# ARIZONA GEOLOGICAL SOCIETY

# 2003 Fall Field Trip

**TORTOLITA MOUNTAINS**
**December 6, 2003**

*LEADER: Charles A. Ferguson*

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# Tortolita Mountains

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by
Charles A. Ferguson

## Introduction

This field trip showcases important geologic features mapped and described during recent STATEMAP funded mapping of the Tortolita Mountains (Skotnicki, 2000, Orr et al., 2002; Richard et al., 2002; Spencer et al., 2002; Ferguson et al., 2003). The Tortolita Mountains mark the northwestern extent of the Catalina metamorphic core complex (Davis, 1980; Banks, 1980; Keith et al., 1980; Dickinson, 1991; Force, 1997). Metamorphic and plutonic rocks of the complex were exhumed along a low-angle detachment fault of Mid-Tertiary age that is exposed along the southern edge of the Rincon and Santa Catalina Mountains and is inferred to lie buried beneath piedmont deposits along the southern edge of the Tortolita Mountains.

Newly recognized structures in the range include a major east-west striking ductile shear zone named the Carpas Wash Shear Zone, a low-angle normal fault on the western piedmont named the the Lower Derrio Canyon fault, and an arcuate normal fault that bounds the western side of the Owl Head Buttes named the Owl Head Buttes fault. The structural geometry of the Chief Butte area, and relationships between the Carpas Wash shear zone and the Guild Wash fault will also be discussed and visited.

Access to the central part of the range is limited due to extremely poor road conditions on public lands, and large areas of private land restricting access in other areas. This field guide is intended to be used along with published geologic maps of the range (chiefly DGM 26; Ferguson et al., 2003). The guide starts at the southeastern edge of the range and works around to the northeast corner. The guide is a work in progress, and we intend to add stops to the guide in the future.

The guide consists of a text describing a series of 13 stops, a map showing the location of stops and access roads (Figure 1), and a list of UTM coordinates of the stops and important road intersections (Table 1). When using the guide, note that maps in the southernmost part of the range are based on the NAD83 datum, whereas NAD27 is used in the north. If you are using a GPS to locate stops and navigate the roads, remember to change the datum when you travel from south to north!

**Stop 1 (station 5)**

Park in a wide area of the wash in Cochie Canyon. Exposures in the wash consist of Pinal Schist intruded by a felsic western facies (coarse-grained leucogranite) of the pluton of Wild Burro Canyon. Climb out of wash and traverse ~400m to the and you will pass through several enclaves of metasedimentary rocks, cross into the main phase of the pluton of Wild Burro Canyon (a biotite-rich potassium feldspar porphyritic quartz monzonite), and cross at least one prominent dike of the Tortolita Mountains Granite. Note the variety of metasedimentary rocks ranging from pure marble, and quartzite, to various calc-silicate schist and psammitic rocks of probable Paleozoic and Mesoproterozoic origin. Enclaves of Mesoproterozoic age (Apache Group) are identified primarily on the basis of whether or not the enclave includes lenses of amphibolite schist which are believed to represent metamorphosed diabase dikes. In some areas, lenses of stretched quartz pebble conglomerate, probably representing Barnes Conglomerate of the Apache Group are preserved in some of the enclaves. A famous photograph of Stan Keith smoking a cigar-shaped stretched pebble was taken in this area (p. 427, Davis, 1984). See if you can find the outcrop!

**Stop 2 (station 10)**
This stop represents the southern edge of the footwall block in the Tortolita Mountains. This spur is composed of pluton of Wild Burro Canyon intruded by a sheared dike of fine-grained leucogranite thought to have come out of the Tortolita Mountains Granite. Enclaves of Paleozoic-Mesoproterozoic banded schist, calc schist, psammite and quartzite with lenses of amphibolite schist are present farther east. Good exposures of potassium feldspar porphyritic Wild Burro quartz monzonite with up to 30% biotite are present at the base of the slope. Look for an outcrop at 0488597E, 3593252N (NAD83) for well-developed top-to-the-southwest, protomylonitic s-c fabric. Note also that the s-c fabric in this outcrop is folded in asymmetric top-to-the-southwest cm-scale folds. These fabrics are typical for this part of the range and are interpreted as evidence of top-to-the-southwest motion along the detachment fault that is buried beneath alluvial cover just to the southwest. A weak, but pervasive, steeply southeast-dipping fabric present in all rocks (including the metasedimentary enclaves) is locally strongly deformed into gently dipping, discrete strong protomylonite and mylonite bands. Figure 2 summarizes some of the principle structural observations of the complex ductile fabrics in the footwall block of the Tortolita Mountains.

STATEMAP funded research in the Tortolita Mountains was augmented by Ar/Ar thermochronologic (Spell et al., 2003) and U-Pb geochronologic (Spencer et al., 2003) analyses of key units throughout the footwall block. The southwesternmost sample of our thermochronologic traverse was collected just to the north of this stop (0488653E, 3593325N) and yielded a biotite cooling age of ~22.4Ma. Additional cooling ages of 23.7Ma (biotite), 24.1Ma (biotite), and 25.3Ma (muscovite) were acquired along our northeast-trending transect at regular intervals of ~3km. The ages indicate that uplift of the range through the closing temperature of approximately 300°C (biotite) to 350°C (muscovite) progressed from northeast to southwest over an interval of ~3 million years.

