GEOLOGIC MAP OF THE GOLDFIELD QUADRANGLE AND THE NORTHERN PART OF THE SUPERSTITTON MTS. SW QUADRANGLES, MARICOPA AND PINAL COUNTIES, ARIZONA

by
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Arizona Geological Survey
Open-File Report 95-9

August, 1995

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

Includes 26 page text and 1:24,000 scale geologic map (2 sheets).

*Jointly funded by the Arizona Geological Survey
and the U.S. Geological Survey STATEMAP Program.
Contract #1434-94-A-1222*

This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards

INTRODUCTION

The Goldfield Quadrangle and Superstition Mountains are located about 40 km due east of Phoenix, Arizona, and a few miles east of Apache Junction, and include part of the Superstition Wilderness Area (Figure 1). Aerially extensive exposures of welded tuff form steep, rugged cliffs in the Superstition Mountains and overlie tilted felsic and mafic volcanic rocks, pre-volcanic cconglomerate, and Precambrian granite and Pinal Schist. This study was carried out concurrently with mapping in the Florence Junction Quadrangle and the southern part of the Weaver's Needle Quadrangle. Mapping in the Goldfield Quadrangle continued from January through April, 1995. The project was jointly funded by the Arizona Geological Survey and the U.S. Geological Survey under the STATEMAP Project, contract #1434-94-A-1222.

ACCESS

Much of the region lies within the Tonto National Forest. Within the study area there are only a few roads which penetrate any distance into the mountains. Highway 60/89 and State Route 88 (the Apache Trail) are the best avenues and afford some of the best views of the western escarpment of the range (Figure 2). Several dirt roads that allow entry into the southern foothills are reached by using the road to the Peralta Trailhead. About two miles up the Peralta Road, turn north after about on a dirt road which heads west and north. On the map it is the road about 1 mile southeast of the RRR Ranch (Apache Land). There are many dirt and paved roads around Dinosaur Mountain and King's Ranch but fences block access to Forest Land. Near Goldfield, a well-graded dirt road extends from just north of the Lost Dutchman State Park to the First Water Trailhead. Numerous well-kept trails provide excellent access to the rugged region north of the main range. The southern part is more remote except via the trail to Hieroglyphic Canyon, which is best reached by driving north of King's Ranch (in section 33) and then heading east to a dirt parking lot at the head of the trail.

The region has seen much historical activity. It includes the Superstition Mining District (later termed the Goldfield Mining District by Keith and others, 1983) which, according to some sources, may have been mined for gold as early as Spanish colonial times or before (Wilburn, 1993). Rusted tools, machine parts, old cans and pieces of metal, bottles, and even boots can be found scattered throughout the mountains. Grey and tan pot sherds, small stone circles and middens, and beautiful petroglyphs attest to the presence of prehistoric inhabitants in the area.

PREVIOUS INVESTIGATIONS

Workers from Arizona State University have studied much of the Goldfield-Superstition volcanic complex. Fodor (1969) studied the rocks in the Goldfield Mountains west of the study area. Stuckless (1969 and 1971) studied the geology and petrology of rocks between the Superstition Mountains and Canyon Lake. Malone (1972) examined the volcanic rocks in the Horse Mesa area, which, along with the Fish Creek area, was re-examined by Isagholian (1983). Suneson (1976) studied the northern and western parts of the Superstition volcanic field, north of the Salt River and west of the Apache Trail to the western boundary of the Mormon Flat Dam Quadrangle. In a paleomagnetic study of some welded tuffs in central Arizona, Sedgeley (1976) collected samples from the Superstition Mountains. Additionally, Hillier (1978) performed a geochemical study of the 'Latite of Government Well'. Prowell (1984) studied the rocks in the north-central part of the volcanic field, directly north of this study. The Mesquite Flat Breccia, north of the study area near Canyon Lake, was investigated concurrently by Rettenmaier (1984). Kilbey (1986) created a 1:12,000 scale map of the Goldfield area, which includes the north-western part of this study.

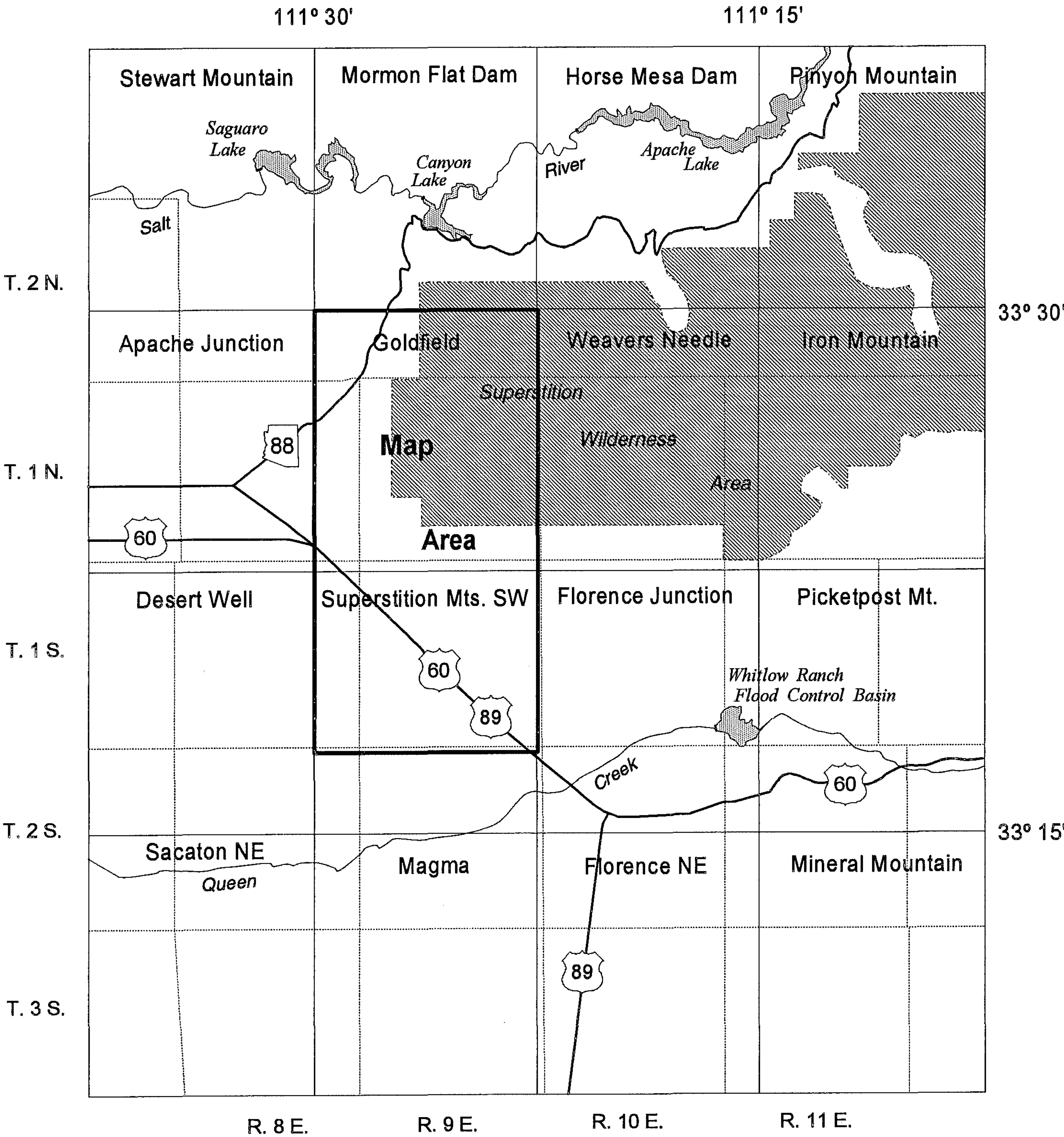

Figure 1. Index map showing the location of the map area and the U.S.G.S. 7.5' Quadrangles.

