-striking, southwest-side-down, high-angle normal faults which have tilted the beds in adjacent fault blocks about 30° to the east-northeast. They are relatively closely spaced and tilt all strata except the youngest Tertiary strata (map unit Tsy) and the Quaternary units. The fact that tilted older basin-fill sedimentary deposits (map unit Tsm) have similar attitudes to the Apache Leap Tuff and appear to conformably overlie it, combined with the observation that the Tertiary units have similar attitudes to the underlying Proterozoic rocks, suggests that there was no significant Mesozoic or early Tertiary deformation in the area.

A few northeast-striking normal faults exposed include the northeast-striking fault south of and parallel to Murray Wash, which cuts several northwest-striking faults but apparently does not cut the Apache Leap Tuff. There is much slope wash in the area so the observation is rather tentative. Also, one of the northwest-striking faults cut by the northeast-striking faults itself cuts Apache Leap Tuff. The timing of northeast-striking faulting is therefore contradictory. Most likely, both fault sets were active at about the same time of Apache Leap volcanism.

MINERALIZATION

The granite in the south, just east of Sleeping Beauty Peak, contains many high-angle fracture zones from a few millimeters to several centimeters wide which contain dark hematite. The hematite may be alteration of disseminated sulfides, which are visible in float below the tailings pile at the extreme southern end of the study area.

One mile north of the southern edge of the map, in the south-central part of section 31, a quarry has been dug into Paleozoic limestone. No evidence of mineralization was seen, although a thin white carbonate crust covers most of the rocks exposed around the quarry. Pieces of fence and other metal objects also have a crust, indicating the encrustation is very young.

Five small pits were found scattered throughout the study area. Each was dug into a fault exposing discontinuous light to dark grey, coarse-grained calcite filling the fault zone from a few millimeters to tens of centimeters wide. No obvious mineralization was associated with the calcite.

Evidence of hydrothermal alteration or mineralization was not observed elsewhere, and no travertine, lacustrine, nor evaporite deposits were seen.

ENGINEERING GEOLOGY

No evidence for Quaternary faulting nor collapsing soils was seen. Mechanically weak zones are confined mostly to the friable purple shales of the Pioneer Shale and the crumbly outcrops of the diabase and Ruin Granite. All three formations erode readily.

There are two marked springs on the map, one near the southern margin of the map and Dagger Spring in the northwest. They both looked dry during July. No other springs nor seeps were discovered during this study. The alluvium in Murray Wash and the wash immediately south is locally very thin and both areas contain patches of thick vegetation, including a few Cottonwood trees. This suggests that water is near the surface. In Murray Wash there is an old cement catch basin just down stream from the conglomerate bed within the Dripping Spring Quartzite. The basin is next to a few Cottonwood trees in the wash.

The best source of aggregate is found in the younger alluvial fan deposits (map unit Qm_2). These deposits contain clasts up to half a meter in diameter but most are under 6 inches. The clay content is low and there is no carbonate in the matrix. The deposits are relatively thick (next to Gerald Wash they are about 30-40 feet thick) and are accessible along the course of the proposed road on the west side of Pinal Creek. The older alluvial fan deposits (map unit Qm_1) may be another good source of aggregate. However, some deposits contain a large percentage of clasts 6-10 inches in diameter, and most exposures are on the east side of Pinal Creek.

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UNIT DESCRIPTIONS

Qyc **Younger channel deposits (Holocene)**--Modern ephemeral stream deposits consisting of unconsolidated sand and gravel and some cobbles, derived from local rock types. The deposits are mostly devoid of vegetation.

Qc **Older channel deposits (Holocene)**--Estimated age < 10 ka. These deposits are elevated between 0.5-1 meter above the youngest stream beds. They are unconsolidated to poorly consolidated and contain a large fraction of sand and silt, although coarser cobbles and rarely boulders are prevalent in many of the smaller tributaries. Much of the sandy material was derived from granite and, to a lesser extent, diabase. The unit is commonly covered with thin soil and thick vegetation.