**Stop 3 (station 19)**
The Lower Derrio Canyon fault is a very low-angle (3-7°) northwest-dipping structure with a thick, and very well-developed chloritic microbreccia in its footwall. Its footwall consists of a muscovite, garnet leucogranite named the granite of Fresnal Canyon, and its hanging wall consists of the 70Ma (Spencer et al., 2003) pluton of Chirreon Wash, a biotite-rich monzogranite to quartz monzonite and granodiorite that represents the oldest Laramide granitoid in the Tortolita Mountains. Brittle kinematics indicate top-to-the-

southwest motion along the fault which is essentially parallel to stretching lineations throughout the range. Despite the fact that this fault is associated with such a well-developed chloritic breccia, its origin and relationship to other structures in the range is poorly understood. To the west, it is buried by alluvium, and to the northeast it gradually dies out into the highly sheared core of the granite of Fresnal Canyon pluton.

**Stop 4 (station 23)**

The Owl Head Buttes fault is a newly recognized structure that bounds the western side of the buttes. A stream-cut exposure of the fault with intense breccia and calcite veins is examined at Stop 4. The hanging wall block of the Tortolita Mountains consists mostly of crystalline basement composed of the Oracle Granite, a coarse-grained, potassium feldspar porphyritic granitoid that intrudes pelitic schist, phyllite, and slate of the Pinal Schist. The crystalline basement is overlain by a sequence of Oligocene mafic and intermediate lava flows preserved in three outliers. The volcanic sequence in each area is known to be correlative because a distinctive, yet thin welded rhyolite ash-flow tuff has been identified in each area. The ash-flow tuff, dated at 26.4Ma (Peters et al., 2003), has also been identified in the Fortified Peak area 20km to the northeast (Orr et al., 2002). The volcanic rocks are exposed in three areas, the Owl Head Buttes being the westernmost. The western boundary of the Owl Head Buttes was previously (Banks et al., 1977) mapped as a steeply east-dipping depositional contact. Slivers of Paleozoic carbonate along the contact were interpreted as slide blocks. Our mapping indicates that the volcanic sequence at Owl Head Buttes dips steeply to the west and a depositional contact with schist clast conglomerate is well-developed along the eastern side of the buttes. The western contact is interpreted as an arcuate, possibly concave-up normal fault, and the carbonate slivers are identified as veins (up to 4m thick in some places) of sparry calcite. In some areas, crystals of barite up to 2cm long line the walls of the calcite veins.

A westerly dip for the sequence at Owl Head Buttes is significant because the same succession at Chief Butte, less than 7km to the northeast, dips steeply in the opposite direction. A thin sliver of similar volcanics half-way in between dips moderately to the north indicating that the hanging wall block includes a major anticlinal tilt-domain boundary.

**Stop 5 (station 27)**

The Guild Wash fault and the Carpas Wash shear zone are nearly coincident just to the south of Guild Wash in this area. At this stop a traverse ~100m south of the road allows you to see both structures. As you walk to the south, a ridge of strongly silicified chloritic breccia, composed of coarse-grained Oracle Granite, rises a few meters above the first wash you cross. To the south of this ridge the granite becomes increasingly mylonitic with a dark brown matrix. The rock is recognizable as "granite" only because of the scattered potassium feldspar porphyroclasts. About 50m farther south the mylonitic fabric becomes very strong, locally ultramylonitic. Abruptly, over a distance of less than 5m, notice that the potassium feldspar porphyroclasts are absent and that the rock is an intensely foliated sericitic schist. This contact is mapped as the Carpas Wash shear zone and as such can be mapped from east to west across the northern part of the range. Foliations and lineations in the vicinity of the Carpas Wash shear zone are summarized in Figure 3. Note that lineations are slightly more westerly than the average for stretching lineations in other parts of the range. Note also that although directional stretching lineations are somewhat evenly distributed in terms of shear sense throughout the rest of the range, directional stretching lineations in the Carpas Wash shear zone are consistently top-to-the-west.

**Stop 6 (station 29)**
The road crosses a rib of silicified, chloritic breccia that corresponds to the eastern strand of the Guild Wash fault. The footwall consists of Oracle Granite that intrudes, on the ridge line to the east, strongly hornfelsed Pinal Schist. Note that Banks et al. (1977) had shown these rocks to be Mesoproterozoic Apache Group and the contact on this ridge as an unconformity. The low area to the northeast of here preserves, despite the sparse exposure, the basal Oligocene unconformity dipping steeply to the east. A thin sequence of andesitic and basaltic lava is overlain by mixed clast conglomerate and both rocks appear to be overridden by a pair of south-dipping reverse faults that carry coarse-grained monolithic fault breccia of crystalline basement in their hanging walls. The faults appear to die upwards into the conglomerate.

**Stop 7 (station 30)**
A southerly strand of the Guild Wash fault is exposed along the eastern side of the wash and in its hanging wall a good exposure of the Carpas Wash shear zone is preserved. Climb out of the wash over an outcrop of chloritic altered fault breccia of granodiorite of the pluton of Chirreon Wash. In the hanging wall, note the same gradual southward increase in intensity of mylonitic fabric in the Oracle Granite as you approach the Carpas Wash shear zone and the relatively abrupt transition into sericitic schist at the shear zone contact. Follow the contact up a small wash and observe a series of fine-grained mafic dikes that intrude the shear zone. The dikes come from a small stock of fine-grained diorite to monzodiorite. The stock appears to intrude another strand of the Guild Wash fault just to the east.

**Stop 8 (station 31)**
The Guild Wash fault is exposed in the road cut where Pinal Schist occurs in the footwall and granite-clast conglomerate in the hanging wall. The fault is marked by hematite stained fault breccia and appears to be relatively steeply north-dipping.