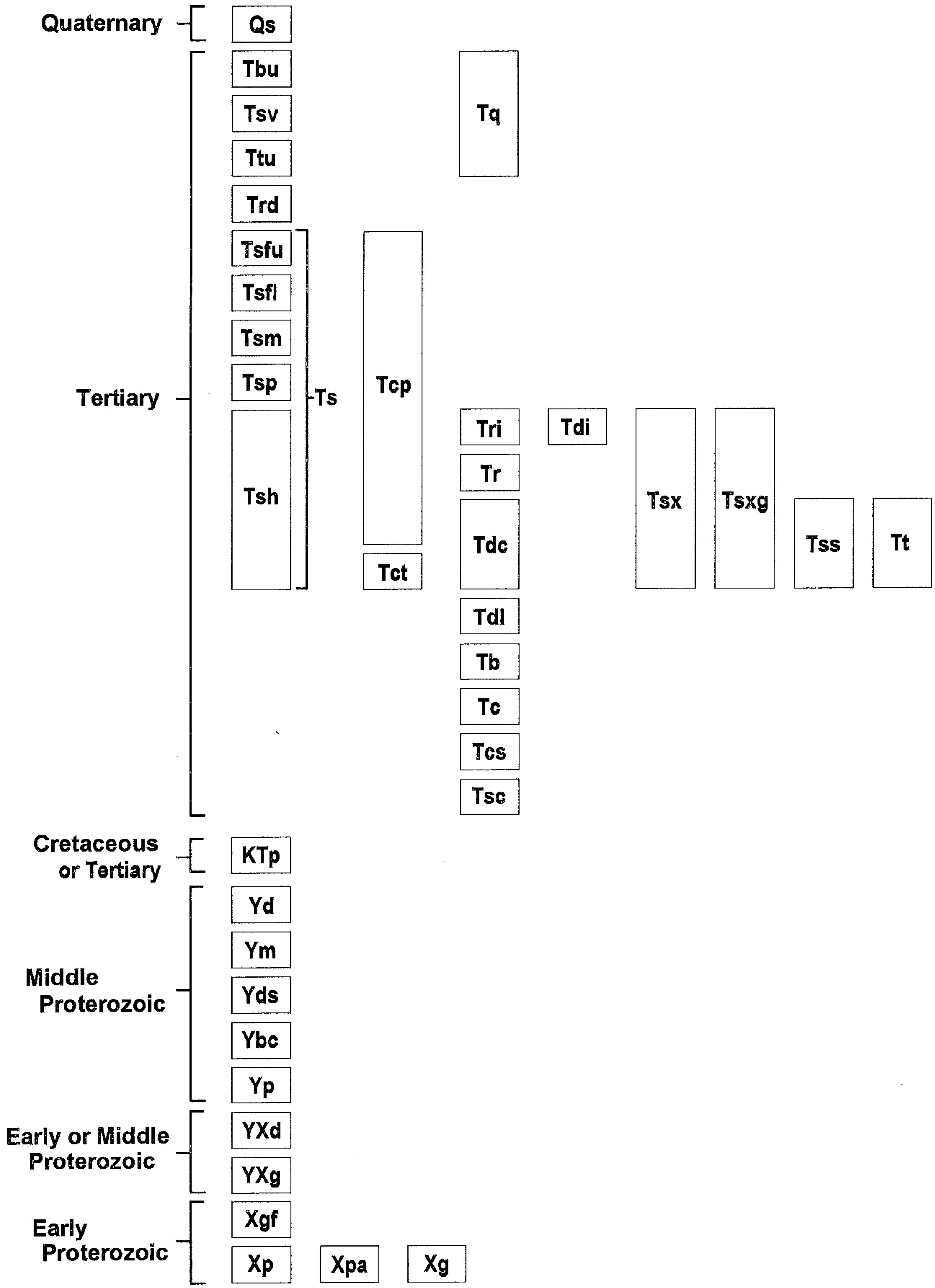

Figure 3. Correlation diagram for units in the Goldfield Quadrangle.

Scarborough (1981a,b) examined the northern edge of the volcanic field during reconnaissance surveys along the Salt River. Sheridan (1968, 1978, 1984, and 1987) has published much about the geology and stratigraphy of the entire volcanic complex; as have Stuckless and Sheridan (1971), Sheridan, Stuckless and Fodor (1970), and Sheridan and Prowell (1984). In a study of the geology and mineral resource potential of the Superstition Wilderness, Peterson and Jinks (1983) produced a 1:48,000 scale map of most of the Superstition Mountains and surrounding area. Melchiorre and Clemens (1993) produced a geologic map of part of the south-central Goldfield Mountains. Wilburn (unpublished) has made extensive surveys of the Goldfield area and has created a map and report about the mineralization in the Superstition Mining District.

Radiometric age determinations for the Goldfield-Superstition volcanic complex--including K-Ar, Rb-Sr, and fission-track ages--were gathered by Damon (1969), Foster (1993), Shafiqullah and others (1980), and Stuckless and Naeser (1972). Stuckless and O'Neil (1973) interpreted the protogenesis of the volcanic complex from strontium- and oxygen-isotope studies.

GEOLOGIC SETTING

The Superstition Mountains are approximately on the boundary between the Basin and Range and Transition Zone physiographic and tectonic provinces. All of the Paleozoic and Mesozoic supracrustal rocks in the study area have been removed by erosion and Tertiary sedimentary and volcanic rocks rest directly on the Precambrian basement (see figure 3). The basement consists of Early Proterozoic Pinal Schist and foliated granite intruded by Early to Middle Proterozoic granitic and minor dioritic rock. These rocks are overlain by faulted and tilted Middle Proterozoic sedimentary and mafic intrusive rocks of the Apache Group. A red-colored pre-volcanic conglomerate and overlying dark blue-grey alkali-olivine basalt are overlain by crystal-rich dacite (referred to by former workers as the latite or dacite complex). The dacite has been dated by the fission-track method on zircons at 29.90 ± 0.50 Ma* (Stuckless and Sheridan, 1971). It was originally thought that the dacite was interbedded with the lower portions of the Superstition Tuff (here termed the Hieroglyphic member) north of Siphon Draw. Re-examination of these rocks in 1997 has shown that the rocks are probably interbedded lenses of monolithic breccia derived from older dacite lavas. This interfingering is particularly well-exposed between the First Water Trailhead and the Massacre Grounds. Zircon fission track ages from the top and bottom of the Superstition Tuff (called the Siphon Draw member by Stuckless and Sheridan, 1971) are 25.00 ± 0.50 Ma* and 24.10 ± 0.90 Ma*, respectively (Stuckless and Sheridan, 1971). Damon and others (1969) reported a K-Ar age of 23.13 ± 1.00 Ma* taken from the west side of Black Mesa.

Apatite fission-track ages from granitic rocks north and northeast of the study area of about 51.70 ± 0.80 Ma* (Stuckless and Naeser, 1972) and between about 40 Ma and 80 Ma (Foster and others, 1993) indicate that the basement rocks were buried between 1 and 6 km deep (depending on the geothermal gradient at the time) until at least the Late Cretaceous and probably the Early Tertiary. The fact that arkosic conglomerate was being deposited in the area probably at least as early as the late Oligocene or early Miocene suggests that the region underwent relatively rapid denundation beginning in the Late Cretaceous.

TERMINOLOGY

Numerous workers in the Goldfield-Superstition Mountains region have introduced many new terms. In several cases the same unit has been called many different names, depending on where the unit was studied and what characteristics and classification schemes were used to make the determination. In an attempt to clarify the volcanic stratigraphy of the region we have created a correlation chart (expanded from Prowell, 1984) which correlates the terminology of many authors who have studied the area (see figure 4). [Further study in 1997 has produced a more accurate correlation of the rock units, in press].

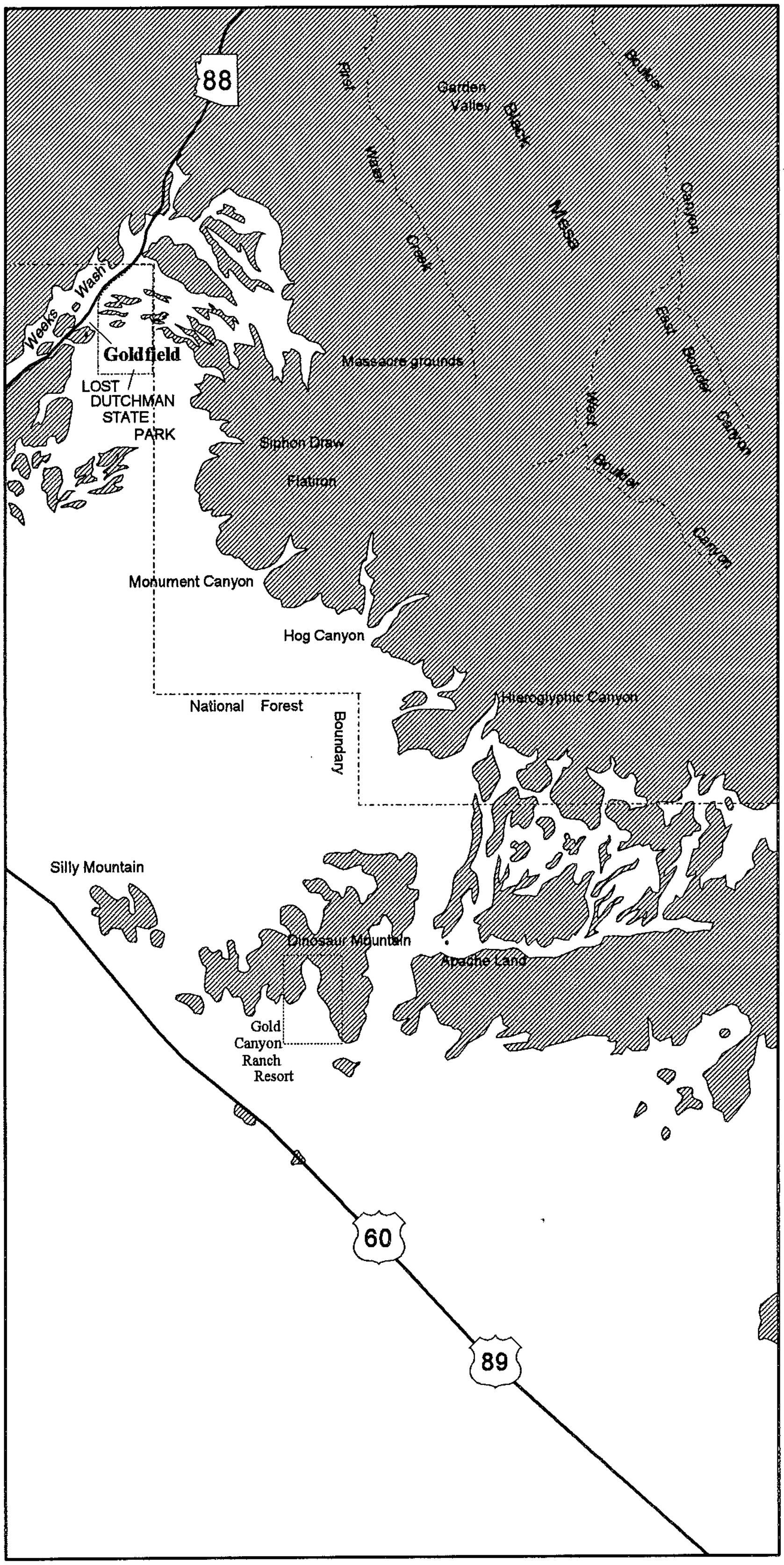

Figure 2. Place names within the map area used in this report.

