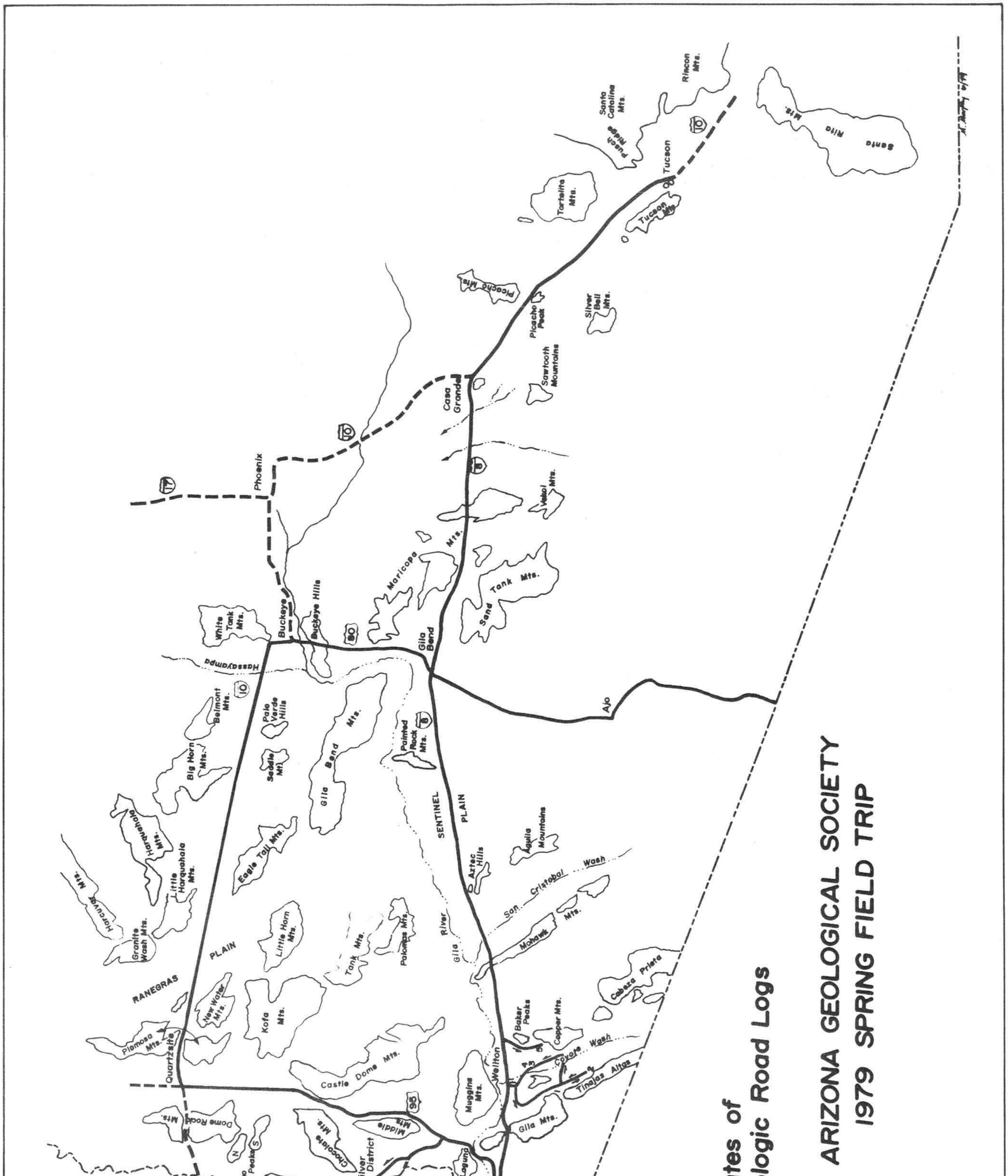

Routes of
Geologic Road Logs
ARIZONA GEOLOGICAL SOCIETY
1979 SPRING FIELD TRIP
Phoenix
Tucson
Buckeye
Gila Bend
Casa Grande
Ajo
Yuma
Quartzsite
Wellton
Santa Catalina Mts.
Rincon Mts.
Santa Rita Mts.
Tucson Mts.
Tortolita Mts.
Picacho Mts.
Picacho Peak
Silver Bell Mts.
Sawtooth Mountains
Maricopa Mts.
Sand Tank Mts.
White Tank Mts.
Buckeye Hills
Hassayampa
Belmont Mts.
Palo Verde Hills
Big Horn Mts.
Saddle Mt.
Gila Bend Mts.
Painted Rock Mts.
SENTINEL PLAIN
Aguila Mountains
Aztec Hills
San Cristobal Wash
Mohawk Mts.
Gila River
Harquahala Mts.
Little Harquahala Mts.
Harcuvar Mts.
Granite Wash Mts.
Eagle Tail Mts.
Little Horn Mts.
Tank Mts.
Palomas Mts.
RANEGRAS PLAIN
New Water Mts.
Kofa Mts.
Plomosa Mts.
Castle Dome Mts.
Baker Peaks
Copper Mts.
Cabeza Prieta
Coyote Wash
Tinajas Altas
Muggins Mts.
Gila Mts.
Dome Rock Mts.
Trigo Peaks
Chocolate Mts.
Middle Mts.
Silver District
Laguna
Trigo Mountains

Geologic Road Logs

1979 Arizona Geological Society Spring Field Trip

Tucson-Yuma-Quartzsite-Buckeye. With side trips to the Marine Corps Gunnery Range and the Silver mining district.

Peter H. Dohms, New Jersey Zinc Co., Tucson
Peter G. Dunn, Quintana Minerals Corp., Tucson
Lucy E. Harding, University of Arizona, Tucson
Richard J. Lundin, Wallaby Enterprises, Tucson
Daniel J. Lynch, University of Arizona, Tucson
Stephen J. Reynolds, University of Arizona, Tucson
John E. Teet, New Jersey Zinc Co., Tucson

TUCSON TO YUMA VIA INTERSTATES 10 AND 8

Distance: 224.3 miles

(by D. J. Lynch)

Milepost
256 Grant Road on-ramp to Interstate 10. Starting point.

16 miles

TO
MP 240 Tucson Mountains and Catalina Mountains

Pusch Ridge and the forerange of the Catalina Mountains lie to the north of this section of freeway. Details of structure are easily seen from the road while traveling northwest. Layering of the Catalina gneiss is warped into a broad anticlinal structure, which is seen to plunge gently to the west. Opposing dips on the limbs are most easily observed from the north section of road. The rocks of Pusch Ridge are alternating layers of dark, biotite augen gneiss and light-colored muscovite granite. Although the K/Ar ages from these rocks fall within the Cenozoic, all of the rocks were formerly thought to be older Precambrian with their argon clocks reset by a mid-Tertiary thermal event. Recent work (Reynolds, pers. comm.) suggests that the dark layers are mylonitized Oracle Granite and the light layers are 50 m.y.-old granite sills intruded at the close of the Laramide and then mylonitized by the event that created the Tortolita-Catalina-Rincon metamorphic core complex.

As you proceed past the end of Pusch Ridge, the erosional amphitheater developed on the Catalina granite will come into view . Intrusion of this pluton 25 m.y. ago was probably responsible for resetting the argon clocks.

To the west of the freeway are the Tucson Mountains, a complex series of intrusions and lava flows which rest on Cretaceous rocks. Rocks of the southern end are rhyolites and monzonites, which have radiometric ages ranging between 50 and 72 m.y., within the time span of the Laramide orogeny. Sentinel Peak ("A" Mountain) and Tumamoc Hill, directly west of Tucson, have a well-exposed section of mid-Tertiary lava flows interbedded with volcaniclastic and sedimentary rocks, which range in age from 27.6 ± 1.2 m.y. (Turkey Track porphyry) to 23.7 ± 0.5 m.y. (the basaltic andesite that caps Tumamoc Hill) (Eastwood, 1970; Phillips, 1976; Shafiqullah and others, 1978).

The Safford Peak group, which lies beyond Ina Road, contains a coarse conglomerate, which rests uncomformably on Cretaceous rocks. This is one of the oldest of the widespread Oligocene conglomerate units found in southern Arizona, its age (39.4 ± 1.3 m.y.) determined on an andesite flow contained in the sequence. The ridges of this mountain group are formed of 28.5 ± 1.9 m.y.-old andesite, and Safford Peak, the highest point, is made of a 25.1 ± 0.9 m.y.-old dacite intrusion. (Ages from Eastwood, 1970.).

9 miles

MP 249 Rillito River

The Rillito River and streams tributary to it are the major drainages for the northern Tucson basin as well as the eastern and southern slopes of the Catalina and Rincon Mountains. Cienega Creek rises in the Sonoita valley east of the Santa Rita Mountains and flows northward to join Pantano Creek in Cienega Pass. Pantano Creek joins the Rillito River northeast of Tucson, and the Rillito joins the Santa Cruz River a few hundred meters west of this bridge. The Tucson basin is drained by rivers that flow around its periphery rather than down the center of the valley.

2 miles

MP 247 Canada del Oro Wash

This creek flows southward out of Canada del Oro, a graben valley that separates the high Catalina Mountains on the east from the lower Tortolita Mountains on the west. Both the Tortolita and Catalina mountain fronts are highly embayed and pedimented indicating a lack of tectonic activity along the basin margin faults during Quaternary time. Since mid(?)-Pleistocene time, large alluvial fans that once buried the Catalina pediment have been partially eroded away resulting in the exhumation and deep dissection of the pediment. Geomorphic, soil, and stratigraphic evidence show that the predominant factors controlling the Quaternary geomorphic evolution of this intermontaine valley have been nontectonic. Climatic change, stream and drainage basin piracy, and other geomorphic variables affecting sediment supply, stream discharge, and aggradation or degradation have influenced the evolution of this landscape (McFadden, 1978).