**Stop 9 (stations 35, 36, 37)**
The Carpas Wash shear zone is exposed just to the south of the wash. Just to the west of the corral (Stop 9a), a prominent plagioclase-porphyritic dacitic dike cuts across the map pattern of the shear zone. The 25.1Ma dike (U-Pb zircon crystallization age of Spencer et al., 2003) is clearly unaffected by the shear zone and provides a minimum age of motion along the dike. Follow the shear zone to the east approximately 350m and look for an exposure of sheared, phenocryst-poor, rhyolite porphyry dike within the shear zone. The orientation of the dike is consistent with top-to-the-west motion in the shear zone. A U-Pb date of this dike would constrain a maximum age for the shear zone.

**Stop 10 (station 43)**
The early Proterozoic of southern Arizona is dominated by the Pinal Schist, a pelitic turbidite sequence that, between Phoenix and Wilcox, is characterized by a lack of igneous rocks. Here, a small exposure of phenocryst-poor rhyolite lava interbedded with the turbiditic rocks is a rare exception. In addition, a thin dacitic ash-flow tuff, and quartz-pebble and rhyolite lava clast conglomerate bed within the turbidite succession has been identified in the hills east of here.

**Stop 11 (station 45)**
A southwest-striking fault dipping 50° north crosses the wash here. Faults of this orientation cut the major fault that bounds the southwestern side of this belt of volcanic rocks. The major fault is interpreted as a gently east-dipping, top-to-the-west normal fault that has been rotated past horizontal and is now oriented as if it were a thrust. In the hangingwall of the minor fault at this stop, a depositional contact between lava flows of the two main types of volcanic rock in this area is preserved; andesitic lava overlain by basaltic lava. In this area, the andesitic lavas are characterized by phenocryst assemblages dominated by plagioclase, and basaltic lavas are dominated by mafic (pyroxene and olivine) phenocrysts. Chemical analyses of these rocks indicate that the andesites are mostly trachyandesite and the basalts range from true basalts to trachybasalt and basaltic trachyandesite (Ferguson et al., 2003). Lava flows in this succession are relatively thin (5-20m) and have very sparse interbeds of volcaniclastic rocks. Dips are consistently 40° to 60° to the northeast.

**Stop 12 and 13 (stations 47, 49)**
Big Mine, Owl Head Mining District. A deep shaft with several steeply west-dipping inclines on the hill to the east make up the most extensively mined area in the district. Detailed studies of the mineralization, alteration, and structure of this district were done by Iles (1966). Abundant copper oxide mineral coatings can be seen in the intensely fractured basaltic lava throughout the area. Note the abundance of gray Pinal Schist in the dump, a rock that is not exposed anywhere near here. The Schist was extracted from the shaft according to mine reports by Iles (1966). Based on our mapping (Ferguson et al., 2003) and descriptions in Iles' (1966) thesis we interpret the main zone of mineralization in this district to be the fault breccia associated with a low-angle, gently east-dipping, top-to-the-west normal fault that was penetrated several hundred feet down in this shaft. We interpret this to be the same major fault we mapped along the western edge of this belt of volcanics. We also map, as did Iles (1966), a younger, high-angle, west-dipping fault just to the west of the mine. The younger fault can be traced to the southeast where it eventually brings to the surface exposures of Pinal Schist in the footwall of the older low-angle fault. Three small windows or fensters of this fault are mapped about 600m to 900m to the southeast of the Big Mine (Stop 13). Farther to the southeast, a larger window into the low-angle fault is preserved across a down-to-the-northwest normal fault.

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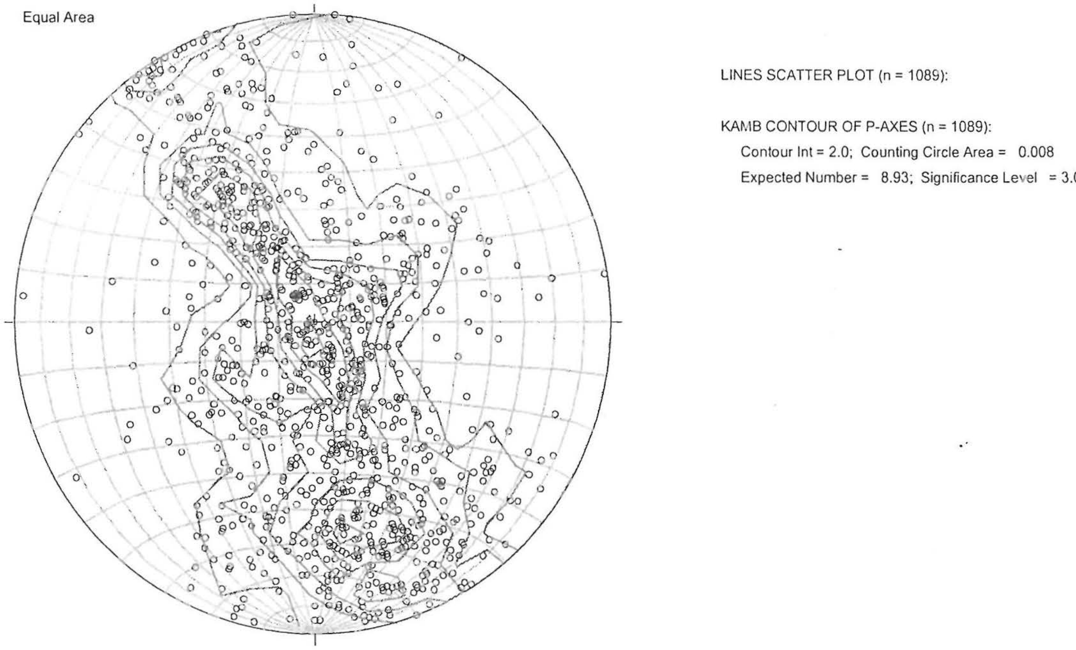
A) Poles to foliation, footwall, Tortolita Mountains