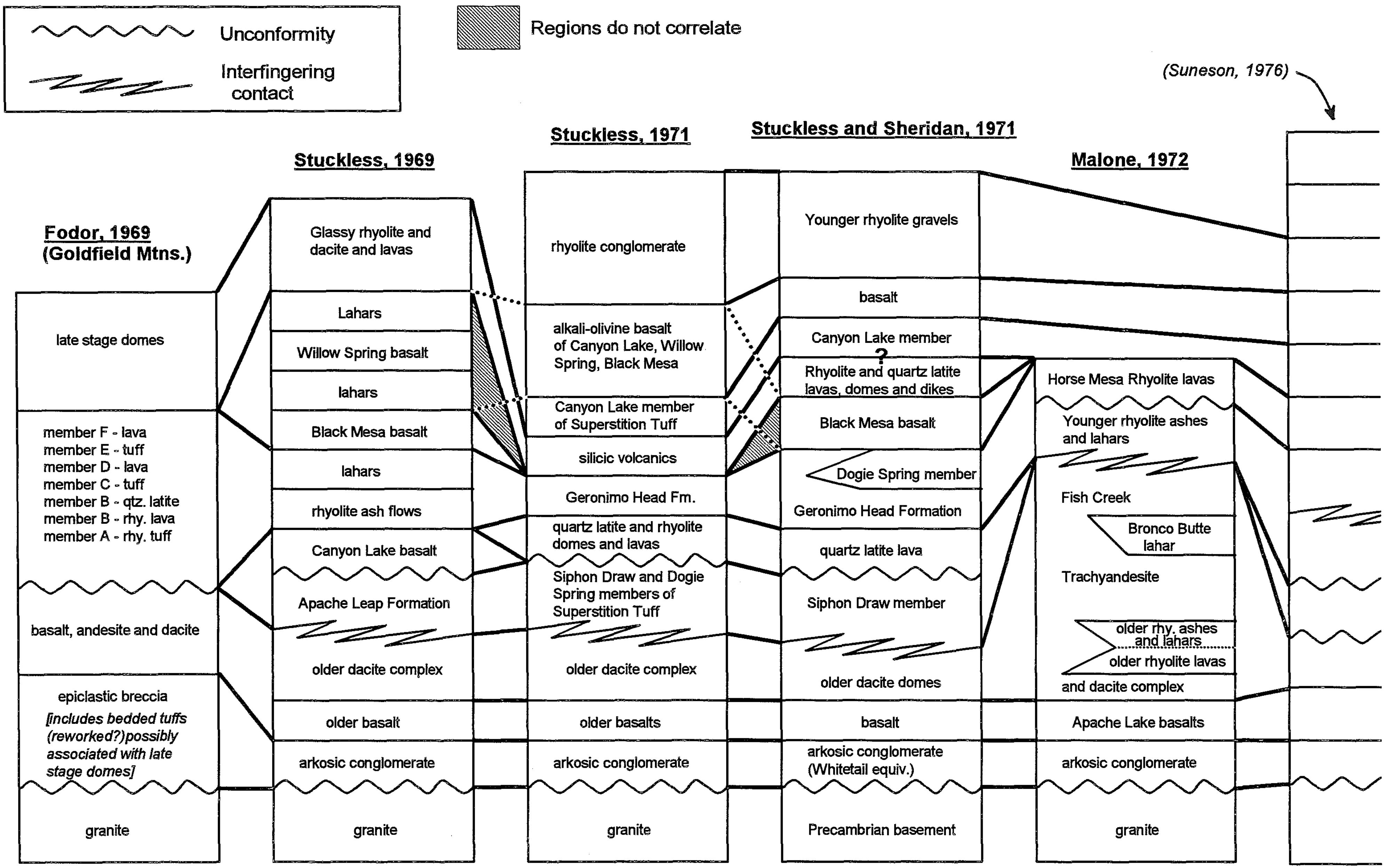

Figure 4a. Correlation of volcanic stratigraphy in the Goldfield-Superstition region (expanded from Prowell, 1984)

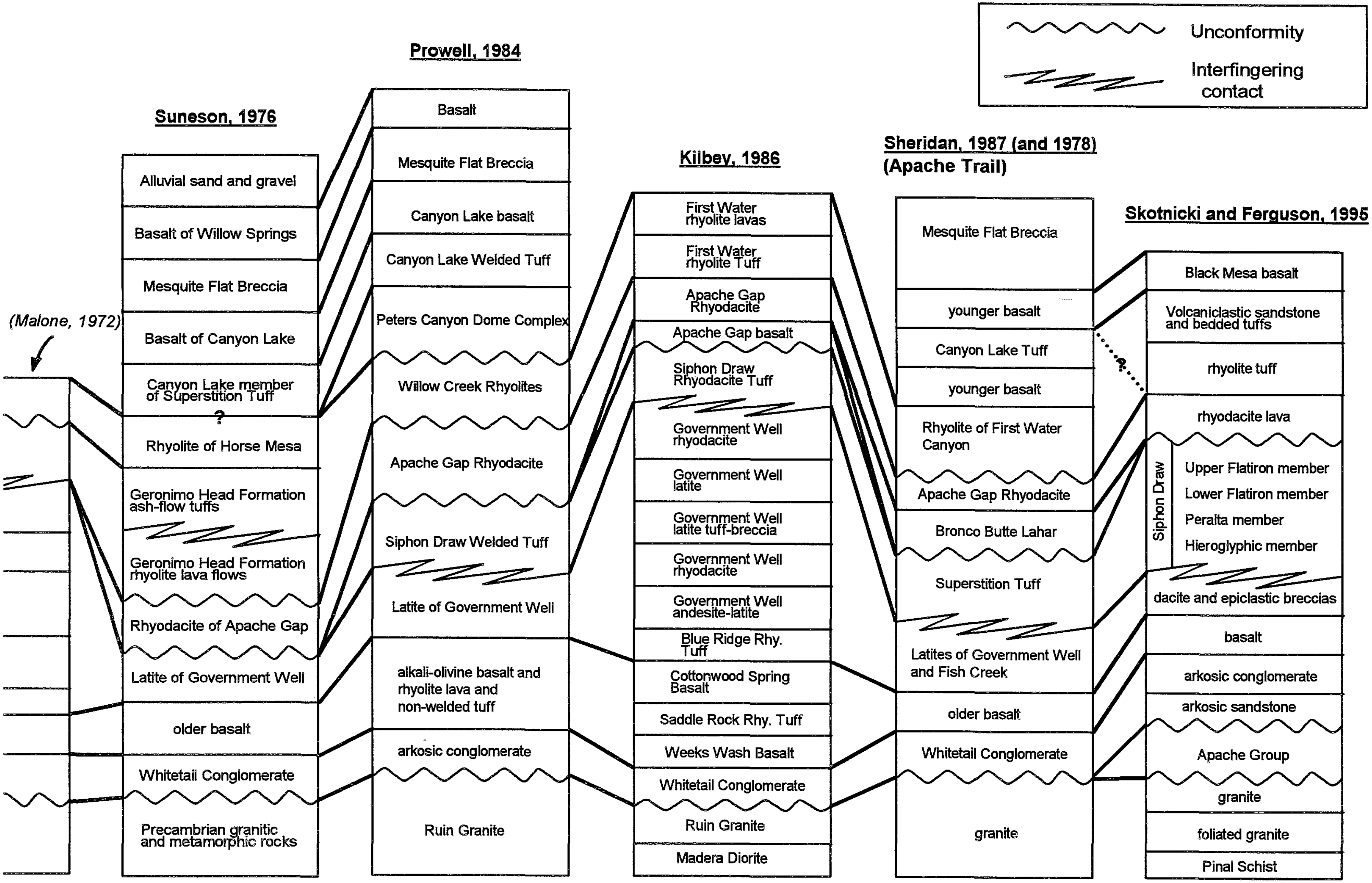

Figure 4b. Correlation of volcanic stratigraphy in the Goldfield-Superstition region (expanded from Prowell, 1984)

We have also tentatively introduced new terms for the Superstition Tuff. We recommend renaming the Siphon Draw, Dogie Spring, and Canyon Lake members all as Superstition Tuff. This allows us to subdivide the Siphon Draw tuff into several members; from bottom to top they are: Hieroglyphic member, Peralta member, Miner's Needle member (thin and discontinuous with respect to the other members), Lower Flatiron member, and Upper Flatiron member. This subdivision appears justified because the members of the Superstition tuff as we mapped them appear to be widespread and mappable over much of the Goldfield and Weaver's Needle Quadrangles. Also, it was thought that the Canyon Lake tuff was much younger than the Siphon Draw tuff based on sphene and zircon dates of 15.9 ± 0.80 Ma* and 15.4 ± 0.80 Ma*, respectively (Stuckless and Sheridan, 1971). New mapping in the Mormon Flat Dam and Horse Mesa Dam quadrangles in 1997 have shown that what has been called the Canyon Lake Tuff is stratigraphically and mineralogically equivalent to the Superstition Tuff. Stuckless and Sheridan (1971) state that the Dogie Spring tuff is both underlain and overlain by nonwelded ash of the Geronimo Head Formation. However, work by Peterson et al. (1983) shows that nowhere is the base of the 'Dogie Spring tuff' exposed. Further study east of Coffee Flat Mountain (Ferguson and Skotnicki, 1995) indicates that the Dogie Spring tuff is mineralogically indistinct from the 'Siphon Draw tuff' (based on visual examination of hand samples and thin sections). Even though Stuckless and Sheridan (1971) reported' an age of 18.85 ± 0.6 0 Ma* for the 'Dogie Spring tuff', the date seems suspect. The 'Dogie Spring tuff is probably the same unit as the 'Siphon Draw tuff'', and here we rename both of them the Superstition Tuff. Peterson and Jinks (1983) suggest that there may be another volcanic center within the Superstition Mountains which they called the LaBarge Canyon couldron. New mapping in 1997 northwest of Miners Needle tentitavely supports this and suggests there might be a structural margin seperating two areas of welded tuff. If there is a structural margin then renaming all of the welded tuff within the area as the Superstition Tuff may be an over simplification. More work needs to be done.

BLACK MESA

Black Mesa is composed of a dark grey to black, fine-grained basalt (dated to the north of the map area on Hackberry Mesa at 14.23 ± 0.47 Ma*, by Scarborough, 1981) overlying water-lain bedded sandstones and tuffs and a lower, discontinuous, massive lithic tuff. Near Hackberry Spring is a well-exposed unconformity between the lower massive tuff and the upper bedded unit. The lower tuff, here bedded, dips 37° to the southeast, whereas the overlying beds dip between 20°-30° to the east-northeast. All three units on Black Mesa generally dip less steeply than the underlying welded tuff (Probably the Hieroglyphic member of the Siphon Draw Tuff).