7 miles

MP 240 Rillito (Cement Plant)

The Arizona Portland Cement Company makes cement out of lower Paleozoic rocks quarried from Twin Peaks (visible to the southwest at 8:00). Several low, isolated bedrock hills can be seen at 1:30. They are composed of altered quartzite, possibly Apache Group, separated by a fault from Oracle(?) Granite at a depth of 80 m. Four drill holes spaced 300 m in cardinal directions from the outcrop hole encountered the granite beneath alluvium at depths ranging from 50 to 120 m without passing through the altered quartzite.

This suggests a buried pediment having a gentle slope to the southwest beneath this area.

8 miles

MP 232 Marana Air Park Road--Pinal County Line

Ragged Top, a mountain with a distinctive irregular skyline, is at 9:00. Biotite from the Ragged Top rhyolite yielded a K/Ar age of 25.6 ± 1.0 m.y. (Eastwood, 1970). The hill at 1:30 is composed of gneiss. Owlhead Butte north of the Tortolita Mountains is at 3:00. Directly ahead is Picacho Peak to the left of the highway and the Picacho Mountains to the right.

7 miles

MP 225 Red Rock Road

Northward from this point, the view is increasingly dominated by Picacho Peak. It has the classic shape of an exhumed volcanic neck, but it actually is a fault-bounded block from the flank of a volcano. Although the flow units cannot be easily differentiated, apparent dips to the right (northeast) can be seen in some planar elements of the rocks. The structural complexity of this peak is typified by the unexplained 50-meter-long block of Oracle Granite found near the summit.

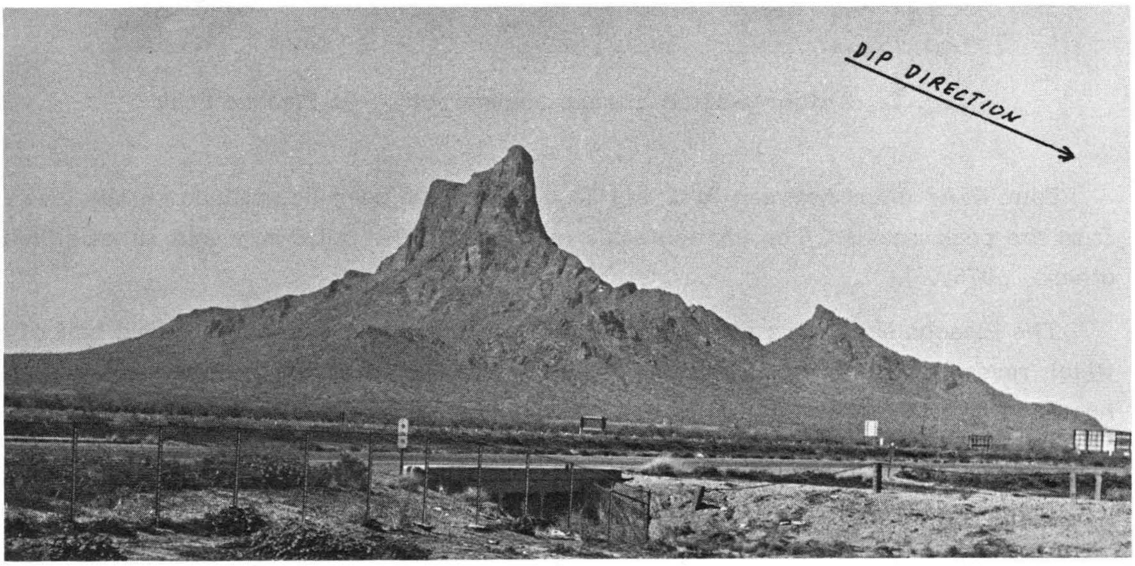


Fig. 1. Picacho Peak. Apparent dip of planar elements in the lava flow sequence is parallel to the "dip direction" line. A coherent block of Oracle Granite underlies the concave slope to the left of the summit.

Three isolated mounds of black-appearing rock occur in the pass and are best seen from near the interchange. The most distant outcrop of this rock lies atop a gneissic ridge extending southeastward from the Picacho Mountains and may not be easily located. This dark-red, aphanitic trachyte is the most potassic of the alkaline rocks of Picacho Peak, having a K_2O content of 12.5%. All the other trachytes and trachy-andesites have combined alkali contents greater than 7.5%, and many of the units are ultra-potassic

(K_2O/Na_2O>10). The ultrapotassic trachytes are autobrecciated, having fractured during the last stages of flow movement. This dark-red to purple color and pervasive autobrecciation are characteristic of all the ultrapotassic rocks in the state.

Fig. 2. Autobrecciated ultrapotassic trachyte at Picacho Peak

Four K/Ar dates between 22.2 and 22.6 m.y. have been determined on the lava flows from the peak massif. The ultrapotassic trachyte is 20.7 ± 0.5 m.y. old (Shafiqullah and others, 1976).

The Picacho Mountains north of the pass are composed in their southern half of gneiss which resembles the Catalina gneiss, although this rock has not been studied in detail. The northern half is granite of a probable Laramide age.

9 miles

MP 216 Earth Fissure

A large earth fissure, striking parallel to the Picacho Mountain front, crosses the highway and railroad at this point. The Picacho basin has dropped more than a meter since 1951 when the cracking began. Subsidence of the Picacho basin is attributed to compaction of sediments upon withdrawal of ground water, but the site of ground breakage is probably close to the eastern basin margin fault. Highway and railroad crews must make repairs every few months.

The Exxon exploratory drill hole is about 10 km north of here. The hole is 3,100 m (10,100 ft) deep. A bed of halite 25 m thick was encountered at a depth of 650 m (1,200 ft), and an additional 1,830 m (6,000 ft) of anhydrite with shale stringers lies beneath the halite. A volcanic unit at a depth of 2,800 m (9,700 ft) is trachyte probably related to the Picacho

Peak rocks and has a K/Ar age of 14.66 ± 0.34 m.y. (Shafiqullah and others, 1976; Peirce, 1976).

16 miles

Interstate 8 to Yuma. Keep right--mileposts change

Road passes north of the Arizola Mountains, which are composed of gneiss.

2 miles

MP 177 Rest Area

6.5 miles

MP 170.5 Santa Cruz Wash

North of the Tucson Mountains, the Santa Cruz River becomes disseminated and poorly defined. Major flood discharges passing through Tucson spread out in these broad basins and either sink into the sediment or evaporate. Dumps of the Sacaton mine can be seen at 3:00 across the valley.

7.5 miles

MP 163 Santa Rosa Wash

From here, the road climbs the alluvial surface to the Vekol Mountains. The upper reach of this surface is a pediment developed on granite bedrock. To the south of the road, mid-Tertiary basalt flows, partially eroded, lie atop alluvial fan deposits, which have been mostly removed. On basalt-capped Table Top Mountain as well as on the promontory northwest of it the basalt is separated from the Precambrian Apache Group by several meters of alluvium.

14 miles

MP 149 Outcrop

The Precambrian granite in this outcrop is almost completely weathered to grus. The relief on this old surface is preserved beneath the basalt that covers it.

4 miles

MP 145 Basalt Outcrop

This basalt is designated on the state map as Quaternary basalt, as is the basalt that covers the crest of the Sand Tank Mountains to the southwest. Both are obviously much older but have not been radiometrically dated.

4 miles

MP 141 Outcrop

Note the baked zone beneath the basalt above the fanglomerate.

22 miles

MP 119 Gila Bend Turnoff

3.2 miles

Intersection of State Highway 85

A road log for this route through Ajo to Lukeville and from Why to Tucson along State Highway 86 by Stanton B. Keith has been published by the Arizona Bureau of Geology as Bulletin 183.

13.8 miles

MP 102 Painted Rock Road Intersection

A broad, low basalt cone is located directly south of this intersection at 9:00. This easternmost volcano of the Sentinel Peak volcanic field with its extremely low aspect ratio (height to width) is typical of cones of this field.

3 miles

MP 99 Painted Rock Mountains and Sentinel Peak Volcanic Field

Rocks of the Painted Rock Mountains closest to the highway are autobrecciated ultra-potassic trachyte flows cut by trachyte dikes. (Cretaceous andesite on the state geologic map). A fine-grained latite(?) intrusion covered by trachyte and alkali rhyolite ash-flow units occupies the northern part of the range.

The highway crosses basalt flows from here to MP 80. The flow units are thin and all of the source cones, except Sentinel Peak, are so low as to be nearly impossible to identify from the highway. The thin lava flows that cover such a wide area and the low cones around source vents indicate basalt of low viscosity. Gas content of this lava may have been so minimal or able to escape so easily that cinder and agglutinate, which form steep cones around source vents in the other Arizona volcanic fields, did not form here.

The flows lie atop well-sorted sediments deposited by the Gila River prior to 3 m.y. ago. The river now flows through a gap between the northern Painted Rock Mountains and the Gila Mountains and has cut a channel through the basalt into the underlying sediments.

14 miles

MP 85 Rest Area

This rest area is constructed on a basalt flow giving an excellent opportunity to examine the surface. Some festoon flow banding can still be seen in the air photos of these flows. All of the small flow-top features have been eroded away leaving a lag surface of basalt cobbles.