B) Stretching lineation, footwall, Tortolita Mountains

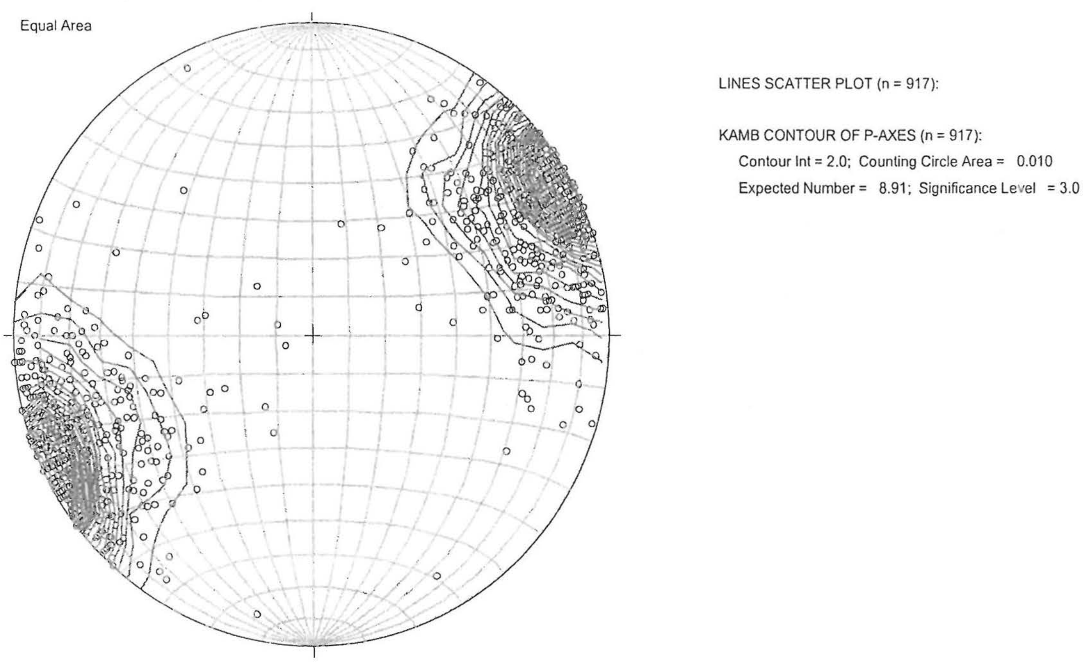
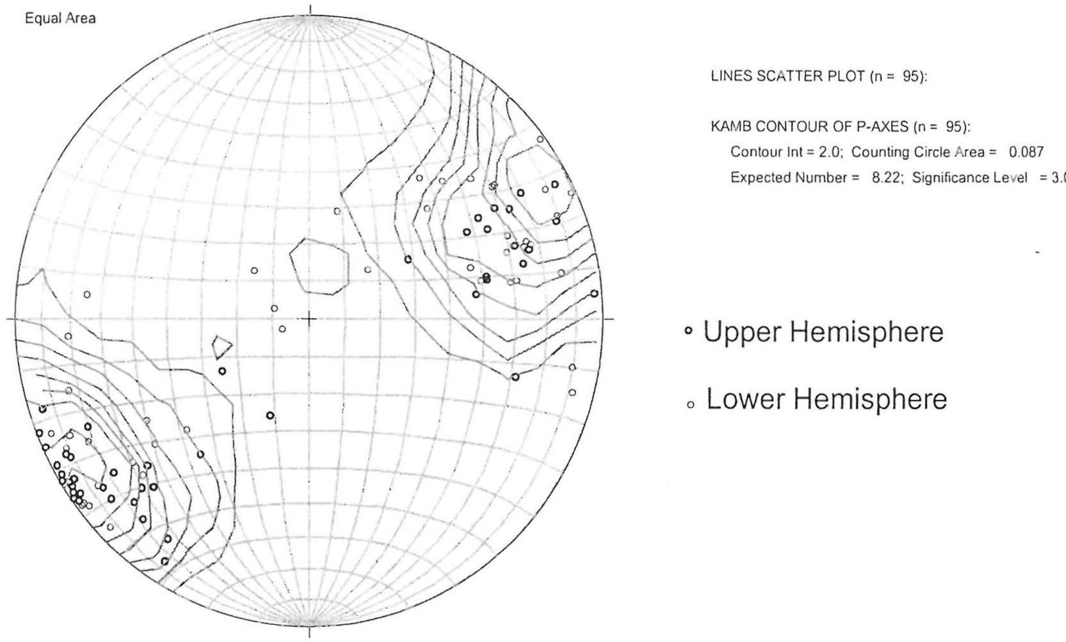



Figure 2a) Lower hemisphere stereonet plot of poles to schistosity, and mylonitic foliation, and 2b) stretching lineation in the footwall of the Tortolita Mountains. Analysis from program SteroWin, v. 1.1, by R.W. Allmendinger (2002).