The relationship of the Black Mesa rocks to older units is not everywhere clear. It is not clear if the basalt is stratigraphically related to the basalt above the 'Canyon Lake Tuff'. The age of 14.23 Ma is consistent with the reported ages for the 'Canyon Lake Tuff'. However, Damon and others (1969) reported a date of 17.8 ± 3.1 Ma for basanite near Hackberry Mesa, and an age of 18.26 ± 3.10 Ma for basalt which overlies Mesquite Flat Breccia and Canyon Lake Tuff (see Suneson, 1976). Both dates have large error bars and are not very useful. The lower limit of these two dates is just slightly older than the 14.23 Ma age reported by Scarborough. The sample with the date of 17.8 Ma almost surely came from Hackberry Mesa. If the basalt above the Mesquite Flat breccia north of the study area is age-equivalent to the basalt on Black Mesa, then the basalt on Black Mesa is younger than the Mesquite Flat Breccia.

North of the map area "lahars" underlying basanite of Hackberry Mesa (Prowell, 1984) unconformably overlie rhyolite tuffs, lahars and flows, termed the Willow Creek rhyolites by Prowell (1984). Prowell subdivided the Geronimo Head Formation (first described by Stuckless, 1971) into the underlying Willow Creek rhyolites and the overlying Peters dome complex on the basis of an unconformity between the two. Nowhere, however, are the rocks on Black Mesa in contact with the rocks of the Peters dome complex. Dates of 16.68 ± 0.50* Ma on sanadine and 16.60 ± 1.10* Ma on sphene were obtained by Stuckless and Sheridan (1971) on the Geronimo Head Formation but it is not clear if these samples were taken from the Willow Creek rhyolites or the Peters dome complex, or if both units exist in the area. Both samples were reported taken from the uppermost ash-flow unit at their localities. Rhyodacites mapped by Peterson and Jinks (1983) appear to be continuous with rocks mapped by Prowell as the Peters dome complex. If these units are continuous and the dates were obtained from this younger unit then the units of Black Mesa are younger than the youngest rhyolites of the Peters dome complex.

STRUCTURE

Much has been written about the existence of calderas in the Goldfield and Superstition Mountains, inferred in part from exposures of voluminous, aerially extensive deposits of welded ash-flow tuffs. Resurgence is often cited as the reason why these welded tuffs in the Superstition Mountains now stand so high above the piedmont. Work in the northern portion of the Superstition volcanic field has revealed a region of complex faulting and basin-formation (Malone, 1972, Isagholian, 1983, Prowell, 1984, Rettenmaier, 1984). Several of the faults appear to have been active during volcanism and it has been suggested that they may indeed be related to resurgence. It has been suggested that long, arcuate faults are caldera-related ring fractures, and arcuate outcrops of rhyolite domes resting on welded tuff may have been related to refracturing of ring fractures and subsequent resurgence of the "Superstition caldera" (Sheridan and others, 1970, Peterson and Jinks, 1983). What has been difficult to show, however, is the location or locations of the actual caldera(s).

Evidence of at least one caldera exists in the Goldfield Quadrangle. The caldera margin itself is spectacularly exposed on the north side of Siphon Draw, a short hike from Lost Dutchman State Park. On the cliff face a high-angle contact (about 60°) between crystal-rich dacite on the west and welded tuff on the east defines the margin. The welded tuff is interbedded with lenticular layers of epiclastic breccia which pinch out rapidly from the contact (see Figure 5). This contact is interpreted to be a caldera fault which down-dropped dacite against dacite and formed a depression which filled with welded tuff and angular, poorly sorted debris shed from the newly formed cliffs of dacite. The contact exposed is a buttress unconformity. Locally the clasts within the breccias are surrounded by a tuffaceous matrix and in other areas the matrix appears to be sand and silt. Excellent exposures of interbedded welded tuff and breccia outcrop near the base of the cliff in the small side canyon about 100 meters north of Siphon Draw. South of this outcrop an east-dipping fault is exposed within the dacite and is truncated by the welded tuff and breccia. This fault is clearly visible from the trail in Siphon Draw as a small linear cave. Shallowly dipping contacts between welded tuff and dacite on the south side of Siphon Draw suggest that the caldera-margin fault swings either in to the east and the margin is buried, or out west of the cliffs and the contact represents welded tuff and breccia deposited on a topographic high of dacite within the caldera.

A similar relationship exists on the southern face of the Superstition Mountains, east of Hieroglyphic Canyon. Enormous thicknesses of epiclastic breccia reaching close to 1000 feet thick are interbedded with welded tuff (see figure 6). The breccias contain various mafic and felsic volcanic clasts as well as clasts of granite, schist and welded tuff. The clasts are also locally surrounded with either a tuffaceous or sedimentary matrix. The interbedded welded tuff and breccias thin rapidly to the west as they lap onto a topographic high of dacite. The dacite high either represents an erosional remnant or a volcanic dome, as has been suggested by previous workers. Within the breccias an interbedded layer of dacite lava (rhyodacite? monolithic breccia?) suggests that dacite volcanism continued during deposition of the breccias. Indeed, an autobrecciated dacite flow at the base of the Peralta member to the northeast shows that volcanism continued at least through deposition of the Hieroglyphic member (or this flow is really a breccia layer). Also, locally within the breccia (and into the Weavers Needle Quadrangle) are huge house-size-or-larger blocks of felsic volcanic blocks (locally mapped separately as Tsxg), suggesting the existence of a steep escarpment at the time of deposition. The dacite here contains interbeds of light tan to light purple gravely volcaniclastic sandstone which, from a distance, resemble bedded tuff.

The interbedded welded tuff and breccia east of Hieroglyphic Canyon dip form layers that dip to the south-southeast--quite different from the overlying welded tuff that forms the main ridge of the Superstition Mountains. The transition from tilted to relatively untilted layers is very abrupt. The abrupt

Siphon Draw

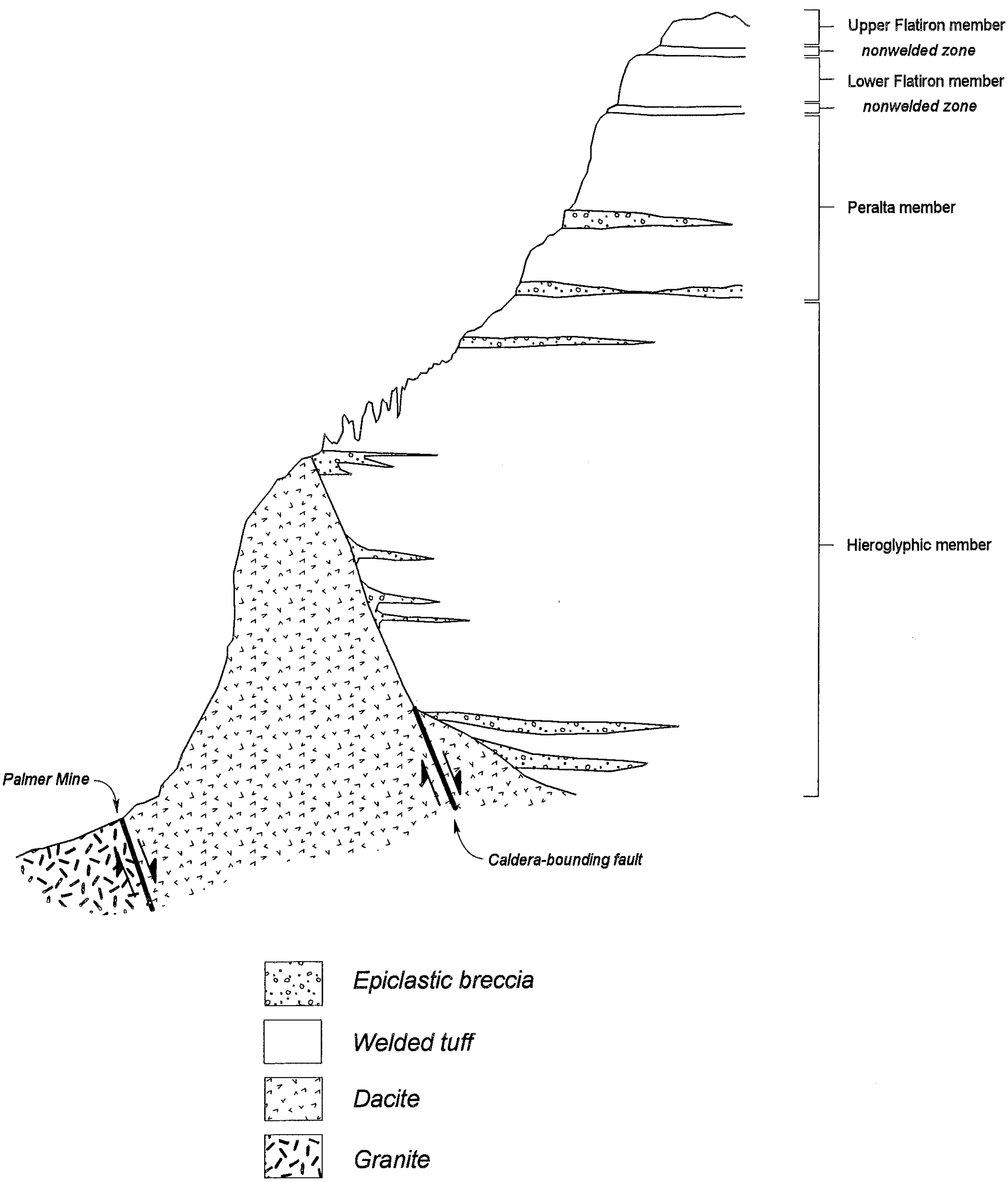

Figure 5. Diagramatic cross-section through Siphon Draw.

change in dip probably cannot be adequately explained by the presence of much paleo-relief before deposition of the breccias and lower welded tuff. A fault in Hieroglyphic Canyon down-drops welded tuff against dacite low in the canyon, yet layers of welded tuff higher up are undisturbed. The inference is that faulting occurred while the lower portions of the Hieroglyphic member were being deposited. The fact that the layers dip toward the probable margin of the caldera suggests that down-dropping occurred along the margin while uplift, possibly a result of upwelling magma, occurred in the center.