The closest mountain range to the southwest is the Aztec Hills. This rock is identified as Mesozoic granite (MAgr) on the state geologic map and is lumped with the Gunnery Range batholith. These rocks have not been investigated in detail, but their lithology is different from that of the Gunnery Range granite.

Directly south of this rest area can be seen the broad basalt mesa of the northern Aguila Mountains. The mesa is capped by a series of 3- to 5-meter-thick basalt flows, which dip about 5° N. This surface is broken by closely spaced normal faults, which strike parallel to the regional structural grain, N. 30° W. They can be easily traced into an older andesite-latite volcanic center south of the mesa. This basalt is identified as Quaternary on the map but is probably older than 10 m.y. The volcanic center to the south, labeled Cretaceous, is probably mid-Tertiary and contemporaneous with the silicic volcanic rocks of the Ajo area.

11 miles

Fig. 3. Faulted and dissected surface of the northern Aguila basalt mesa. The older volcanic center can be seen beyond the far end of the mesa. Photograph courtesy of W. C. Tucker, Jr., Southwestern Exploration Associates, Inc., Tucson.

MP 74 <u>Aztec</u>

Beyond Aztec is the San Cristobal Valley. The Air Force M-X missile test trench is on the west side of this valley next to the Mohawk Mountains.

6 miles

MP 68 <u>Dateland Air Force Station Foundations</u>

8 miles

MP 60 <u>San Cristobal Wash</u>

6 miles

MP 54 <u>Mohawk Mountains Road Cuts</u>

Precambrian gneiss is exposed in this road cut. Tops of the Mohawk sand dunes can be seen from the western slope of this range.

Fig. 4. Eastern flank of the Mohawk Mountains seen from the south. The line that defines the mountain front by connecting the ends of the spurs appears straight, but the actual mountain front is embayed by pedimentation and is quite sinuous. This mountain front is no longer tectonically active. Photograph courtesy of W. C. Tucker, Jr., Southwestern Exploration Associates, Inc., Tucson.

12 miles

MP 42 Tacna Interchange

The dark hills located both north and south of here are composed of mid-Tertiary sedimentary rocks, which will be examined in detail in the Baker Peaks area south of the freeway.

11 miles

MP 31 Wellton Interchange

Geologic road log for the Marine Corps Gunnery Range begins just south of this exit and proceeds south.

North of Wellton are the Muggins Mountains, site of uranium exploration. Bones of an early Miocene(?) camel *Stenomylus arizonesis* were collected from a site 6 miles northeast of Wellton (Wood, 1956).

9 miles

MP 22 Rest Area

Examine the fine-grained sediments across the fence.

1 mile

MP 21 Gila Mountains

The rock here is described as Mesozoic on the state map. Eldred Wilson thought its metamorphism was related to emplacement of the granite to the south, which he considered to be Mesozoic. Two K/Ar ages on biotite separates from this gneiss (199 and 319 m.y.) are wildly discordant and obviously reset (Eberly and Stanley, 1978). Careful observation of the rock in the vicinity of MP 19 shows it to be an angular fanglomerate with a red matrix and containing diabase dikes, rather than being solid gneiss. At MP 18, younger fanglomerate of similar clast size and shape but lacking the red matrix is exposed.

Beyond MP 17, the freeway crosses the Plain of Yuma to the Colorado River terraces in Yuma. The hill in the far distance is Pilot Knob in California. Zircon Pb dates of around 1700 m.y. have been reported for this rock. Knobs of granitic rock in Yuma, which are described on the map as being part of the Gunnery Range batholith (MZgr), are of entirely different lithology. Eberly and Stanley (1978) report a K/Ar age of 39.5 m.y. However, L. T. Silver (written commun., 1968, cited in Olmsted and others, 1973) obtained a 1440-m.y. uranium-lead date on zircon from a porphyritic quartz monzonite in a road cut on US 95 just east of the railroad overpass in Yuma.

10.3 miles

Yuma. Business Loop. Exit 9.

End of log.

MARINE CORPS GUNNERY RANGE

Distance: 62.8 miles

(by D. J. Lynch and R. J. Lundin)

Wellton Interchange, MP 31 on Interstate 8

This road log covers features located on the U.S. Air Force Gunnery Range R2301. Permission to enter this range must be gained in writing from the Commandant, U.S. Marine Corps Air Station, Yuma. Although this part of the range is used primarily for computer-scored air-to-air fighter tactics and ground access to civilians is easy to obtain, the range may occasionally be closed for live firing exercises, and aircraft will sometimes use this area to jettison live bombs in an emergency. Don't pick up anything that looks like military hardware while on the range.

Cumulative mileage

0.0 Cross Wellton Interceptor canal south of Interstate 8. Begin mileage count.

1.5 miles

1.5 Road turns to cross levee; stay on main road.

1.0 mile

2.5 Buildings on left (if not, you're lost—go back to levee).

0.4 mile

2.9 T intersection at 14th Street; turn right (west).

4.0 miles

6.9 T intersection at Camino del Diablo; turn left (south). The Gila Mountains are to the west and south; Wellton Hills to the east-southeast.

1.0 mile

7.9 Enter Gunnery Range here

Low gneiss inselbergs, stone building, road intersection to right.

The inselbergs project from a broad pediment which extends northward from the foot of Sheep Mountain. The Sheep Mountain scarp is easily seen south of this place. It lies behind the dark hills with the prominent white pegmatite veins, which can be reached by this road. All of the visible bedrock here is Precambrian gneiss and schist. Schenker (1977) divided the thin alluvial cover into four units based on their surface appearance and other geomorphic criteria. Q-1, the oldest, is a poorly sorted fanglomerate, which is now deeply dissected and lacks terraces. It is probably more than a million years old and may represent deposits from the last pulse of tectonic activity in the area. Q-2 and Q-3 alluvium fills the valleys cut into Q-1. Q-2 is an older alluvium with a well-developed B soil horizon indicative of deposition in a humid, cool climate, perhaps during the latest glacial event. The three Q-2 terraces identified represent individual surfaces of aggradation in interpluvial periods of reduced rainfall and, perhaps, higher temperatures.

Q-3 is bar-and-swale alluvium having an arid soil profile with a calcium carbonate horizon. Four subunits of Q-3 have been mapped on the basis of their desert varnish and thickness of carbonate layer. Q-4 constitutes the most recent stream deposits, and it lacks both soil development and desert varnish. The road beyond these inselbergs crosses a broad sheet-wash plain of Q-4.

4.1 miles

12.0 Power pole next to road—mileage check.

1.5 miles

13.5 STOP #1. View Sheep Mountain scarp to west

The Sheep Mountain scarp shows many of the characteristics of an active mountain front, including the linear base, triangular facets on the ridges, and steep alluvial cones at the mountain front. However, this scarp is not developed along an active mountain-front fault but rather along a shear zone, which is parallel to the contact of the Gunnery Range batholith about 4 km to the south. Traverses across the shear zone show mylonite gneiss with foliation parallel to the zone but no fault. The shear zone can be followed into the Gila Mountains to the west where it becomes broader and disappears within a few kilometers

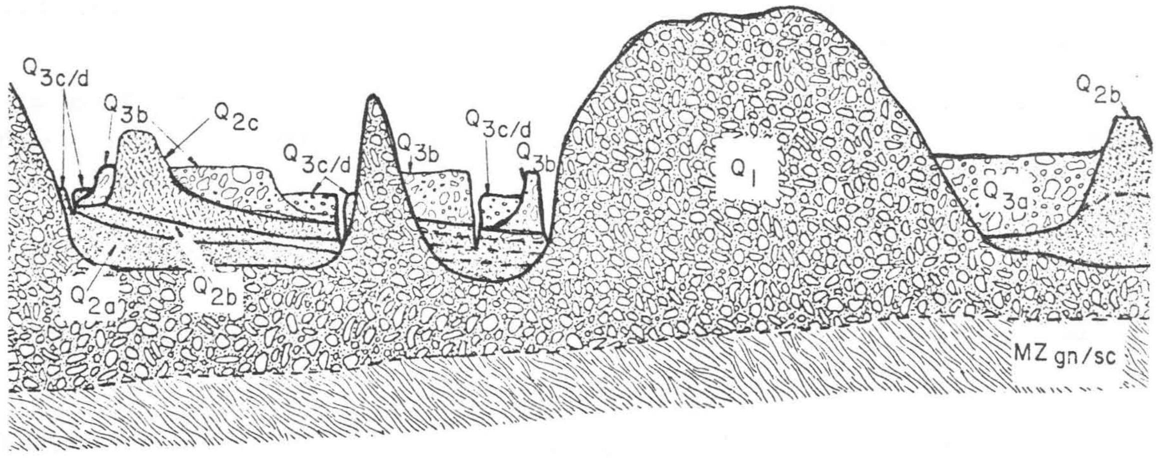


Fig. 5. Alluvial units on the pediment north of the Sheep Mountain scarp—from Schenker (1977)

Fig. 6. Sheep Mountain scarp. The straight mountain front, triangular facets, and alluvial cones can be seen in this view. Schenker's Q-1 alluvium forms the dissected surface in the foreground.

of the mountain front. This scarp has resulted apparently from relatively recent erosion along a structural weakness related to emplacement of the batholith

South of this scarp is the contact between the light-colored Gunnery Range granite and the dark-colored Precambrian gneisses. Unpublished K/Ar ages determined on biotite from this granite correspond to the end of the Laramide orogeny between 50 and 55 m.y. ago. These are probably cooling ages.