Qy **Holocene alluvial surfaces (Holocene)**--These deposits form small fans originating from some of the smaller drainages and are mapped separately from older channel deposits (map unit Qc) mostly on the basis of topography. These deposits are unconsolidated to poorly consolidated and contain silt, sand, gravel and cobbles originating from the local bedrock. They form relatively steep fans compared to the older channel deposits.

Qt **Talus (Quaternary)**--Unconsolidated, poorly sorted angular debris, locally derived, and mantling a few of the steeper slopes. The most common clast type by far is Dripping Spring Quartzite. None of the clasts observed exhibited desert varnish.

Qr **River terrace deposits (Quaternary)**--Poorly to moderately consolidated, poorly sorted silt, sand, gravel and cobbles. Larger clasts are subrounded. Exposed in the east-central part of the study area.

Qm_2 **Younger Pleistocene alluvial fan deposits (Quaternary)**--Unconsolidated to moderately consolidated deposits consisting of thinly stratified interbedded sandstone and conglomerate. Map unit underlies geomorphic surfaces that are topographically above channel deposits and Holocene alluvial surfaces (map units Qcy, Qc, and Qy) and below surfaces underlain by older alluvium (map unit Qm_1). Exposures on west side of Pinal Creek are up to 10 meters thick. Estimated age 10-100 ka. Beds are typically a few to tens of centimeters thick and are generally moderately sorted such that finer-grained sand and gravel layers are interbedded with coarser gravel and cobble layers. Clasts are composed of local rock types and are up to 0.5 meters in diameter, although most are sand- to cobble-size. All layers contain abundant sand and silt. Matrix contains no carbonate. Upper meter or so contains about 10-20% clay, but sand and silt dominate. Upper surface is covered by an open pavement of subrounded to subangular cobbles comprising less than 30% of the surface and are surrounded by much granite grus. The cobbles exhibit a weak varnish on some clasts.

Qm_1 **Older Pleistocene alluvial fan deposits (Quaternary)**--This unit forms the upper surface of map unit Tsy. Estimated age 150-1000 Ka. Locally, there is much soil development. Grass and low small desert trees are common on these deposits. The surface formed by deposits of this unit is similar to that on Qm_2 and is underlain by subangular to subrounded cobbles surrounded by a silt and sand matrix. Some of the clasts exhibit varnish. There appear to be equivalent

surfaces on the west side of Pinal Creek just north of Murray Wash. However, on the east side of Pinal Creek, just outside the southeast edge of the map, exposures in a quarry cut look very similar to the underlying younger basin-fill deposits (map unit Tsy).

Tsy **Younger basin-fill deposits (Tertiary)**--These deposits consist of moderately to well consolidated, moderately to poorly sorted, subangular to subrounded silt, sand, gravel and cobbles. The unit is tan to light brown and is generally slightly darker than older basin-fill deposits of map unit Tsm. All stratification observed is subhorizontal. The only exposures are on the east side of Pinal Creek.

Tsm **Older basin-fill deposits (Tertiary)**--This unit is composed of thinly to coarsely bedded, light tan, interbedded gravely sandstone and conglomerate. It contains subangular to subrounded, silt- to boulder-size clasts derived from all of the local rock types, in a light tan silt and sand, carbonate-rich matrix. The unit is moderately to strongly consolidated and forms steep, rounded, resistant ridges which are commonly deeply dissected. All exposures are on the west side of Pinal Creek, and can generally be distinguished from the younger basin-fill deposits in two ways: Tsm is commonly lighter in color, and it is tilted by as much as 30°.

Tta **Apache Leap Tuff (Tertiary)**--Welded ash-flow tuff containing 1-4 mm diameter phenocrysts of subhedral, rounded, partially resorbed clear quartz, subhedral and commonly broken clear to light grey feldspar, and fresh subhedral biotite, all in a light cream-colored aphanitic matrix. The unit commonly displays eutaxitic foliation defined by 1-10 cm augen-like cavities from weathered pumice or defined by weak related lineation on weathered surfaces. Subrounded xenoliths of diabase 1-5 cm wide are sparse yet widespread. Locally, the bottom 1-3 meters are vitrophyric and strongly welded, containing 1-10 cm long, compressed black crystal-rich pumice fragments. The tuff weathers into resistant, tan-colored ridges with rounded boulders separated by deeply weathered and recessed joints. At the outcrop scale, individual rocks break easily with one hammer blow and readily disintegrate into sand.