Immediately south, in the northeast corner of T. 1 N. section 35, a steep contact between an older dacite lava (map unit Tdl) and epiclastic breccia suggests this contact may have also been a caldera margin. A northwest-trending fault juxtaposes welded tuff of the Peralta member on the south against dacite and welded tuff of the Hieroglyphic member on the north. Welded tuff of the Peralta member directly overlies and truncates the steep contact between the older dacite and breccias. This is important for it shows that, upon reconstruction of the units on either side of the northwest-trending fault, the inferred caldera margin was elevated (relative to the lower contact of the Peralta member to the north) about 1600 feet. This is supported by the fact that there are no welded tuff members below the Peralta member in section 35.

The impressive, high-standing range of the Superstition Mountains is a relatively flat-lying, undisturbed block bounded on at least three sides by high-angle faults (see figure 7). A northeast-trending, southeast-dipping high-angle normal fault separates the northwestern cliff face from the flat valley to the west. The fault is not very well-exposed but it down-drops dacite on the east against granite on the west.

The northwest-trending fault exposed near Hieroglyphic Canyon bounds the south side of the range. It is a high-angle fault and dips to the north. The fault is poorly exposed, but if the hills south of the fault are indeed underlain by welded tuff of the Peralta member, then it must be a reverse fault. If, as stated, there was at least 1600 feet of relative uplift of the north side, and the welded tuff members in the main range of the mountains are subhorizontal, then the entire block was elevated at least 1600 feet relative to those hills. If the western escarpment was raised that much and there are still supracrustal rocks down-dropped against granite, then there had to have been more than 1600 feet of subsidence in the caldera. The reverse offset on the fault near Hieroglyphic Canyon is probably the best evidence for probable resurgence in the caldera.

The north side of the relatively horizontal Superstition Mountains block is bounded by a north-dipping, northwest-trending normal fault. The amount of offset on this fault is uncertain but it down-drops welded tuff (probably the Hieroglyphic member) and dacite on the north against the same units on the south. On the north side of the fault, near the Massacre Grounds, is a thinly bedded to massive, light yellow, nonwelded tuff of uncertain origin. Light colored, nonwelded zones are common east of the study area between Miners Needle and the Peralta Trailhead, where they separate ash-flow units, and commonly thin and thicken within a short distance. It is thus possible that the tuff near the Massacre Grounds may be a nonwelded break between welded ash-flow members in the area. However, the area has not been completely studied. The northwest-trending bounding fault separates the relatively undisturbed, high-standing block on the south from an intensely faulted terrain on the north and defines a break-away zone.

In the Goldfield area at least two different sets of faults are exposed; a north- to northwest-trending high-angle set, and a north-trending low-angle set. All faults but one dip to the west-southwest. The north-northeast trending fault bounding the western escarpment of the Superstition Mountains appears to dip to the east. Although the area underlain by granite west of this fault is a low, relatively flat valley, the block of granite actually represents a horst separating the main range from the Goldfield area. This inverse topography also exists in the valley on the south side of the range south of the Peralta Trailhead, in the Weavers Needle Quadrangle. Near Goldfield the relationships between the low-angle and high-angle faults are not well-exposed. One exposure, about one mile north of Lost Dutchman State Park, on the west side of the Apache Trail, clearly shows a northwest-trending fault cutting a north-trending low-angle fault. However, rock units exposed on isolated hills around Goldfield do not continue along their strike to the west side of Weeks Wash. This suggests that a major north- northeast-trending fault (probably a continuation of the fault to the north) underlies Weeks Wash and offsets the older(?) northwest-trending high-angle faults.

MINERALIZATION

Superstition Mountains: Little mineralization is visible in the welded tuff. East of the First Water Trailhead, hematite is locally abundant on fault and fracture surfaces. Locally, minor light grey chalcedony also fills some fractures. No other mineralization was seen.

To the south of Hieroglyphic Canyon, many prospects have been dug into Pinal Schist. Epidote-rich foliated amphibolite lenses locally contain traces of chrysocola, hematite, and white quartz, especially near the contact with the Pinal Schist. Chrysocola stains are locally visible at the contact between Pinal Schist and nonfoliated diorite (map unit YXd).

In the south-central part of section 35, a hill of white quartz, locally stained with hematite, crops out within granite. There are several dirt roads leading to the hill, which has been heavily quarried, but no evidence of hydrothermal minerals other than quartz was seen.

Below black Mesa a thin rhyodacite flow has been mostly altered to light grey porcelanite such that, in most areas, all that is visible are 1-4 mm clear, subrounded quartz phenocrysts in a light grey aphanitic matrix. A few dikes in the area have also been similarly altered.

Goldfield:[Because many of the mines around Goldfield have been disturbed, partially buried or completely covered, it was not possible to directly study most of the workings. Therefore, much of the following was taken (and modified) from an unpublished report by J.D. Wilburn.] The Superstition Mining District (later termed the Goldfield Mining District by Keith and others, 1983) was established in 1893 and includes the area in and around Goldfield (see figure 8). Though not a large district locally, the ore was incredibly rich. During its heyday from 1893 to 1898, the Mammoth, Bull Dog, and Black Queen mines produced $1 million in gold and silver from rich electrum deposits. A dozen smaller mines also have produced gold and silver. Sporadic mining in the district, as late as 1986, produced a total of about 60,000 ounces of gold and 20,000 ounces of silver.

Throughout the Goldfield area, faults and fractures are locally filled with coarse-grained calcite and crystal-rich dacite dikes having mineral compositions similar to the dacite lavas (map unit Tdc). In fact, all dikes observed were the same composition. Locally, broad areas of rock have been hydrothermally altered. Two miles south of Goldfield hills of dacite are altered to light hues of pink, green and grey. The mafic minerals have been weakly altered to hematite and the feldspars appear to have been altered to clay minerals. Chloritic alteration and dark hematite staining (possibly from the alteration of disseminated sulfides) was also seen. Many outcrops display small areas of iridescent limonite, with metallic colors resembling bornite. The colorful outcrops have attracted prospectors, evident by shallow pits and trenches in the area. Intense hydrothermal alteration occurs in the white-colored pits just south of Mountain View road, where most of the area is light colored clay and possibly gypsum(?).

Hydrothermal solutions have preferentially altered the dacite. Locally. however, the lowermost 3 meters or so of basalt is also altered to light shades of pink and tan. Chrysocola stains fractures (N15°W, 55°) in basalt on hills almost 3 miles north of Goldfield. In this area manganese films are common on fractures in dacite.

Mammoth Mine. The district's largest mine, the Mammoth, was dug into arkosic conglomerate along one or more north-trending normal faults. Outcrops are very limited, but the fault(s) separate conglomerate and basalt in the hanging wall block from granite in the footwall block. Immediately to the south of the mine an exposure of dacite crops out in a large trench. The dacite is bounded on both the east and west by high-angle contacts but the dacite is white and hydrothermally altered to clays, and the exposures in the trench are crumbly and indistinct. It is possible that the dacite is not a down-dropped block, as shown on the map, but is actually an intrusion. The electrum-rich Mormon Stope in the mine occurs within a high-angle shear zone (here called the Mammoth Fault) 30 feet wide, and dips 83°W.

Between 65 and 200 feet below the surface the Mormon Stope produced over 40,000 ounces of gold. Gold occurred abundantly as wire, dust, and flakes in white to glassy quartz stained strongly by pyrolusite, hematite, and limonite. A smaller ore body occurred 500 feet south on the fault. Rich ore extended to 400 feet in narrow veins. Below 1,022 feet, ore values diminished.

Black Queen Mine. The Black Queen Mine lies about 3,000 feet north of the Mammoth Mine in a zone of complex faulting. In the main exposed pit a high-angle fault zone, down-dropping basalt on the west from sandy conglomerate on the east, strikes N30°E-N40°E, is about 20 feet wide, and contained epithermal quartz rich in gold and silver. Rich ore stained strongly by pyrolusite and minor hematite contained free gold as dust, flakes, and wires. The electrum contained 36% silver. No sulfides occur in the ore. High-grade ore carried hundreds of ounces of gold per ton in narrow veins 1-5 inches wide. One five inch wide vein, assaying 100 ounces of gold per ton, was stoped from the 150 foot level for 75 feet. Total gold production was about 6,000 ounces. Down-faulted basalt in the hanging wall contained a large manganiferous calcite vein about 3 feet wide and 100 feet in length, and carries low values in gold and silver.

Old Wasp Mine. The old Wasp Mine lies about 1,000 feet south of the Mormon Stope on the foot wall of the Mammoth Fault. The ore shoot is unique in the district, occurring in silicified granite which resembles rusty rhyolite. A shear zone, dipping from about 75° to near-vertical, contained fine electrum (gold and about 20% silver). Free gold with minor galena, cerrusite, and malachite occurred central to the ore shoot. In 1983, within 30 feet of the surface, the ore yielded over 2,500 ounces of gold. The ore shoot pinched to a narrow vein. An old drift underground intersected the ore shoot on the 1,022 foot level where gold values averaged 0.66 ounces per ton along 40 feet of the drift.

Bluebird Mine. A fault zone, dipping 60°-70° to the west cuts conglomerate and interbedded basalt on the hill immediately south of Goldfield. The fault contained a small elliptical shoot of quartz about 3 feet wide, which was very rich in electrum. The original shaft was 55 feet deep, now 120 feet deep. Production is unknown.

Bull Dog Mine. The Bull Dog Mine lies 1.35 miles west of Goldfield (in the Apache Junction Quadrangle) dug into a near-vertical fault zone filled with a large manganiferous calcite vein 400 feet in length. The fault separates granite in the hanging wall on the east from granite in the foot wall on the west. The south end of the large calcite vein contained a large shoot of epithermal quartz 45 feet long and 3 feet wide rich in electrum and assaying in gold up to 250 ounces per ton. The quartz locally surrounded by brecciated volcanic rocks and calcite. Near the surface the ore contained pyrolusite but no sulfides. At 105 feet pyrite was abundant. The vein is fractured and contains slicks, indicating renewed faulting after emplacement. The mine has produced about 6,700 ounces of gold. Other manganiferous calcite veins occur in the vicinity of the mine.

*These radiometric ages have been recalculated using updated decay constants.

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UNIT DESCRIPTIONS FOR THE GOLDFIELD QUADRANGLE
AZGS-OFR-95-9

Qs **Quaternary surficial deposits**--Unconsolidated to moderately well-consolidated sand, gravel and conglomerate deposits of various ages.