1.8 miles

15.3 Good road turns to the right toward the Air Force test station; go straight ahead.

0.9 mile

16.2 Road intersection. This road is dragged periodically to detect footprints of illegal aliens walking up the valley. We will return to this point. Copper Mountains 9:30-10:30, Cabeza Prieta Mountains 10:30-11:30, Raven Butte 1:00.

3.0 miles

19.2 Road to right (west) leads to Cipriano Pass.

2.2 miles

21.4 Road to right--turn off to Raven Butte. The tracks are prominent; do not drive on the desert surface beyond the tracks because the damage is long lasting.

2.9 miles

24.3 STOP #2. Base of Raven Butte

Raven Butte, as seen from a distance, appears to be a large basalt plug. Its shiny black surface contrasts markedly with the tan-white granite that forms the mountain west of it and the desert floor around it. Less than a quarter of its bulk is basalt; the rest is an armor of basalt boulders covering granite slopes beneath. This stop is near the south ridge, the only place where this armor is stripped away to expose the internal structure.

Granite bedrock forms the lower part of the pedestal. Grus alluvium containing rounded granite boulders up to 1 m rests on the bedrock pedestal and separates the granite from the basalt. Although this depositional contact is exposed only in this place, for a total length of 5 m, the rest of the butte suggests that this contact is either a buried pediment or a surface of low relief. The grus above probably represents a mountain-front alluvial fan.

The lowermost lava flow rests on and preserves the old fan surface. Another 2 m of grus alluvium above this lava flow indicates no change in the depositional environment after its eruption. Nine more flows cover this thin layer of alluvium without break. Lack of alluvium between the flows may indicate insufficient time between eruptions or a change in the depositional environment, possibly due to the accumulation of lava on the fan surface.

Raven Butte is joined to the Tinajas Altas mountain massif by a sharp granite ridge. A shear zone is located a few meters to the west of the lowest basalt outcrop.

The basalt armor consists of boulders weathered out of the massive centers of the flows.

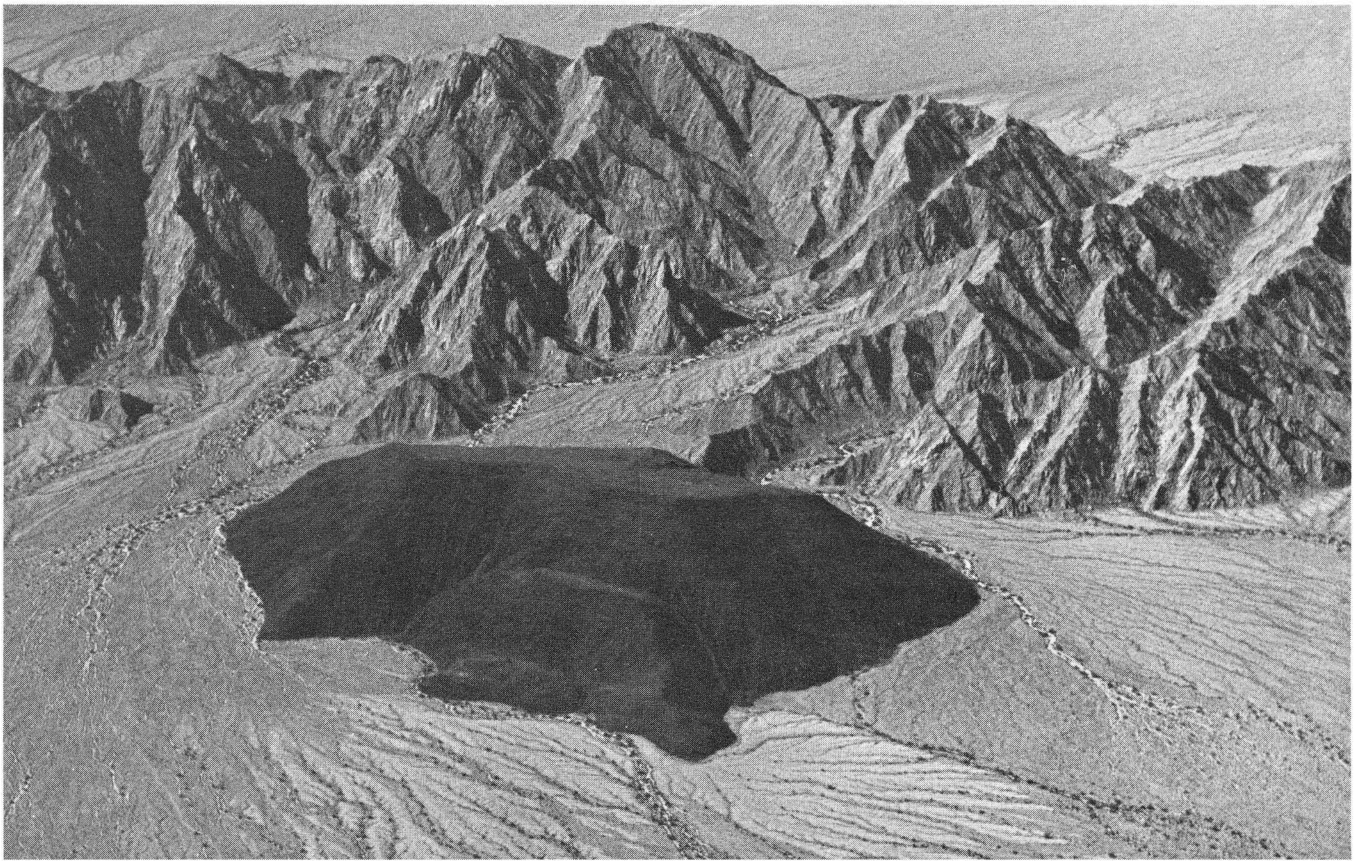


Fig. 7. Raven Butte. The appearance of great flow thickness results from a basalt-boulder armor covering the lower slopes. A step block can be seen on the east side where the flows have slid down 110 m. The break is on a line connecting the easternmost spurs of the mountain range which may correspond to the valley margin fault. The hummock of debris at the base of this block suggests that it may be a simple landslide block and may not be related to basin-and-range faulting.

These boulders are nearly free of internal stresses as evidenced by the extreme difficulty encountered in attempting to break one open. They are attacked only by surficial weathering, which gives them a very long life in this arid environment.

Numerous basalt-covered hills akin to Raven Butte are found in this desert. Three of them may be easily seen to the southeast of Raven Butte, the largest being Tordillo Mountain. Raven Butte is the only one that is almost completely boulder armored; the others exhibit their internal structures much more clearly. Each has buried a remnant of desert identical to that surrounding them. In addition, other desert geomorphic features have been buried by andesite lava flows in the Cabeza Prieta Mountains. Lynch has inferred that arid climatic conditions similar to those active today were characteristic of this region at the time of eruption 10 to 17 m.y. ago (see Shafiqullah and others, this volume).

Geomorphic aspects of equigranular granite weathering in an arid environment are well illustrated in the vicinity of Raven Butte. The irregular nature of the mountain front with its many re-entrants shows it to be an inactive front. Mountain slopes meet the flat desert floor at a sharp angle over most of the front save where major drainages exit from the

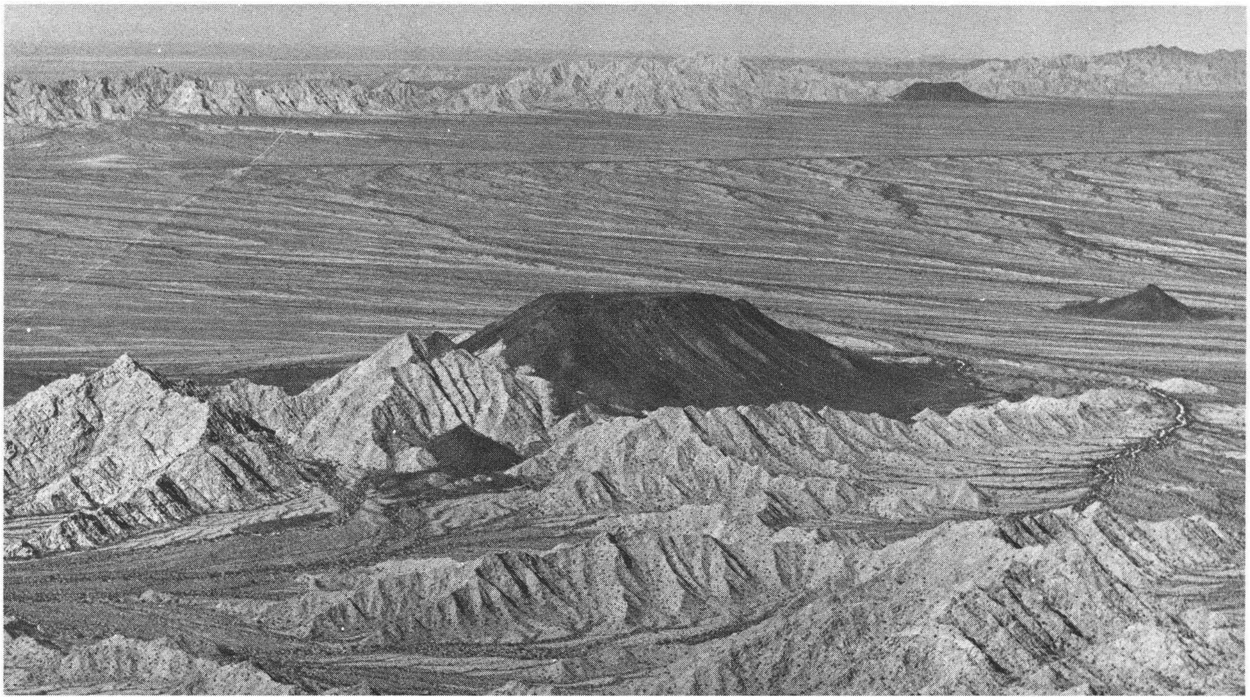


Fig. 8. Tordillo Mountain. This mountain and the basalt remnant north of it are features similar to Raven Butte, seen in the far background. In this part of the Cabeza Prieta Mountains, filling of these arid-climate erosional features is more obvious than at Raven Butte.

mountains. This results from surface weathering of the granite into small grains. Violent rainfalls from convective storms sweep the slopes and carry the detritus to the desert floor where the flow spreads out distributing the detritus. Retrace route back to Camino del Diablo.