C) Directed stretching lineation, footwall, Tortolita Mountains




D) Poles to crenulation cleavage and shear bands, footwall, Tortolita Mountains

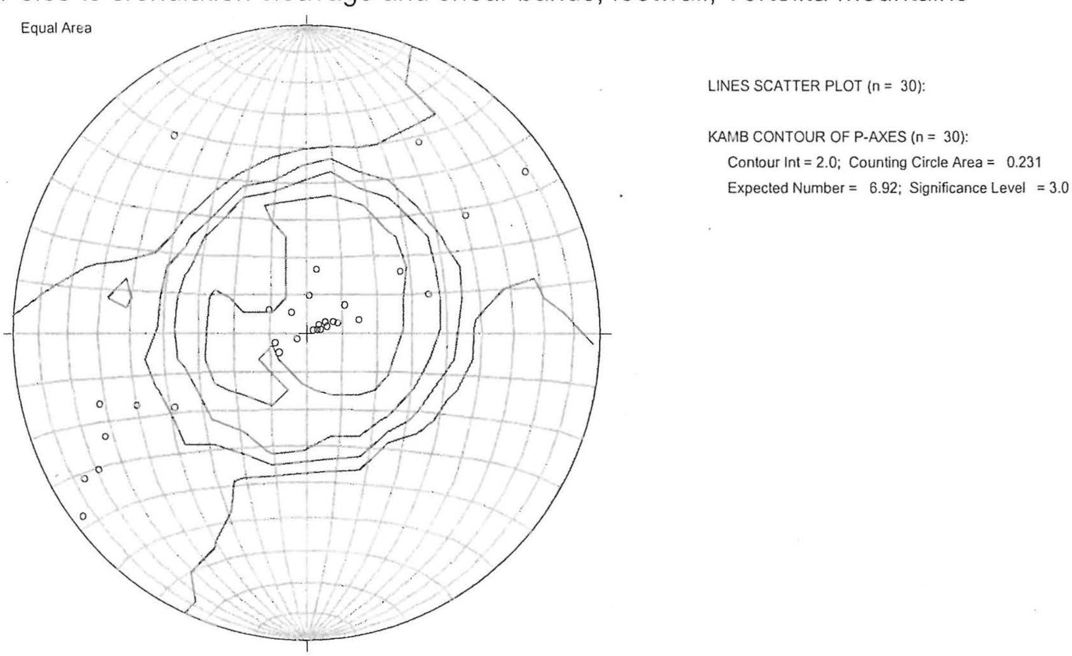
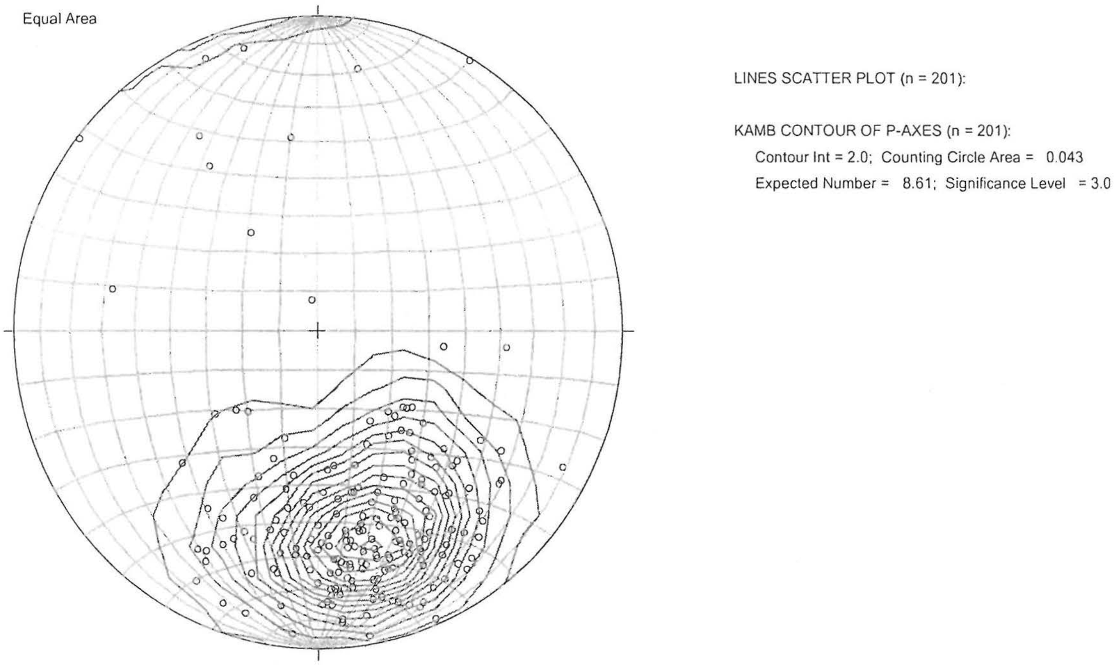



Figure 3c) Stereonet plot of directed stretching lineation, and 3d) lower hemisphere stereonet poles to crenulation cleavage and shear bands in the footwall of the Tortolita Mountains. Analysis from program SteroWin, v. 1.1, by R.W. Allmendinger (2002).

A) Poles to foliation, Carpas Wash shear zone, northern Tortolita Mountains




B) Directed stretching lineations, Carpas Wash shear zone, northern Tortolita Mountains