Tbu **Basalt**--Very fine-grained, dark grey to black basalt containing 1-2 mm phenocrysts of clear plagioclase, olivine locally altered to red iron oxides, and rare clear nepheline.

Tsv **Volcaniclastic sandstone**--Yellow, thinly bedded volcaniclastic sandstone and possibly minor tuff. Beds are normally graded and contain rounded cobbles of welded tuff and dacite near the base and sand-sized volcanic fragments, quartz, and pumice near the top. Locally, on the south and southwest sides of Black Mesa, the unit is light brown and erodes readily, forming a steep slope. Excellent exposures along First Water Creek contain thinly bedded air-fall tuff layers up to 1 meter or so thick. Near Hackberry Spring tuffaceous sandstones unconformably overlie more steeply tilted bedded lithic tuff (map unit Ttu).

Tq **Quartz latite**--Crystal-rich (>35%) lavas containing plagioclase, sanidine, quartz, and biotite ± hornblende. Quartz phenocrysts are typically large (up to 1 cm) and embayed. This unit is very resistant and forms steep cliffs in the northeast corner of the map area. Prowell (1984) described variations in the percentage and abundance of phenocrysts for separate flows and named the unit the Peters Canyon dome complex.

Ttu **Lithic tuff**--Commonly nonbedded, but locally bedded massive yellow lithic tuff containing 1-3 mm phenocrysts of subhedral biotite and plagioclase. Contains subangular pebble- to cobble-size clasts of dacite (map unit Tdc), basalt, and pumice, in a light yellow to tan matrix. Fresh surfaces are light yellow to light grey. Weathered surfaces are tan to yellow and are locally either lighter or darker than adjacent volcaniclastic sandstone (map unit Tsv). Resistant and forms small cliffs.

Trd **Rhyodacite**--Yellow to grey rhyodacite lava containing about 5% 1-3 mm subhedral phenocrysts of biotite, plagioclase, and quartz. This unit forms a 0-8 meter-thick lens below lithic tuffs below Black Mesa. Towards the southwest end of Black Mesa the lava has been strongly altered to light grey porcelanite, in which the only phenocrysts visible are clear quartz. A few small porcelanite dikes appear to cut across welded tuff and the rhyodacite.

Ts **Superstition Tuff (or Siphon Draw Tuff)**--A very thick (several 100's of meters) sequence of crystal-rich rhyodacite ash-flow tuffs containing 25-40% phenocrysts of feldspar, biotite, and resorbed quartz. Quartz phenocrysts, commonly as large as 1 cm, comprise about half of the total phenocryst population which seems to distinguish this unit from the Comet Peak Tuff (map unit Tcp) in which quartz comprises one third or less of the phenocrysts. The size range of the other phenocrysts is 1-5 mm. The Superstition Tuff is separated into numerous sub-units by poorly welded to nonwelded zones of varying thickness (1-20 meters) that are commonly lithic-rich. Some zones appear to represent thin autobrecciated lava flows of dacite (and mafic lavas in the Weavers Needle Quadrangle). Many of these units can be correlated across great distances along the steep mountain front of the Superstition Mountains by physically tracing the more prominent unit boundaries, and this technique forms the basis for the definition of a number of members. Stuckless and Sheridan (1971) reported fission-track ages on zircon from the bottom and top, respectively, of the Superstition Tuff, of 24.10 ± 0.90 Ma* and 25.00 ± 0.50 Ma.* A K-Ar age reported by Damon and others (1969) of 23.13 ± 1.00 was taken from near Black Mesa.

Tsfu/l **Upper and Lower Flatiron members of the Superstition Tuff**--Two prominent members (lower, Tsfl, and upper, Tsfu) named for "The Flatiron", which make up the high, flat peaks at the west end of the Superstition Mountains. The basal contacts of each member are marked by prominent benches or ledges that can be traced eastward from the Flatiron to the to the highest point of the Superstition Mountains (near Hieroglyphic Canyon). The basal contact of the lower Flatiron member is the narrow ledge in the middle of the big cliff that makes up "The Flatiron". This ledge corresponds to a 3-10 meter-thick, light-colored, lithic-rich, poorly welded to nonwelded zone with a sharp base and a gradational upper contact into densely welded tuff. The base of the upper Flatiron member forms the broad "flat" area above the same major cliff. From The Flatiron area, the base of the lower member can be physically traced to its currently known eastern limit just west of Fremont Saddle at the head of Peralta Canyon (in the Weavers Needle Quadrangle). Note that the lower cliff in The Flatiron area corresponds to the Peralta member.

Tsm **Miners Needle member of the Superstition Tuff**--This unit is named for a package of several (2-5) thin, welded or poorly welded flow units that crop out through the middle of Miners Needle (in the Weavers Needle Quadrangle). The flow units are bounded by sharp contacts, and at the base of at least one of the flow units, a 1-3 meter-thick, pyroclastic surge sequence is noted at numerous localities. In the Weavers Needle Quadrangle the surge sequence(s) have upper and lower contacts that dip consistently dip 10° to 20° steeper to the north than the eutaxitic foliation in the surrounding welded tuff.. Westward from Miners Needle, in the Goldfield quadrangle, the Miners Needle member thins to less than 2-3 meters, and consists of a lithic-rich, nonwelded tuff zone that is shown without thickness on the map (i.e., the contact between the Hieroglyphic and Peralta Canyon members). In some areas lithic-rich tuffs of the Miners Needle member grade into thin autobrecciated dacite.

Tsp **Peralta member of the Superstition Tuff**--A thick, typically massive unit that underlies the Flatiron members and overlies the Hieroglyphic member. The base is defined by the top of the Miners Needle break (mapped the Miners Needle member to the east in the Weavers Needle Quadrangle) . Locally the member includes breaks (<2 m), recessive, inversely graded zones. In Siphon Draw the lower part of the member includes at least two, discontinuous, 0-20 meter-thick dacite-rich breccia horizons.

Tsh **Hieroglyphic member of the Superstition Tuff**--A thick sequence of densely welded tuff that underlies the Miners Needle break (mapped as a member to the east in the Weavers Needle Quadrangle where it is thicker). The lower part of this unit in its type area of Hieroglyphic Spring is dark red-brown in color and contains distinctive, dark red-colored, poorly compacted crystal-rich pumice fragments or magma clots from 2-20 cm wide. The abundance of these red clots or pumice diminish upward, and the upper 100-150 meters of the member is indistinguishable from the overlying members. The unit contains numerous breccia units along the steep, south-facing front of the Superstition Mountains, and near Siphon Draw, interbedded with welded to nonwelded tuff.

Tcp **Tuff of Comet Peak**--Crystal-rich, rhyodacite, welded ash-flow tuff containing 30-40% phenocrysts of feldspar, quartz, and biotite. Marginally distinguishable(?) from the

Superstition Tuff because feldspar phenocrysts are more abundant than quartz, but very similar in all other aspects. The unit contains abundant biotite (1-3%), and quartz phenocrysts are strongly resorbed. The base of the tuff is locally a dark colored vitrophyre displaying lineated pumice fragments which consistently trend NNE. The Comet Peak Tuff has previously been referred to as the Superstition Tuff, but its phenocryst assemblage (in particular its quartz to feldspar ratio of between 1:2 and 2:3) is more akin to the younger Apache Leap Tuff. We also believe that the Comet Peak Tuff may be distinguished from the Apache Leap Tuff, because it seems to fill a cauldron-like depression in the south-central part of the Florence Junction Quadrangle--bounded by a fault on the east side--originally referred to as the Florence Junction Cauldron (Sheridan and others, 1970). The Apache Leap Tuff was probably derived from the Haunted Canyon Cauldron (Peterson, 1960) and therefore the Comet Peak Tuff may represent a distinct welded ash flow tuff.

Tct **Tuff of Comet Peak, poorly welded interval**--Lithic-rich, poorly welded zone of the Comet Peak Tuff.

Tri **Intrusive rhyolite**--Contains <5% anhedral to subhedral phenocrysts of feldspar and biotite in a tan to light grey aphanitic groundmass. Forms dikes at Dinosaur Mountain and one dike in Hieroglyphic Canyon. Commonly flow-banded.

Tdi **Intrusive dacite**--Crystal rich dacite 1-10 mm subhedral to euhedral phenocrysts of light grey plagioclase, black biotite and hornblende (both locally altered to hematite), and less abundant resorbed quartz, all in a pale green to tan aphanitic matrix. Plagioclase crystals have white rims or are completely white, with altered cores. Forms resistant, pale green dikes which intrude faults in the Goldfield area. At Dinosaur Mountain several large intrusive bodies of dacite and associated dikes are cross-cut by more resistant, rhyolite dikes which are sub-parallel to the dacite dikes. This unit is probably equivalent to rhyodacite dikes containing more resorbed quartz in the Weavers Needle Quadrangle near Dacite Cliffs (Ferguson, and Skotnicki, in press).

Tr **Rhyolite**--Crystal-poor, light tan lavas containing less than 2% anhedral to subhedral phenocrysts of clear to light grey plagioclase and fresh black biotite in a light tan to light pink aphanitic matrix. Locally flow-banded and rarely vitrophyric. Well exposed west of Dinosaur Mountain and at Silly Mountain where the unit forms steep, rounded, resistant hills.

Tsx **Mesobreccia**--Very poorly sorted, clast-supported rock avalanche deposits interbedded with welded tuff. Clasts, though as large as several meters, are typically less than 1 meter in size. The matrix consists of gradations between two types: 1) light-colored nonwelded tuff of similar composition to the welded tuff, and 2) dark red-brown to purple fine-grained granular material interpreted as autoclastic detritus derived from abrasion of the lithic blocks during their emplacement (probably as avalanches). Near Siphon Draw the deposits consist of angular to subrounded sand- to boulder-size clasts of dacite. East of Hieroglyphic Canyon the unit is interbedded with discontinuous, south-dipping layers of welded tuff and contain sand- to boulder-size clasts of felsic volcanic rocks of various types, welded tuff, basalt, and minor granite.