2.9 miles

27.2 Intersection with Camino del Diablo; turn left (north).

5.3 miles

32.5 Intersection with cross valley road; turn right (east). Copper Mountains directly ahead, Wellton Hills 9:00, Raven Butte 3:00, Cabeza Prieta Peak 1:30.

2.0 miles

34.5 Coyote Wash, west branch.

0.3 mile

34.8 Coyote Wash, main channels. Coyote Wash is the main drainage in the Lechugilla Valley. It is an anastomosing channel system in the nearly horizontal center of the valley where the western channel drains the west side and the eastern channel drains the east side with few clearly defined connections between the two channel systems.

0.7 mile

35.5 Wrecked Aircraft in the Road. This is a private aircraft, not a military crash site.

2.2 miles

37.7 Road intersection. Turn left (north).

0.7 mile

38.4 Biotite gneiss is intruded by pegmatites in stringers. Schlieren in the gneissic fabric are oriented northwest.

5.0 miles

43.4 View to the northwest of gold-silver prospects along the contact of the granite-biotite gneiss and later pegmatite dikes. The dikes are visible along the ridge line and are iron stained so as to show a color contrast. According to S. B. Keith (1978), metal production from these prospects has been small.

0.7 mile

44.1 STOP #3

Look at pegmatites in biotite-granite gneiss.

0.9 mile

45.0 STOP #4

Look at mineralization and rock types at the Poor Man mine (see S. B. Keith, 1978, for description).

0.2 mile

45.2 Leave Wellton Hills.

3.7 miles

48.9 Intersection with main road to Gunnery Range. Wellton-Mohawk Canal on right. Turn right.

0.2 mile

49.1 Cross Wellton-Mohawk Canal.

0.6 mile

49.7 Turn east onto Interstate 8.

7.0 miles

56.7 Exit from the Interstate at the Roll exit. Proceed south.

0.5 mile

57.2 Intersection of Roll exit at Avenue 35-E. Antelope Hill outcrops of mid-Tertiary sediments similar to those at Baker Tanks to the north. Go south on dirt road.

1.1 miles

58.3 Continue straight ahead.

0.9 mile

59.2 Continue to the left fork.

1.0 mile

60.2 Outcrops on east side of road are arkose with large clasts of granitic and gneissic material.

0.2 mile

60.4 Cross wash.

0.1 mile

60.5 Well-developed pediment surface.

0.5 mile

61.0 Take right fork of road. Granite gneiss in outcrop.

0.8 mile

61.8 STOP #5. Pavilion at Baker Tanks

The stream channel here provides an excellent exposure of a mid-Tertiary conglomerate unit that is probably contemporaneous with clastic rocks of eastern and central Arizona given the names Pantano, Helmet, and Locomotive. At this exposure, the rock is clearly a conglomerate having well-rounded, some nearly spherical, clasts contained within a well-sorted matrix. A few of the clasts exceed 50 cm in diameter, and they are entirely contained within a

Fig. 9. Exhumed pediment south of Baker Peaks. Baker Peaks (in the foreground) are composed of the sedimentary rock to be examined at the last stop. Copper Mountains are beyond the pediment to the south.

sand matrix. Discontinuous layers of poorly sorted, more angular material contained within this deposit look much like the bar-and-swale deposits of the surrounding desert. Rounding and sorting indicate some transportation from the source locality, and the size of the clasts requires a high-energy depositional environment. As a first approximation, depositional conditions may have been similar to those active today in this region (see Shafiqullah and others, this volume).

Approximately one mile east of this locality, in the same stream channel, the fragmental material is significantly different. All of the clasts are angular, sorting is nonexistent, and a matrix is not always easy to identify. The trip planners gave this rock the name "hypabyssal fanglomerate" because of its resemblance to brecciated plutonic rock, but the discontinuous layers of well-sorted sand show it to be a true fanglomerate composed of material moved only a short distance from its source.

The provenance of these deposits is unclear, but the close proximity of fanglomerate to conglomerate is further evidence of similarity between their depositional environment and that active today. Tectonic activity in mid-Tertiary time undoubtedly created mountains that were eroded and the material was transported to local basins. The following Basin and Range disturbance has largely obscured these basins, and the deposits are only found in the present mountain blocks. These beds were tilted during the transition from the mid-Tertiary orogeny to the Basin and Range disturbance in much the same manner as the Pantano fanglomerates found east of Tucson.

Fig. 10. Kinter(?) formation at Baker Tanks. Large, rounded boulders of gneiss and granite are contained within a well-sorted arkosic sandstone matrix.

A mid-Tertiary age is assigned to these beds because of their lithologic similarity to known mid-Tertiary clastic units in other parts of the state, their steep dips in this mountain block, and their tentative correlation with Miocene beds of the Muggins Mountains to the north where lower Miocene camel bones were found (Wood, 1956). Casual searching of the area around Baker Tanks failed to find any clasts of the 50+- m.y.- old Gunnery Range granite that crops out 25 km to the south.

Baker Tanks and environs are part of a large exhumed pediment. This part of the southern Basin and Range province has been tectonically inactive for many millions of years, an excellent environment for pedimentation. Exhumation of this one is probably due to downcutting of the nearby Gila River rather than to uplift of the mountain block.

End of log.

YUMA TO QUARTZSITE VIA U.S. 95

Distance: 78.8 miles

(by R. J. Lundin, L. E. Harding, P. H. Dohms, and J. E. Teet)

Cumulative mileage

0.0 Starting Point: Facing north on east side of Araby Road at intersection with west entrance to Arizona Western College, 0.6 mile north of Araby Road interchange of Interstate 8 (Exit 7).

Starting point is on alluvial Yuma Mesa south and above the intense agricultural development surrounding the Gila and lower Colorado Rivers. Drive north.

1.0 mile

1.0 Turn right onto U.S. Highway 95.

1.5 miles

2.5 North entrance to Arizona Western College.

3.2 miles

5.7 Cross Gila Gravity Main Canal. The aroma is not from orange blossoms.

1.3 miles

7.0 Laguna Mountains at 12:00 are made up of Precambrian complex.

1.7 miles

8.7 United Metro gravel pit on right; Yuma County pit on left.

0.6 mile

9.3 Small outcrops of Precambrian rocks, which are outliers of Laguna Mountains. Entering Gila River Valley.

0.4 mile

9.7 Wellton-Mohawk Irrigation Project canals. Large canal carries fresh water east (upstream). Small canal carries brackish waste water west (downstream) to site of Bureau of Reclamation's desalting plant. Eventual destination of this water is Mexico.

0.3 mile

10.0 At 10:00 is McPhaul Bridge, a one-lane suspension bridge over Gila River, now closed.

0.4 mile

10.4 Precambrian of northern Laguna Mountains visible at 9:00.

0.2 mile

10.6 Gila River bridge. White and blue herons are occasionally visible in pools during periods of low water.

0.5 mile

11.1 9:00-12:00, northern Laguna Mountains; several small gold prospects in shear zones.

1.4 miles

12.5 Castle Dome Peak visible at 12:00. The peak is part of a possible Tertiary ignimbrite complex.

1.2 miles

13.7 Enter Yuma Proving Ground; Muggins Mountains at 3:00.

2.1 miles

15.8 Main entrance to Yuma Proving Ground, 155 mm and 208 mm cannons.

2.7 miles

18.5 Signs point to Martinez Lake Recreation Area, Imperial National Wildlife Refuge. Road log for Silver mining district begins here.

Note the Quaternary alluvium and sediments that have been deposited on the outwash plain from the northeast extension of the Laguna Mountains.

2.7 miles

21.2 View to the east of the Muggins Mountains. These mountains lie on the Yuma Proving Ground Military Reservation and are composed of Mesozoic(?) metamorphics and sediments, Mesozoic(?) sediments and volcanics, Tertiary lacustrine and fluvial sediments, Tertiary volcanics, and Quaternary sediments. There have been a number of occurrences of uranium noted in association with Tertiary lacustrine sediments in the area. Also, there are significant placer gold deposits in the Quaternary gravels.