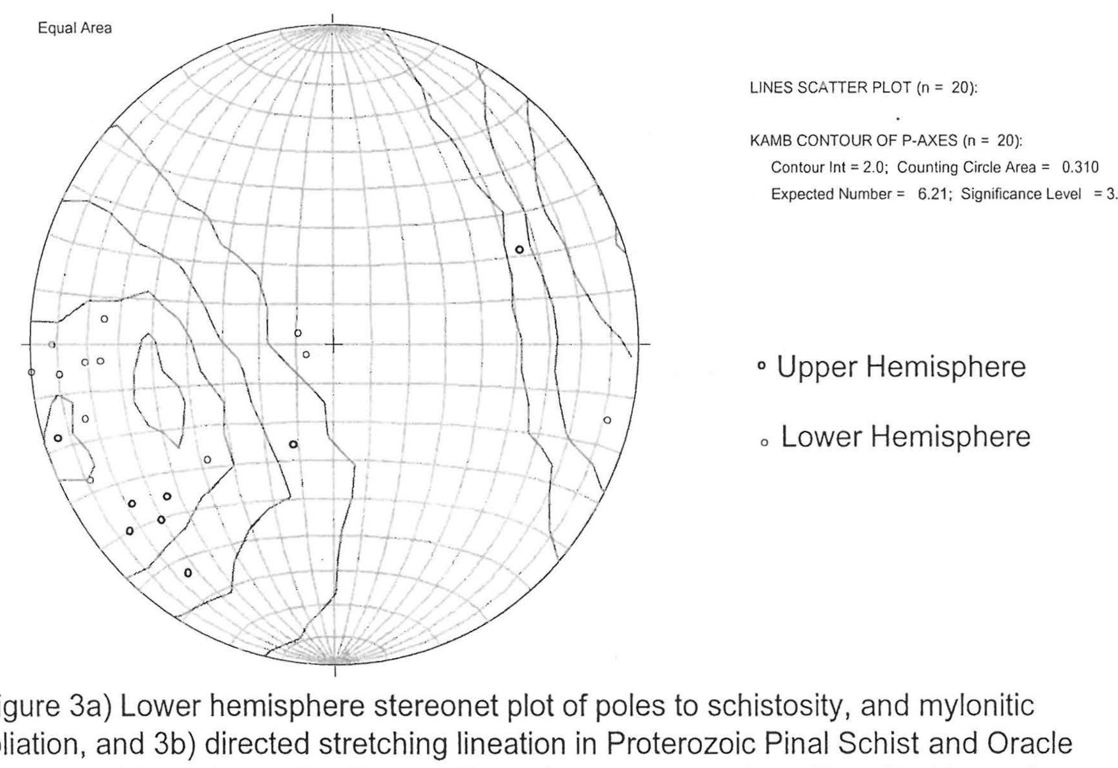
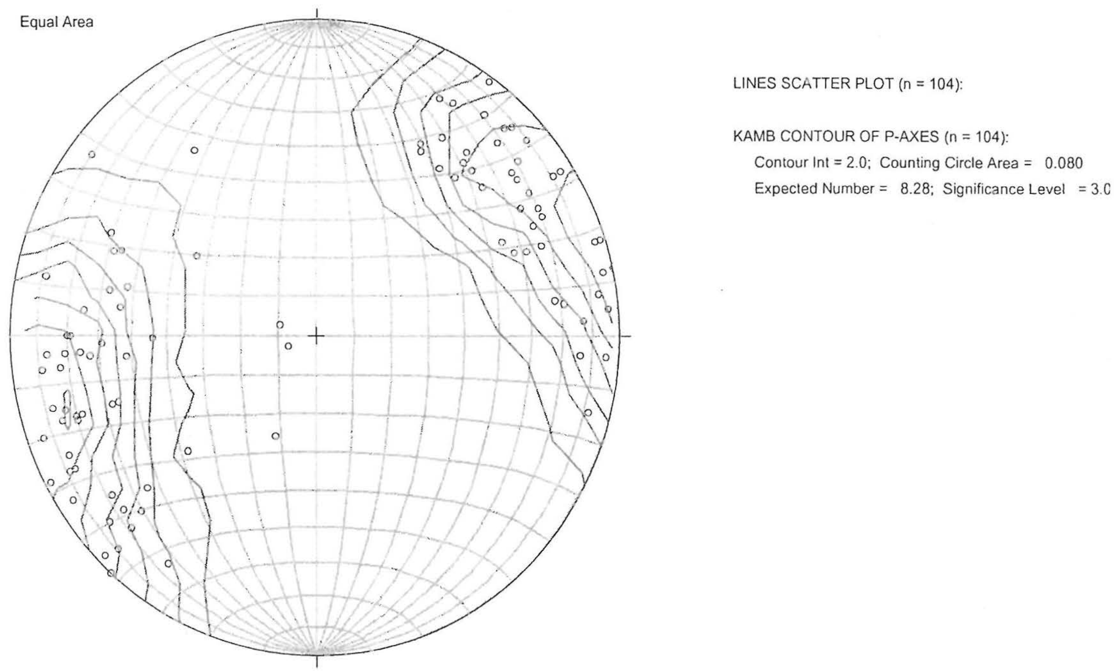



Figure 3a) Lower hemisphere stereonet plot of poles to schistosity, and mylonitic foliation, and 3b) directed stretching lineation in Proterozoic Pinal Schist and Oracle Granite within and near the Carpas Wash shear zone, northern Tortolita Mountains. Analysis from program SteroWin, v. 1.1, by R.W. Allmendinger (2002).

C) Older lineations (including stretching lineation), Carpas Wash Shear Zone, northern Tortolita Mountains