Tt **Bedded tuff (Tertiary)**--This unit is the non-welded base of the Apache Leap Tuff. It is light grey to white and contains subhedral phenocrysts of partially resorbed clear quartz, clear to white feldspar, and biotite in a light grey to white aphanitic matrix. Bedding is visible locally and is parallel to foliation in the Apache Leap Tuff. The unit is discontinuous and crumbles easily with one hammer blow.

Pzs **Carbonate, undivided (Paleozoic)**--Light grey to light blue grey massive micrite. Weathers into step-like ledges with rough, textured surfaces. Locally interbedded with 10-40 cm thick layers of purple shale. The limestone contains disarticulated crinoids, rugose corals, and brachiopods. Broken brachiopod shells 5-10 mm wide are abundant within a light tan layer 1-3 meters thick, about 10 meters up from the base of the limestone. In the northern part of section 31, at the north end of the limestone quarry, a small cut has exposed a karst surface overlain by terra rosa, chert and limestone debris 2-3 meters thick, and is overlain by 2-3 meters of purple shale. The unit forms resistant caps to hills. Individual blocks can be broken with 2-3 hammer blows.

Yd **Diabase (Proterozoic)**--Dark green to grey-green diabase composed of 1-10 mm, interlocking, tabular, subhedral phenocrysts of green to black pyroxene, clear to white plagioclase, and 1-3 mm opaque minerals (magnetite?). Phenocrysts are

commonly between 1-5 mm long and locally are up to 20 mm. The opaque minerals are commonly altered to red iron oxides and give the rock a slight rusty color. Generally, the diabase is highly weathered and easily crumbles with a hammer blow. It is highly fractured and erodes easily, forming slopes and valleys. Much of the sandy material in the washes is derived from the diabase. However, locally the rock is coherent and very resistant, forming steep, boulder-covered outcrops that, from a distance, resemble granite. At these outcrops the rock commonly takes 6-7 hammer blows before it breaks (none are near the proposed road). The diabase in central Arizona has been dated by several authors at between about 1040 Ma and 1150 Ma (Wrucke, 1989).

Ym **Mescal Limestone (Proterozoic)**-- Limestone and/or dolomite commonly with 10-30 cm thick beds which erode into step-like layers on weathered surfaces. This unit can usually be distinguished from the Paleozoic limestones by the following: the Mescal Limestone is highly fractured and locally slightly folded, it is a light to medium gull grey, as opposed to the typically light blue-grey of the Paleozoic limestones; it contains abundant lenticular to irregularly shaped, commonly anastomosing stringers of dark brown to black chert; and it contains no visible fossils. Locally, chert is very abundant and forms long, thin laminae parallel to bedding, helping to increase the unit's resistance to erosion. The unit forms the resistant hill tops in the northern half of the study area. It is highly fractured but some fractures appear to have healed. Individual blocks can be broken with 2-3 hammer blows.

Ydsc **Conglomerate within Dripping Spring Quartzite (Proterozoic)**--Light to medium grey conglomerate interbedded with the Dripping Spring Quartzite. The unit resembles the Barnes and Scanlan Conglomerates in that it is moderately well-sorted and contains well-rounded pebble- to cobble-size clasts of quartz, quartzite and jasper in a sandy, arkosic, siliceous matrix. The conglomerate commonly separates an underlying pink to tan, fine-grained argillaceous siltstone layer from an overlying white to tan, coarser-grained quartzite layer. It is remotely possible that this unit and the overlying quartzite are actually Troy Quartzite or Bolsa Quartzite.