2.0 miles

23.2 View of Tertiary(?) basalt flows forming a low hill to the northeast.

4.0 miles

27.2 View of Chocolate Mountains to the northwest.

0.2 mile

27.4 Access road turnoff to the Kofa Wilderness and Castle Dome Mountains.

1.7 miles

29.1 View of Castle Dome Mountains and well-developed desert pavement surface.

4.3 miles

33.4 View to the southwest of lit-par-lit intrusion of pegmatitic dikes into folds in Mesozoic(?) metamorphics.

2.4 miles

35.8 View of Kofa Mountains from the southwest. The Castle Dome Mountains and Castle Dome mining district lie to the east. The rocks cropping out in the Castle Dome Mountains consist of a thick sequence of mid-Tertiary volcanics, strongly metamorphosed sediments, a series of felsic dikes that have a general northwest trend, and the remnants of a Tertiary(?) basalt field. Mineralization in the Castle Dome district consists of lead, silver, fluorite, barite, manganese, zinc, copper, gold, vanadium, molybdenum, beryllium, antimony, selenium, arsenic, and uranium in veins and ore shoots along the dike contacts between the felsic dikes and the metasediments and volcanics. Brecciated shear zones act as the host for most of the mineralization, but some replacement deposits have been noted in the district.

0.7 mile

36.5 View of Tertiary(?) volcanics to the northwest.

1.3 miles

37.8 Contact between Tertiary(?) volcanics and sediments.

0.4 mile

38.2 View of the northern Chocolate Mountains and Indian Wash drainage.

2.6 miles

40.8 View of stratigraphy in the north end of the Castle Dome Mountains. The volcanics that make up this part of the Castle Dome Mountains are thought to be Tertiary in age and may lie relatively undeformed.

4.5 miles

45.3 View of Tertiary(?) volcanics overlying sediments to the west and northwest in low hills.

2.4 miles

47.7 Zeolites in Tertiary volcanics and sediments are being mined by Yuma Zeolite Corporation. The zeolites occur in the light-tan material that crops out to the southeast of the open-pit operations.

0.1 mile

47.8 Tertiary(?) volcanics in road cut.

0.7 mile

48.5 View ahead of La Posa Plain—Tyson Wash area.

1.4 miles

49.9 Stone Cabin Store and Kofa Mountains—King Valley Turnoff

3.2 miles

53.1 View of the volcanic stratigraphy in the Kofa Mountains to the northeast

1.7 miles

54.8 Cibola Lake Turnoff

2.9 miles

57.7 Palm Canyon Turnoff

View to the east of the Kofa Mountains. The Kofa Mountains are part of a mid-Tertiary(?) ignimbrite complex overlying a basement of Mesozoic sedimentary and plutonic rocks. The thick tilted layers visible just north of Palm Canyon are ash-flow tuffs erupted as thick, single cooling units. Elsewhere are additional intermediate to felsic ash-flow tuffs and associated flows and volcaniclastic strata. On the southeastern margin of the range, probably not visible from the road, Mesozoic(?) metasediments are exposed near the Kofa mine. Mineralization in the Kofa, or S. H. mining district, consists of gold, silver, manganese, tungsten, copper, and lead in lensing fissure veins that cut the volcanics and the metasediments. Signal Peak at the head of Palm Canyon is the highest peak in this part of southwestern Arizona and has a spectacular view.

To the west of the highway are the Trigo Peaks.

11.6 miles

69.3 Crystal Hill Campground; Kofa Game Range Turnoff to east

View to the west of the Dome Rock Mountains. Recent master's theses in the Dome Rocks are by Marshak (1979) and Crowl (1979). The range contains presumed Jurassic volcanic sequences, Jurassic(?) plutons (Miller, 1970), and overlying Mesozoic metasediments. The steep, south-dipping beds consist of at least 15,000 feet of Mesozoic metasediments. The northwest-trending low pass through the Dome Rocks is Copper Bottom Pass with Cunningham Mountain to the south. A northwest-trending strike-slip fault with a disputed amount of offset and of unknown age underlies the pass. The fault separates two sequences of metavolcanic and metasedimentary rocks. On the north side of the pass, penetratively foliated metavolcanic rocks probably underlie the metasediments (Marshak, 1979). The Copper Bottom mine is in the metavolcanic sequence. On the south side of the pass, a metavolcaniclastic sequence, which yielded an allochthonous Permian guide fossil, is in high-angle fault contact with a metasedimentary sequence similar to that on the north side of the pass. In the area of La Cholla Peak there are numerous gold placer deposits, and throughout the range there are fissure-type gold, silver, copper, lead, zinc, molybdenum, and mercury deposits. In the Dome Rocks a series of fault-bounded sequences of metasediments is exposed continuously from the southernmost end of the range almost 15 miles northward to I-10.

To the southeast of U.S. 95 are the jagged peaks of the Livingston Hills. The Livingston Hills Formation, a 12,000-foot clastic sequence, makes up the hills. The sequence dips homoclinally southward and has been studied by Miller (1966) and Harding (1978).

The Crystal Hill Campground is at the southern end of the New Water Mountains, recently studied by Robison (1979). The New Water Mountains contain continental red bed deposits (Miller, 1970) now considered to be part of the Livingston Hills Formation.

To the east and northeast of the road are the Plomosa Mountains. Two dark ridges on the west side of the mountains consist of metavolcanic rocks, which Miller (1970) said may be either Precambrian or Mesozoic in age and which may correlate with those in the Dome Rock Mountains. Precambrian quartz monzonite (Miller, 1970; Miller and McKee, 1971) underlies the western part of the range. Fossiliferous Paleozoic rocks and unfossiliferous, severely deformed Paleozoic rocks crop out within a few kilometers of each other in the central, northern, and eastern parts of the range. Overlying the Paleozoic and metavolcanic sequences are the continental red beds and Livingston Hills Formation. Igneous rocks of presumed Mesozoic age intrude the Paleozoic and Mesozoic sediments. All these rocks are cut by major low-angle faults. The Paleozoic and Mesozoic sediments display mild metamorphism and are locally strongly deformed. Mid-Tertiary volcanics overlie the older rocks. Mineralization occurs as gold, silver, copper, lead, zinc, manganese, barite, iron, tungsten, and beryllium deposits in veins and replacement deposits in the entire range of host rocks. For additional discussion of the Plomosa Mountains, see the Quartzsite—Buckeye road log.

6.2 miles

75.5 La Posa BLM Campground.

1.9 miles

77.4 View of BLM Campground to the west and of mining operations on the eastern flank of Granite Mountain in the Middle Camp--Oro Fino mining district. Mineralization consists of gold, silver, copper, lead, and zinc in quartz veins along the contact between granite bodies and later pegmatite dikes.

1.4 miles

78.8 Quartzsite, Arizona .

End of log

MARTINEZ LAKE TURNOFF TO BLACK ROCK MINE, SILVER MINING DISTRICT

Distance: 25.2 miles

(by P. H. Dohms, J. E. Teet, and P. G. Dunn)

Cumulative Mileage

0.0 Starting Point. Martinez Lake Turnoff on U.S. Highway 95. Turn west off US 95. Signs point to Martinez Lake Recreation Area, Imperial National Wildlife Refuge.

2.2 miles

2.2 Airfield at 9:00. Facility of Yuma Proving Grounds.

0.2 mile

2.4 Intersection: take right fork (straight).

1.6 miles

4.0 Chocolate Mountains (California) at 9:00. Phillips parachute drop zone at 3:00.

1.5 miles

5.5 Trigo Mountains at 12:00.

1.7 miles

7.2 Miocene(?) volcanics, 9:00-11:00.

1.9 miles

9.1 Leave Yuma Proving Grounds. Towns of Fishers Landing (10:00) and Martinez Lake (12:00-2:00) in view.

1.1 miles

10.2 TURN RIGHT onto gravel road.

1.0 mile

11.2 Martinez Lake at 9:00. Little Picacho Peak, California, at 1:00. Note alluvial terrace over which you are driving.

1.1 miles

12.3 JUNCTION. TURN RIGHT on road marked "Red Cloud Road."

0.7 mile

13.0 Enter Imperial National Wildlife Refuge, 25,000-acre migration rest stop for ducks and geese. Make note of regulations concerning permitted activities.

0.3 mile

13.3 JUNCTION. Continue straight ahead on one-lane dirt road. Wide road to left goes to Refuge Headquarters and Meers Point Campground.

1.5 miles

14.8 Tertiary (Miocene?) volcanics at 3:00. Note relationship with terrace gravel.

0.7 mile

15.5 Note picturesque volcanics--tuffaceous and pyroclastic material.

0.5 mile

16.0 Enter southeast corner of Picacho, Arizona-California 7½-minute quadrangle, near south side of sec. 35, T. 4 S., R. 22 W.

0.4 mile

16.4 Steep narrow roadcut in soft pink pyroclastic volcanics.

0.9 mile

17.3 "Tunnel of trees"--entering Yuma Wash. The thick brush provides an impediment to the occasional flash floods down Yuma Wash with flows becoming constricted and coursing along the road. Note elevations of some of the flood debris in the brush alongside the road.

0.2 mile

17.5 Road to Clear Lake goes to left. Last access to river. A side trip in here (0.2 mi) would provide a good opportunity to study the interface between severe desert and riparian geomorphology and life forms.

0.4 mile

17.9 Boundary. Leave Imperial National Wildlife Refuge. Re-enter Yuma Proving Grounds. Periodic warning signs advise of presence of unexploded ammunition east (3:00) of road. Note outcrop of Precambrian complex at 9:00.

0.3 mile

18.2 Small outliers of volcanics. Yuma Wash closely follows a generally north-south contact separating Precambrian on the west from Tertiary volcanics to the east.