D) Stretching lineation, Carpas Wash Shear Zone, northern Tortolita Mountains

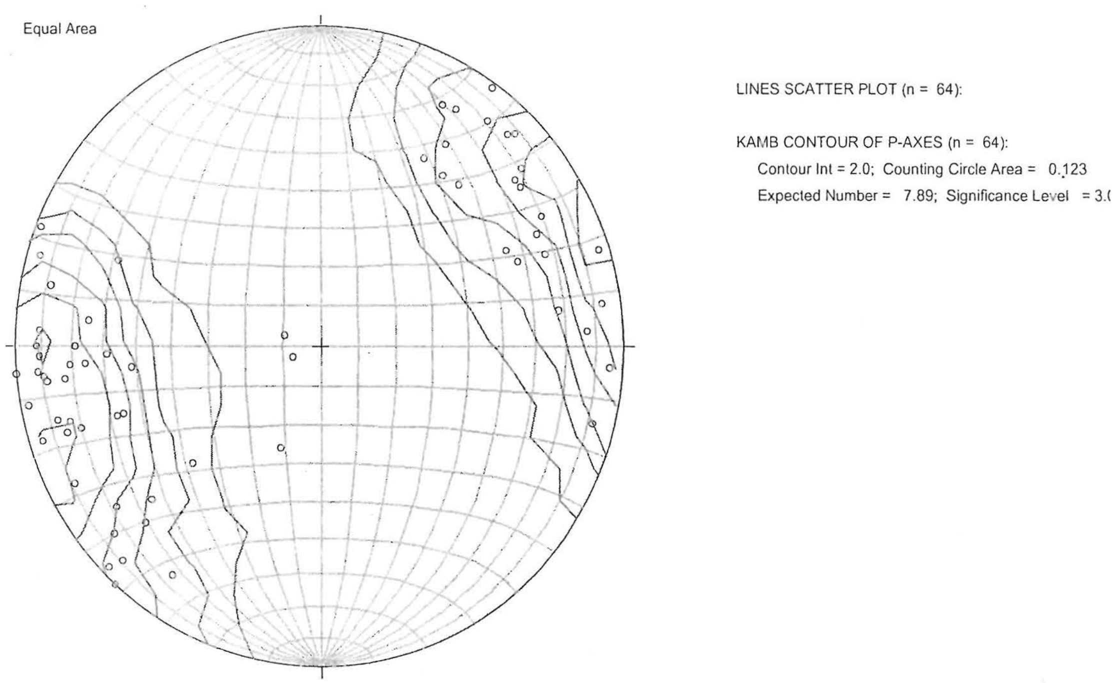



Figure 3c) Lower hemisphere stereonet plot of mineral lineation, crenulation lineation, stretching lineation, and hinge lines of isoclinal folds, and 3d) stretching lineation in Proterozoic Pinal Schist and Oracle Granite within and near the Carpas Wash shear zone, northern Tortolita Mountains. Analysis from program SteroWin, v. 1.1, by R.W. Allmendinger (2002).

E) Younger lineations, Carpas Wash shear zone, northern Tortolita Mountains

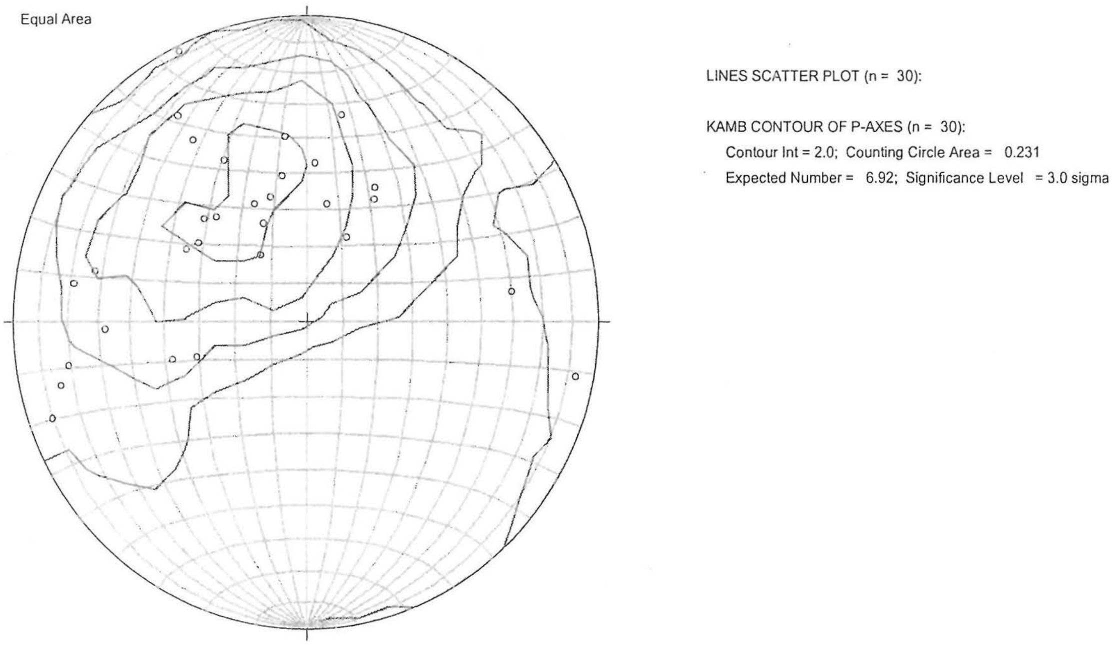



Figure 3e) Lower hemisphere stereonet plot of hinge lines of close to open mesocopic folds (commonly chevron forms) that deform mylonitic foliation and schistosity in Proterozoic Pinal Schist and Oracle Granite within and near the Carpas Wash shear zone, northern Tortolita Mountains. Analysis from program SteroWin, v. 1.1, by R.W. Allmendinger (2002).

Table 1 UTM Grid zone 12 locations of road landmarks and stops for field trip to the Tortolita Mountains