Tsxg **Megabreccia**--Lithic breccias with matrix similar to map unit Tsx, but distinguished because of the exceptionally large size (greater than tens of meters) of the lithic blocks. The large lithic blocks are also characteristically monolithic, either rhyolite lava (map unit Tr), or dacite lava (map unit Tdl), and it appears in some areas that these blocks may be only partially dismembered lava flows interfingering with the Superstition Tuff.

Tdc **Dacite**--Contains subhedral 1-15 mm phenocrysts of clear to light grey plagioclase and subhedral to euhedral 1-8 mm phenocrysts of biotite and hornblende in a dark maroon to blue-purple aphanitic matrix. The unit is crystal-rich, containing about 20-25% phenocrysts. Exposures near Dinosaur Mountain are fresh and locally vitrophyric. They also contain thin layers of yellow bedded tuff. At Silly Mountain flow-banding within the unit is parallel to flow-banding in the surrounding rhyolite. Immediately east of Hieroglyphic Canyon the dacite contains beds of volcaniclastic sandstone (map unit Tss) and forms a steep abutment to onlapping welded tuff and breccia, and may represent a volcanic dome. Near Goldfield the unit is interbedded with basalt, dacite breccia, tuffaceous breccia, and locally bedded tuff. The bedded tuff occurs both as thin bands 1-3 meters thick within the dacite and as dacite-lithic-rich zones at the base above basalt. Between the Massacre Grounds and First Water Trailhead strongly indurated to crumbly dacite autobreccia is interbedded with welded tuff of probably the Hieroglyphic member and possibly epiclastic breccias. Stuckless and Sheridan (1971) reported a date of 29.0 ± 0.5 Ma on zircon from a sample of this unit taken from an exposure in Hieroglyphic Canyon. The sample was reported taken from the base of a dome, but the base of the unit is not exposed in Hieroglyphic Canyon.

Tss **Sandstone**--Thinly bedded, moderately sorted volcaniclastic sandstone composed of subangular sand- and gravel-size clasts of dacite in a purple, sandy matrix. The clasts are derived from the underlying dacite. The deposits are 4-10 meters thick but pinch out up hill, and are overlain by interbedded breccia and welded tuff.

Tdl **Lower dacite**--Relatively crystal-poor lava (2-5% phenocrysts). Contains phenocrysts of subhedral biotite, hornblende, and feldspar (probably plagioclase) in a grey to maroon aphanitic groundmass. Mafics are commonly altered to hematite. Plagioclase(?) is commonly altered to a yellow, crumbly mineral, possibly zeolite. There is much secondary quartz, locally, forming crusts on joint surfaces and filling fractures. Weathers brown to maroon and erodes into rounded hills. Exposed only on hills about 2 miles east of Hieroglyphic Canyon. Probably equivalent to the San Mateo Castro Ranch Dacite in the Florence Junction Quadrangle (Ferguson and Skotnicki, in press).

Tt **Bedded tuff**--Undivided yellow to tan bedded lithic tuffs containing various subangular volcanic clasts and less abundant granite. Near the Massacre Grounds the unit contains steep tabular cross-beds with fine-grained well-sorted sand-sized sand grains and eolian in character. In the northeast corner of the map the tuff reaches several hundred feet thick where it underlies and is interbedded with quartz latite.

Tb **Basalt**--Fine-grained, medium to dark blue grey flows and locally autobreccia containing 1-3 mm phenocrysts of clear plagioclase, and olivine altered to red iron oxides. Locally vesicular. In the Goldfield area the unit is locally interbedded with dacite (map unit Tdc) and thin tuffs 1-3 meters thick associated with the dacite (mapped as Tdc). Near King's Ranch basalt is interbedded with conglomerate (map unit Tc). Erodes readily and forms low dark-colored hills.

Tc **Conglomerate**--Poorly sorted, poorly to moderately indurated, clast-supported cobble conglomerate in a red, sandy, arkosic matrix, locally interbedded with thin red sandstone layers (which are rarely exposed). Contains mostly clasts derived from the Younger Proterozoic Apache Group, including quartz-jasper pebble metaconglomerate, tan to purple argillite and siltstone, and tan-brown-purple quartzite. Other clasts include red-grey bedded limestone (possibly Paleozoic), light grey foliated metarhyolite, chlorite schist, foliated granite/granodiorite, nonfoliated diorite, nonfoliated granite, and rare basalt. The unit forms resistant hills which readily shed material and cover most exposures.

Tcs **Sandstone**--Consists of thinly bedded, clast-supported gravely sandstone and minor conglomerate, containing subangular moderately sorted to poorly sorted clasts derived almost entirely from nonfoliated granite. Commonly forms light tan to pale red smooth outcrops.

Tsc **Conglomerate and sandstone, undivided**--Interbedded red sandstone and conglomerate. The unit contains a mixture of clast types contained in both map units Tc and Ts. Also mapped where slope wash and vegetation made it difficult to distinguish between map units Tc and Ts.

TKp **Porphyry (Tertiary or Cretaceous)**--Grey-tan porphyritic rock containing 2-15 mm orthoclase phenocrysts and small clots of green-black biotite, in a fine-grained to aphanitic matrix of feldspar and quartz. Weathers light tan. Outcrops in very limited exposures within Pinal Schist in the southeast part of the study area.

Yd **Diabase (Proterozoic)**--Dark grey-green diabase composed of 1-5 mm, interlocking, tabular, subhedral phenocrysts of green to black pyroxene, clear to white plagioclase, and 1-3 mm opaque minerals (magnetite?). The opaque minerals are commonly altered to red iron oxides and give the rock a slight rusty color. The unit is highly weathered and erodes easily into low, crumbly slopes. The diabase in central Arizona has been dated by several authors at between about 1040 Ma and 1150 Ma (Wrucke, 1989).

Apache Group

Ym **Mescal Limestone (Proterozoic)**--Light grey limestone and/or dolomite commonly with 10-30 cm-thick beds which erode into step-like layers on weathered surfaces. Contains 1-3 cm-thick layers of brown chert. Highly fractured and locally intruded by diabase. Caps one hill on the southeast edge of the map area. Compared to other units, few plants grow on the Mescal Limestone.

Yds **Dripping Spring Quartzite (Proterozoic)**--Light tan to pink and white, metamorphosed sandstone interbedded with minor pebble-sized sandy conglomerate and siltstone. The unit is generally well-sorted, containing subrounded sand-size grains of quartz and light pink feldspar in a siliceous matrix. Cross-beds are abundant. Ripple marks are rare (two showed current directions of about N20°E). Highly fractured and locally brecciated. Commonly breaks along bedding planes to form step-like, blocky outcrops. Dip directions suggest minor folding. The unit is resistant and forms steep, rounded hills. The outcrop east of the fault contact with Mescal Limestone rests on orthogneiss.

Ybc **Barnes Conglomerate member of Dripping Spring Quartzite (Proterozoic)**--Grey to tan, 1-3 meter-thick conglomerate containing moderately well-sorted, well-rounded pebbles and small cobbles of white vein quartz, and grey, red, and tan quartzite and jasper, all in a tan to grey, sandy, arkosic, siliceous matrix. Locally, the unit forms a small ledge but it usually blends in with the detritus-covered slope of Dripping Spring Quartzite and Pioneer

Shale, and can be discerned by the abundance of rounded pebbles weathering out on the surface.

Yp **Pioneer Shale (Proterozoic)**--This unit consists of thinly bedded purple, and locally tan, shale and siltstone. It is exposed in small, discontinuous outcrops on the southeast edge of the map.

Older Proterozoic Intrusive and Metamorphic Rocks

YXd **Diorite (Proterozoic)**--Coarse-grained, nonfoliated rock containing 1-6 mm subhedral phenocrysts of dark green to black amphibole and variable, but lesser amounts, of light grey plagioclase. Intrudes Pinal Schist, foliated amphibolite, and granite in the southeast part of the map area. Fresh surfaces are dark green to black. Weathered surfaces are medium grey-green. The unit is less resistant than the Pinal Schist and forms saddles and low hills. Closely resembles nonfoliated diorite in the Picketpost Mountain Quadrangle which may be related to the Madera Diorite.

YXg **Granite (Proterozoic)**--Heterogeneous, light grey intrusive rock containing 1-3 cm subhedral phenocrysts of pink orthoclase and phenocrysts of milky grey quartz, white subhedral plagioclase, and clumps of subhedral biotite. Locally, the unit is slightly finer-grained and contains less quartz and may be quartz monzonite. It readily erodes and forms valleys and low, light orange, crumbly grus-covered hills. In the southeastern part of the study area, about three meters away from the contact with the Pinal Schist the granite is fine-grained and rich in epidote. On a small scale the contact itself is undulatory and locally discordant to foliation in the Pinal Schist, indicating it is an intrusive contact. In the southeast corner of section 35, T. 1 N., are many connected pits and roads dug into a quartz-rich hill. Whole-rock ages of between 1540 ± 84 Ma and 1507 ± 84 Ma* were reported from samples taken from near Peralta Trailhead (Stuckless and Naeser, 1972).

Xgf **Foliated granite (Proterozoic)**--Has a similar composition as map unit YXg. Exposed only in low hills east of Hieroglyphic Canyon. Intensity of foliation increases from south to north. Protolith in the south has a granular texture. Protolith in the north is exposed in isolated exposures immediately adjacent to or south of Tertiary supracrustal rocks and is intensely foliated and resembles Pinal Schist.

Xp **Pinal Schist (Proterozoic)**--Complex metamorphic suite of polydeformed supracrustal rocks. The unit is dominated by silver-grey metapelites containing fine-grained quartz and serricite, but also includes thin layers of marbles, calc-silicates, quartzites and amphibolites (in most areas mapped separately). White quartz segregations form several-centimeter-thick, discontinuous vein-like lenses which are more resistant than the fine-grained schist and accumulate farther down slope where they form a large percentage of clasts in the adjacent Quaternary deposits. The schist displays a prominent foliation that is slightly discordant (by <10°) to compositional layering, and which reveals itself as a fabric parallel to the limbs of isoclinal folds of the more psammitic schists and quartzites. Near the east edge of the map area the Pinal Schist contains a foliated granitic protolith (map unit Xpg).