0.4 mile

18.6 Benchmark--elevation +258 MSL.

2.2 miles

20.8 Climb up out of Yuma Wash, begin driving westerly across terrace gravels toward the Trigo Mountains. Elevation approximately +480 MSL. Trigo Mountains are composed of Precambrian which extends from the Colorado River, at 9:00, to approximately 1:00. Tertiary volcanics crop out north of that point. Note steep banks of wash cutting into terrace immediately south (9:00) of road at 21.4 miles.

1.6 miles

22.4 Enter an unnamed wash tributary to Yuma Wash. Outcrop at 9:00 is a complex of gneiss, schist, and granite of likely Precambrian age. This complex is thought to represent the upper plate of the Chocolate Mountains—Orocopia—Vincent thrust. Schist thought to be equivalent to the lower-plate Orocopia Schist crops out 3 miles south-southwest of here near the mouth of Arrastra Wash.

1.1 miles

23.5 Note geomorphology in this area with Precambrian rocks, terrace gravel remnants, and recent stream alluvium.

0.4 mile

23.9 Broken pile of whitewashed stones thought to mark the western edge of the Yuma Proving Grounds. Enter BLM land.

0.3 mile

24.2 Divide separating drainage systems of Yuma Wash and Black Rock Wash. Enter Silver district, elevation approximately +795 feet, MSL.

0.3 mile

24.5 Bench Mark, elevation 764 feet, at 9:00. Note terrace gravels underlying road.

0.4 mile

24.9 Narrow spot in road. Red-stained volcanics at 3:00; Precambrian at 9:00.

0.05 mile

24.95 Outcrop of dark-red conglomerate underlies terrace gravel at base of bank at 3:00. Elsewhere in the district this formation underlies a white, well-bedded tuff. Also, a small vein cutting this unit has been noted in one location.

0.05 mile

25.0 Dead-end road to left; bear right.

0.2 mile

25.2 Black Rock mine. Park on either side of road downwash from dump or to right of road upwash from mine workings. Do not block the road; visitor traffic is to be expected.

Figure 11 shows the geology of the Black Rock mine area with six indicated stops for a short walking tour.

SUPPLEMENTAL ROAD LOG

Black Rock Mine to Red Cloud Mine

(Not an official part of this tour)

Distance: 1.3 miles

(All mileages are a continuation of those shown on the Martinez Lake Turnoff to Black Rock mine road log.)

25.2 Base of Black Rock mine dump where the Black Rock vein enters the wash. Continue northwest.

0.4 mile

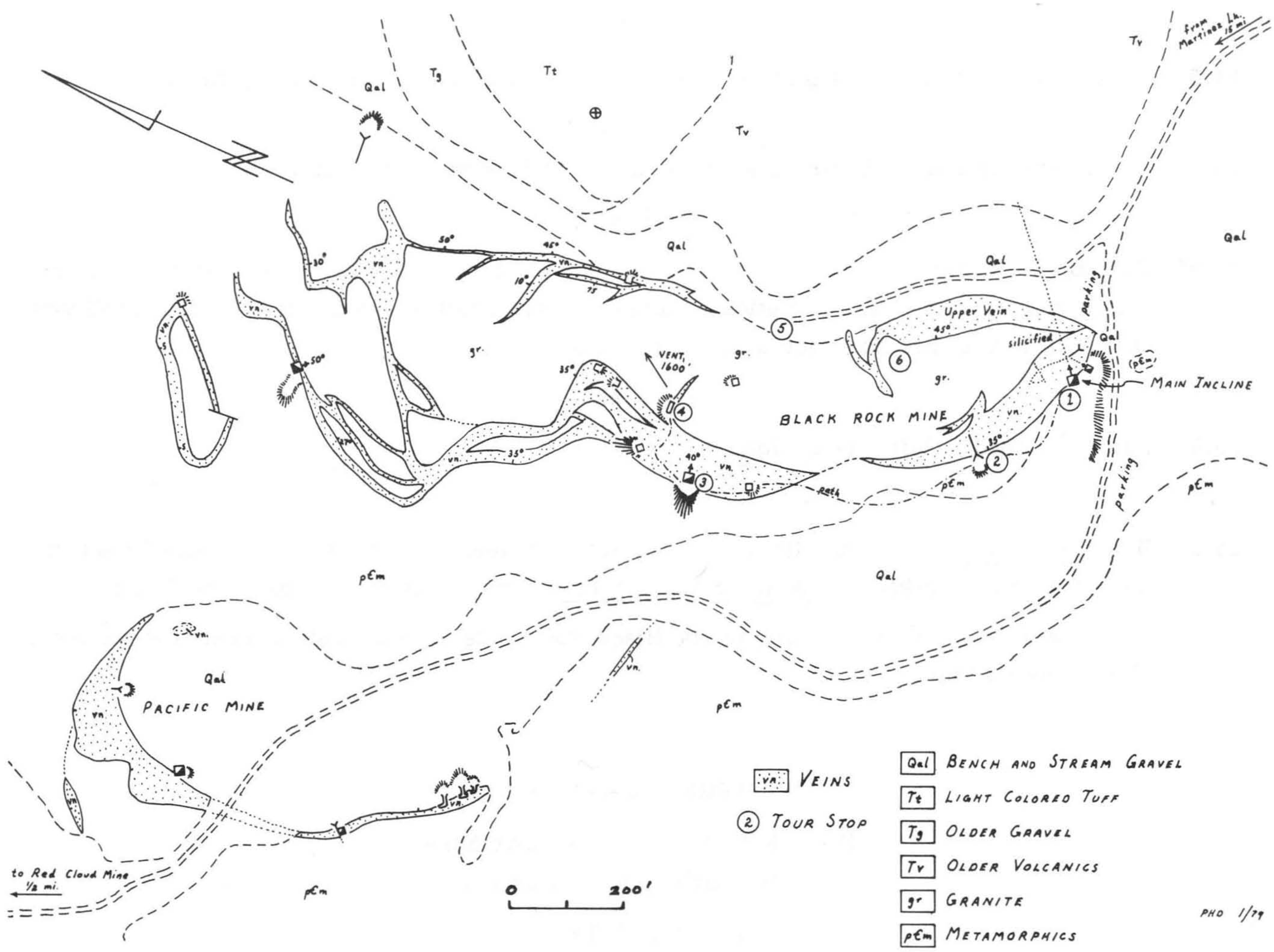
25.6 Optional Stop. At this point the fishhook-shaped Pacific vein crosses the wash. The surface geology is shown on the sketch map for the Black Rock tour (Fig. 11).

0.1 mile

25.7 Papago mine at 9:00, 500 feet distant--developing a blind vein almost completely covered by gravel. At 11:00 the small holes in the bank of the wash were once miners' dwellings, part of the town of Silent.

0.2 mile

25.9 On skyline at 12:00, the light-colored pyramid-shaped peak is of flat-lying volcanics overlying Precambrian. The volcanics are correlated with similar-appearing material cropping out at the foot of the same ridge 500 feet lower in elevation. The intervening fault system is occupied by the Padre Kino vein.



Stop 1. Main Incline. Note pseudo-footwall and hanging wall, true footwall, and outcropping mineralization.

Stop 2. Adit. Excellent exposure of footwall of lower massive vein sitting on metamorphic rocks.

Stop 3.. North Incline. Note different ages of veins, cross-cutting veins, and breccia textures.

Stop 4. Pit north of North Incline--viewpoint.

a. N. 60° W.--1,000 feet, "fishhook"-shaped Pacific vein.

b. North--150 feet, anastomosing veins in canyon.

c. N. 30° E.—1,600 feet, volcanic vent with flat, air-laid tuffs.

Stop 5. Collar of discovery drill hole, DDH #1, thickest vein intersected in district.

Stop 6. Footwall area of upper massive vein, strong brecciation, and multiple ages of veining.

Fig. 11. Geologic map showing walking tour stops of the Black Rock mine, Silver district, Yuma County, Arizona.

0.4 mile

26.3 Red Cloud mill site visible at 9:00.

0.2 mile

26.5 Leave main road, turn about 30 degrees left and park on flat short of mine dumps. The dumps, pit, and outcrop comprise the Red Cloud mine. Caution--Do not approach the vertical shaft or attempt to go underground. The mining activities of rockhounds searching for wulfenite have made the workings exceedingly hazardous.

Return to U.S. Highway 95.

End of log

QUARTZSITE TO BUCKEYE VIA INTERSTATE 10

Distance: 93 miles

(by S. J. Reynolds)

Cumulative Mileage

0.0 Quartzsite. On-ramp to Interstate 10 on east side of town. Begin mileage count.

Quartzsite lies within the La Posa Plain, a north-south-trending valley whose bottom is approximately 900 feet above sea level in the area of the city. The valley's major drainage, Tyson Wash, flows north-northwest from Quartzsite, eventually joining the Colorado River valley. Mountain fronts adjacent to the plain are sinuous and deeply embayed.

West of Quartzsite are the Dome Rock Mountains. Exposed immediately north of and within the low pass I-10 follows to the west is a granitic pluton of probably Jurassic age. It is locally altered and intruded by a younger, equigranular, Late Cretaceous(?) quartz monzonite. The Jurassic(?) granite intrudes a sequence of slightly metamorphosed volcanic and volcaniclastic rocks that crop out extensively south of I-10 (mapped on the state geologic map as Mesozoic schist). Further south, the volcanics are overlain by a thick sequence of interbedded quartzites, quartz pebble conglomerates, and phyllites (mapped as Mesozoic sediments). Mining activity in the area was predominantly concerned with significant gold placers, minor gold veins, and sporadic copper-lead-zinc mineralization adjacent to the granitic plutons. Total metal production for the area through 1974 is slightly greater than $2.6 million (Keith, 1978).