Yds **Dripping Spring Quartzite (Proterozoic)**--Light tan to pink and white, thinly bedded metamorphosed sandstone, locally siltstone and rarely gravel-size conglomerate. The unit is generally well-sorted, containing moderately sub-rounded sand-size grains of quartz and light pink feldspar in a siliceous matrix. Cross-beds are abundant. Ripple marks are rare. Metamorphosed to quartzite but highly fractured and locally brecciated, especially adjacent to faults. Locally slightly folded. Commonly breaks along bedding planes to form step-like, blocky outcrops. The unit is resistant and forms steep rounded hills and small cliffs. Breaks with 3-4 hammer blows. The quartzite in the northern part of the study area contains a 5-8 meter thick layer of purple to tan, thinly bedded shale and minor sandstone near the base (above the mapped marker bed. Locally the shale layer contains rounded, green-yellow disk-shaped clasts up to several centimeters wide. The layer thickens northward, and is not visible to the south. The Dripping Spring Quartzite in the study area also contains an interbedded conglomerate 0-3 meters thick, mapped separately as Ydsc.

Ydsb **Barnes Conglomerate member of Dripping Spring Quartzite (Proterozoic)**--Grey to tan conglomerate containing moderately well sorted, well rounded pebbles and

cobbles of white vein quartz, and grey, red and tan quartzite and jasper, all in a tan to grey sandy, arkosic siliceous matrix. Imbrication is visible locally (not measured). The unit is typically between 1-3 meters thick and forms small cliffs and ledges. It is best exposed on either side of Highway 88 near Hicks Wash. The unit is fractured but generally resistant. Some of the fractures have healed with a silica cement.

Yp **Pioneer Shale (Proterozoic)**--This unit consists of thinly bedded purple, and locally tan, shale and siltstone metamorphosed to slate. The lower part is locally interbedded with a dark grey to tan quartzite layer which is exposed north of the study area and thins southward over a short distance. Mud cracks are abundant and ripple marks are visible locally (very limited data suggests current direction was to the northeast). The unit is highly fractured and erodes easily into smooth, dark-colored slopes. South of Dagger Spring the Pioneer Shale contains an intercalated conglomerate layer which merges laterally with the Scanlan Conglomerate.

Ypc **Conglomerate within Pioneer Shale (Proterozoic)**--Light steel grey pebble conglomerate, 1-5 meters thick, interbedded with purple shales of the Pioneer Shale. Exposed only on the northwest side of Hicks Wash south of Dagger Spring. The unit is merges laterally with the Scanlan Conglomerate but splits into two distinct layers. Contains moderately sorted, well-rounded clasts of light grey to tan and white quartz, quartzite and jasper, in a sandy arkosic matrix. Locally, it also contains thinly stratified, cross-bedded tan to grey quartzite layers up to 10 cm thick. Typically forms a small resistant ledge or small cliff. Individual outcrops are locally crumbly or very resistant.

Yps **Scanlan Conglomerate member of the Pioneer Shale (Proterozoic)**--The Scanlan Conglomerate appears lithologically indistinguishable from the Barnes Conglomerate in that it is moderately well-sorted and contains well-rounded pebble- to cobble-size clasts of quartz, quartzite and jasper in a sandy, arkosic siliceous matrix. It is 1-5 meters thick. Its position at the base of the Pioneer Shale is the best distinguishing factor. Locally, the lower part of the unit is rich in angular, poorly sorted debris derived from the underlying granite. In some places the granitic debris makes up most of the unit, and in other areas it is mixed with white, rounded quartz pebbles. The unit is generally resistant and forms a small cliff or ledge. Individual blocks are very resistant and take 4-5 hammer blows to break. Where fractured, individual blocks easily separate from the outcrop.

Yg **Ruin Granite (Proterozoic)**--Coarse-grained, K-feldspar porphyritic granite containing 1-10 mm wide anhedral to subhedral phenocrysts of white to milky quartz and plagioclase, about 5% 1-5 mm subhedral biotite, and 1-5 cm anhedral to subhedral pink megacrysts of K-feldspar. Plagioclase is commonly altered to a white chalky substance. The granite is rarely resistant and forms rounded boulders, but almost everywhere it is highly fractured and erodes easily into low crumbly hills with and orange-brown color. In most areas it is covered with grus and sandy silt from a few centimeters to 1-2 meters thick. Below the grus the rock is highly weathered and crumbles easily when struck by a hammer.