Xpa **Pinal Schist amphibolite (Proterozoic)**--Dark green to black, foliated, fine-grained amphibole with lesser amounts of white to pink feldspar and quartz, which form thin, 1-3 mm-thick, discontinuous leucosomes. Locally very rich in epidote. The unit forms lenticular, dike-like bodies within the Pinal Schist in the southern part of the map area. Individual bodies are up to about 10 meters thick. The unit is locally composed of fine-grained, dark grey to tan quartz/quartzite bands up to several meters thick and tens of meters long. The bands contain small isoclinal folds and 1-10 mm-thick darker laminations parallel to foliation. The quartz layers are commonly associated with bands of epidote and epidote mixed with marble. These calc-silicate bands resemble similar bands north of the Queen Creek reservoir and at Milk Ranch, in the Florence Junction Quadrangle (Ferguson and Skotnicki, in press).

Xg **Orthogneiss (Proterozoic)**--Foliated granitic protolith exposed within the Pinal Schist on the southeast edge of the map area. It is slightly lighter grey than the Pinal Schist and consists of discontinuous melanosomes of dark green biotite up to 2 mm thick and leucosomes of pink and white feldspar and clear-grey quartz. The rock is coarse-grained locally but mostly fine-grained with crystals between 1-5 mm.

*These radiometric ages have been recomputed using updated decay constants.

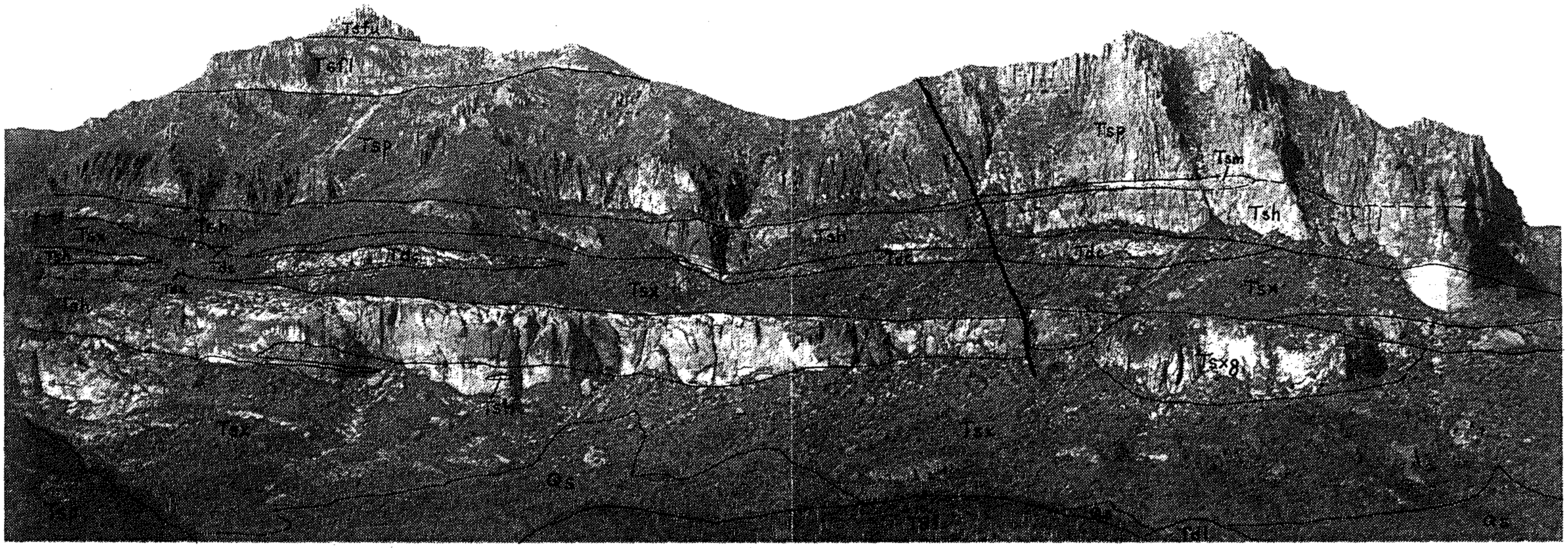

Figure 6. South-facing cliffs of the Superstition Mountains, east of Hieroglyphic Canyon. View is to the north. Photo taken from the hills of Pinal Schist near LAT33° 22' 30", LONG 111° 22' 30".

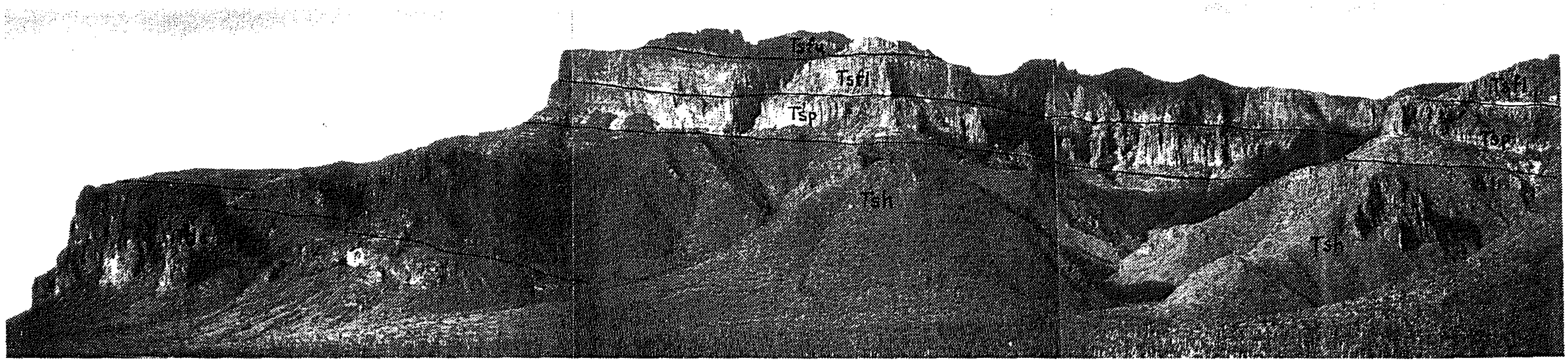

Figure 7. South-facing cliffs near the west end of the Superstition Mountains. Hog Canyon is visible to the right of center. Photo taken from hill north of King's Ranch.

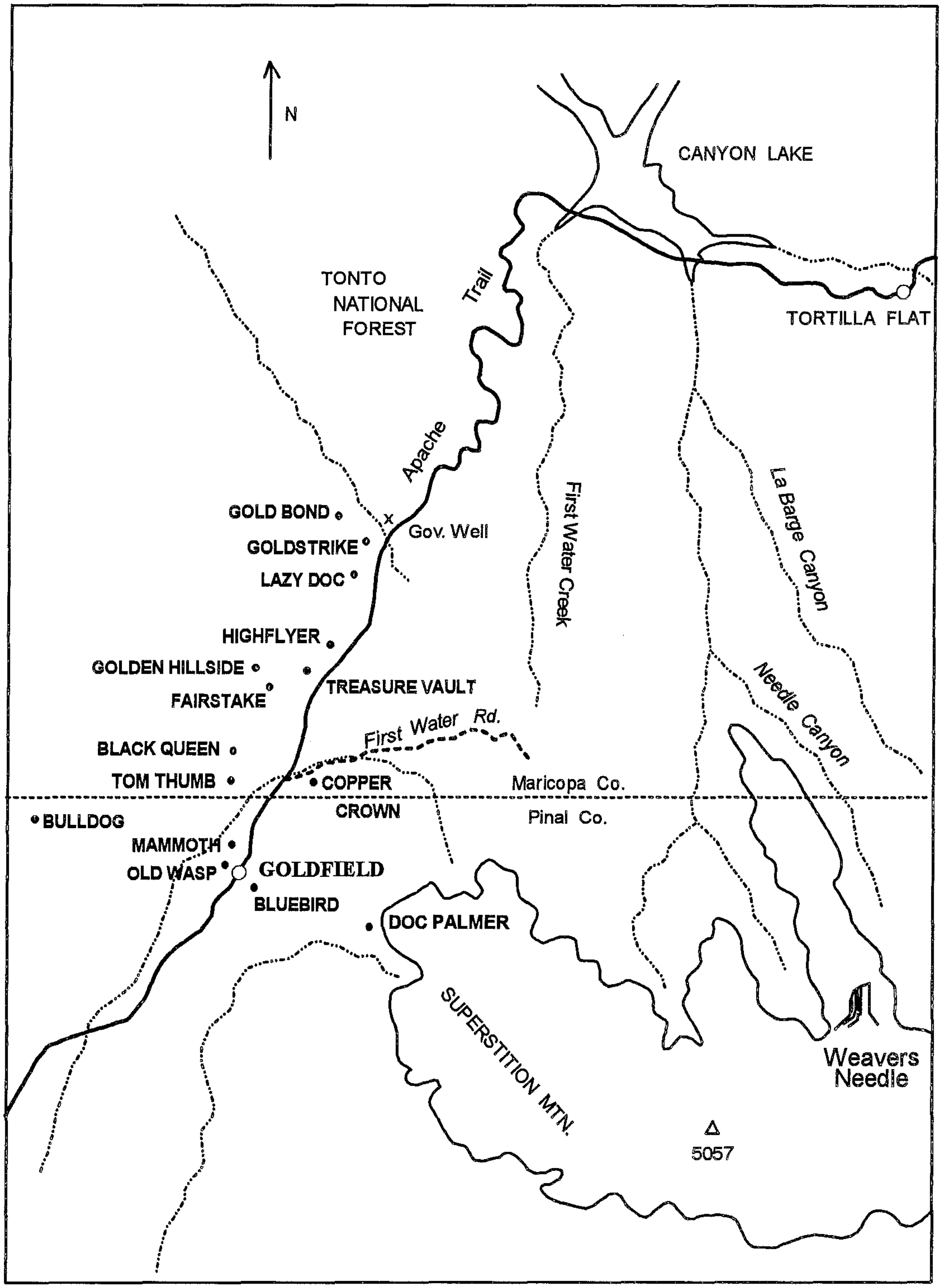

Figure 8. Location of named mines in the Goldfield area (from Wilburn, 1993).