East of Quartzsite are the Plomosa Mountains. Jemmet (1966) has mapped the northern Plomosa Mountains, Miller (1966, 1970) has mapped the southern part of the range, and Harding (1978) and Robison (1979) have studied Mesozoic stratigraphy of the southern half of the range.

In the northern Plomosas northeast of Quartzsite, probably Precambrian basement and metamorphosed Paleozoic and Mesozoic(?) strata are exposed along with mid-Tertiary volcanic and clastic rocks. The central Plomosa Mountains (immediately north of I-10) are almost entirely composed of mid-Tertiary volcanics. Complex geology dominates the southern Plomosa Mountains with exposures of Precambrian quartz monzonite; metamorphosed and unmetamorphosed Paleozoic strata (including Bolsa Quartzite, Abrigo Formation, Martin Formation, Escabrosa Limestone, and Supai Formation, Coconino Sandstone, and Kaibab Limestone); Mesozoic metavolcanics, continental red beds, and Livingston Hills Formation (thick sequence of conglomerate, sandstone, and siltstone); abundant Mesozoic(?) intrusive-extrusive silicic igneous rocks; and mid-Tertiary andesite and basalt. Pre-Tertiary formations are locally metamorphosed and displaced by low-angle faults. Most rock units, including the mid-Tertiary volcanics, are in places cut by northwest-trending dip-slip and strike-slip faults. For additional discussion see the Yuma-Quartzsite log.

Mineralization in the Plomosa Mountains is as varied as the geology (Keith, 1978). Deposits of copper-gold, lead-zinc-silver, barite-fluorite, tungsten, and gold placers have all been worked.

7 miles

7.0 STOP #1. Gold Nugget Road exit

Mid-Tertiary andesites are exposed north of exit and in small, flat-topped hills immediately south of exit. After exiting, drive south on paved road for approximately half a mile. From here, Paleozoic rocks, clearly visible to southwest, can be reached via a half-mile hike. Higher hills behind Paleozoics are composed of Precambrian quartz monzonite. Miocene(?) basalts are exposed to the southeast. The dirt road that turns south from paved road follows up Italian and Apache Washes. This road provides access to excellent exposures of the Precambrian quartz monzonite, Mesozoic continental red beds, and Livingston Hills Formation, and low-angle fault contacts between different units. Miller's (1970) map is a must for those interested in examining the fascinating geology of this range.

4 miles

11.0 Viewpoint #2 (no stop needed). Junction U.S. 60

U.S. 60 bears east-northeast through Salome, Wenden, and ultimately Wickenburg. Five miles east of this junction, U.S. 60 passes through the Bear Hills, clearly visible in the foreground. In these hills, mid-Tertiary andesitic volcanics contain fractures filled with copper-silver-gold mineralization and manganese oxides (Keith, 1978). Interstate entering Ranegras Plain.

14 miles

25.0 STOP #3. Vicksburg Road exit

Northeast of here, U.S. 60 enters Granite Wash Pass, which separates the Granite Wash Mountains to the north from the Little Harquahala Mountains to the south. Along the western side of the Granite Wash Mountains are gently dipping Mesozoic sandstones, siltstone, shale, and conglomerate and interlayered sills(?) of mafic igneous rock. They are locally highly metamorphosed and cut by two distinct Late Cretaceous plutons. Copper-gold and tungsten mineralization occurs adjacent to the plutons.

South of Granite Wash Pass are the Little Harquahala Mountains, an area whose geology is varied and complex. The Granite Wash Pass granodiorite extends into the north part of the range where it intrudes Mesozoic strata. Mesozoic rocks, widely exposed in the western parts of the range, consist of volcanic and volcaniclastic sequences, quartz-rich and feldspathic sandstones, and local carbonates. These are in faulted contact with an altered, porphyritic granite (Precambrian?) to the east.

The southeast portions of the range (with obvious layering) are Paleozoic strata, including Bolsa, Abrigo, Martin, Redwall, and Supai equivalents. These rocks strike northeast, are folded and locally overturned, and overlie the porphyritic granite along a low-angle fault. Pyramid Peak and associated bedrock outliers west of the range are composed of mid-Tertiary volcanics. Upper Bouse Wash flows (intermittently) northerly between Pyramid Peak and Vicksburg exit.

The most important mineral deposits in the Little Harquahala Mountains are the Bonanza and Gold Eagle mines, which contained shoots of high-grade gold ore. Mining was active in the late 19th century, and total precious and base metal production in the district is valued at nearly $3 million (Keith, 1978).

South of I-10 are the New Water, Little Horn, and more distant Kofa Mountains. All three ranges are composed predominantly of mid-Tertiary volcanics, and all exhibit interesting physiographies. Copper and gold-silver mineralization occurs in these ranges.

8 miles

33.0 STOP #4. Hovatter Road exit

Here you are near the boundary between the Ranegras Plain to the west and the Harquahala Plain to the east. The small hills immediately north of the exit are mid-Tertiary volcanics (andesites). In the subdued Black Rock Hills south of the exit, three distinct rock units crop out. Along the western edge, quartzite, siltstone, and quartz-pebble conglomerate are exposed. These rocks are probably correlatives of Miller's Mesozoic continental red beds in the Quartzsite quadrangle. To the east, they are in apparent fault contact with minor exposures of Mesozoic volcanic flows and agglomerates. The volcanics overlie a west-dipping fault whose footwall contains a porphyritic granite, similar to that in the Little Harquahala Mountains. These relationships can be seen from short hikes south off the well-maintained dirt road that extends south from the exit.

Similar relationships described for the Little Harquahala Mountains (see Stop #3) can be examined from the generally well-maintained road north of the exit (road to Salome via Little Harquahala Mountains). The Paleozoic section (Bolsa, Abrigo, Martin, Redwall, and Supai equivalents) and its fault contact with an underlying granite can be seen near the base of Martin Peak, the first large peak east of the road. In hills northwest of Martin Peak, the Mesozoic volcanic section is well exposed. In addition, the gold mines of the area (Bonanza mine and Golden Eagle mine) are easily accessible north of Martin Peak.

Northeast of the Little Harquahala Mountains is the larger, broad crest of the Harquahala Mountains. Varga (1977) has studied the geology of the western end of the range. In this part of the range a folded and faulted Paleozoic section overlies an altered, locally porphyritic granite. The higher main part of the range is composed of a complex assortment of plutonic (locally foliated) and metamorphic rocks. Paleozoic rocks exposed on the southeastern edge of the range are highly metamorphosed and deformed but include Permian Coconino Sandstone and Kaibab Limestone. The southern flank of the range contains variably metamorphosed Mesozoic(?) impure clastic rocks. Mineralization within the range includes showings of copper, gold, and tungsten.

28 miles

61.0 STOP #5. Salome Road exit

From this exit, excellent views are afforded of the Eagle Tail Mountains southwest of I-10. These mountains reveal a thick sequence of mid-Tertiary ash-flow tuff and lava, which dips gently to the southwest. They overlie a basement of locally foliated granitic rocks and are intruded by numerous northwest-trending dikes, sills, and plugs. Copper, gold, and silver occur in fractures cutting both the volcanic and basement rocks (Keith, 1978). The single large flat-topped butte in the center of the range is Courthouse Rock.

North of I-10 are the Big Horn Mountains, which are largely comprised of mid-Tertiary volcanic rocks. The volcanics rest on a basement of Precambrian metamorphic rocks and later granodiorite. Copper-gold mineralization occurs sporadically through the range.

Due south of this exit (in the distance) are the Gila Bend Mountains. In this range Miocene volcanics overlie a Precambrian basement of granite and metamorphic rocks. Several young basalt flows in the area have yielded late Miocene to early Pleistocene K-Ar ages (as reported in preliminary report for Palo Verde nuclear generator site).

13 miles

74.0 STOP #6. Tonopah exit

This stop is within the Tonopah desert. The Hassayampa River lies to the east and flows south into the Gila River southwest of Buckeye. North of the Tonopah desert are the Belmont Mountains, a range composed of Precambrian granite and metamorphic rocks, mid-Tertiary volcanic rocks, and abundant Tertiary dikes. Flatiron Mountain and additional buttes south of the Belmont Mountains are underlain by mid-Tertiary andesitic volcanics.

The high range directly to the east is the White Tank Mountains. The mountains are one of a series of "metamorphic core complexes" in this region (others include Harquahala and South Mountains). Precambrian gneiss and younger granitic intrusions make up most of the range. Both rock types locally exhibit a gently dipping mylonitic foliation on the east flank of the range. Muscovite granite and alaskite-pegmatite are abundant near the crest of the range. Porphyritic Precambrian granite is exposed at the range's southern end while a probable Tertiary pluton is exposed in the northwestern corner of the range.

South of the White Tank Mountains are the topographically subdued Buckeye Hills. Rock exposed in the hills include Precambrian granite and metamorphic rocks plus a muscovite granite, alaskite, and pegmatite complex of unknown age. These rocks locally exhibit a gently inclined mylonitic foliation.

Immediately south of this stop are the Palo Verde Hills and Saddle Mountain (to the west). Both are composed of a thick sequence of mid-Tertiary volcanics ranging from andesite to rhyolite. The Palo Verde nuclear generating facility is being constructed east of the Palo Verde Hills. In the small hill north of Saddle Mountain, a greenschist is exposed whose coloration can generally be seen from moderate distances.

19 miles

93.0 EXIT #7. Turnoff to U.S. 80

End of log.

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