| Map # | UTME | UTMN | Datum | 7.5' Quadrangle | Notes |
|---|---|---|---|---|---|
| 1 | 479300 | 3592097 | NAD83 | Marana | Turn onto graded gravel road from frontage road |
| 2 | 481257 | 3592262 | NAD83 | Marana | Cross CAP canal |
| 3 | 481697 | 3592559 | NAD83 | Marana | Gate on Owlhead Ranch Road, turn east on graded gravel road |
| 4 | 483941 | 3594768 | NAD83 | Marana | Take east fork, graded gravel roads |
| 5 | 489127 | 3594334 | NAD83 | Ruelas Canyon | **Stop 1** |
| 6 | 488534 | 3594143 | NAD83 | Ruelas Canyon | 4WD road descends into Cochie Canyon, turn north and drive in wash |
| 7 | 488497 | 3594193 | NAD83 | Ruelas Canyon | Drill site along 4WD road, continue east towards Cochie Canyon |
| 8 | 488173 | 3594244 | NAD83 | Marana | 4WD road to east intersects graded gravel road |
| 9 | 487999 | 3594381 | NAD83 | Marana | Cattle guard near corral on graded gravel road |
| 10 | 488551 | 3593200 | NAD83 | Ruelas Canyon | **Stop 2** |
| 11 | 488470 | 3592741 | NAD83 | Ruelas Canyon | Turn north on 4WD road |
| 12 | 488014 | 3592594 | NAD83 | Marana | 4WD road crosses wash |
| 13 | 487951 | 3592906 | NAD83 | Marana | Gate |
| 14 | 487861 | 3593050 | NAD83 | Marana | 4WD road crosses Cochie Canyon Wash |
| 15 | 487519 | 3594367 | NAD83 | Marana | 4WD road intersects graded gravel road where telephone lines cross |
| 16 | 487630 | 3598201 | NAD27 | Desert Peak | Take west fork, graded gravel roads |
| 17 | 487679 | 3598841 | NAD27 | Desert Peak | Ridge crest in Fresnal Canyon Leucogranite, stay on main road |
| 18 | 487462 | 3599102 | NAD27 | Desert Peak | 4WD road intersects Mule Deer Road |
| 19 | 487232 | 3599065 | NAD27 | Desert Peak | **Stop 3** |
| 20 | 487256 | 3601531 | NAD27 | Desert Peak | Intersection, Mule Deer Road with Owlhead Ranch Road |
| 21 | 487263 | 3603759 | NAD27 | Desert Peak | Crested Saguaro Road turns east from Owlhead Ranch Road |
| 22 | 488057 | 3603755 | NAD27 | Desert Peak | Hannibal Road turns north from Crested Saguaro Road |
| 23 | 488046 | 3604351 | NAD27 | Desert Peak | **Stop 4** |
| 24 | 488586 | 3603766 | NAD27 | Tortolita Mountains | Intersection, Crested Saguaro and Pipeline road |
| 25 | 490008 | 3604870 | NAD27 | Tortolita Mountains | Powerline and pipeline roads cross |
| 26 | 491386 | 3605179 | NAD27 | Tortolita Mountains | Powerline road intersects graded gravel road |
| 27 | 493064 | 3605588 | NAD27 | Tortolita Mountains | **Stop 5** |
| 28 | 496016 | 3606249 | NAD27 | Tortolita Mountains | Gate at crossroads |
| 29 | 496383 | 3606004 | NAD27 | Tortolita Mountains | **Stop 6** |
| 30 | 496700 | 3604942 | NAD27 | Tortolita Mountains | **Stop 7** |
| 31 | 498000 | 3606850 | NAD27 | Tortolita Mountains | **Stop 8** |

Table 1(continued) UTM Grid zone 12 locations of road landmarks and stops for field trip to the Tortolita Mountains

| | | | | | |
|---|---|---|---|---|---|
| 32 | 498300 | 3606750 | NAD27 | Tortolita Mountains | Gate, continue along power line road |
| 33 | 501200 | 3606800 | NAD27 | Oracle Junction | Powerline Road nears Substation, intersects cutoff to N-S road |
| 34 | 502400 | 3605125 | NAD27 | Oracle Junction | Carpas Wash Road intersects N-S road |
| 35 | 500435 | 3604850 | NAD27 | Oracle Junction | **Stop 9** |
| 36 | 500406 | 3604834 | NAD27 | Oracle Junction | **Stop 9a** |
| 37 | 500061 | 3604752 | NAD27 | Oracle Junction | **Stop 9b** |
| 38 | 495378 | 3606563 | NAD27 | Tortolita Mountains | 3-way intersection, north fork leads to locked gate at ranch |
| 39 | 493555 | 3606575 | NAD27 | Tortolita Mountains | 4WD road intersects graded gravel road |
| 40 | 493007 | 3606901 | NAD27 | Tortolita Mountains | 4WD road intersects pipeline road |
| 41 | 495000 | 3608186 | NAD27 | Tortolita Mountains | Locked gate on pipeline road |
| 42 | 494581 | 3607915 | NAD27 | Tortolita Mountains | Wash (road) intersects pipeline road |
| 43 | 492720 | 3608730 | NAD27 | Tortolita Mountains | **Stop 10** |
| 44 | 492456 | 3609248 | NAD27 | Tortolita Mountains | Take 4WD road that crosses wash |
| 45 | 492968 | 3609134 | NAD27 | Tortolita Mountains | **Stop 11** |
| 46 | 493492 | 3609292 | NAD27 | Tortolita Mountains | 3-way intersection |
| 47 | 493636 | 3609432 | NAD27 | Tortolita Mountains | **Stop 12** |
| 48 | 493794 | 3609429 | NAD27 | Tortolita Mountains | 3-way intersection |
| 49 | 494100 | 3609150 | NAD27 | Tortolita Mountains | **Stop 13** |
| 50 | 495583 | 3608586 | NAD27 | Tortolita Mountains | Pipeline road intersects graded gravel road |
| 51 | 495298 | 3608864 | NAD27 | Tortolita Mountains | 4WD road intersects graded gravel road |
| 52 | 494082 | 3609997 | NAD27 | Chief Butte | 3-way intersection near water tank |
| 53 | 495268 | 3609937 | NAD27 | Chief Butte | 3-way intersection just west of cattle guard |
| 54 | 499852 | 3609857 | NAD27 | Chief Butte | Graded gravel road intersects US 89 |
| 55 | 496000 | 3608000 | NAD27 | Chief Butte | Tuttle Ranch, locked gates |

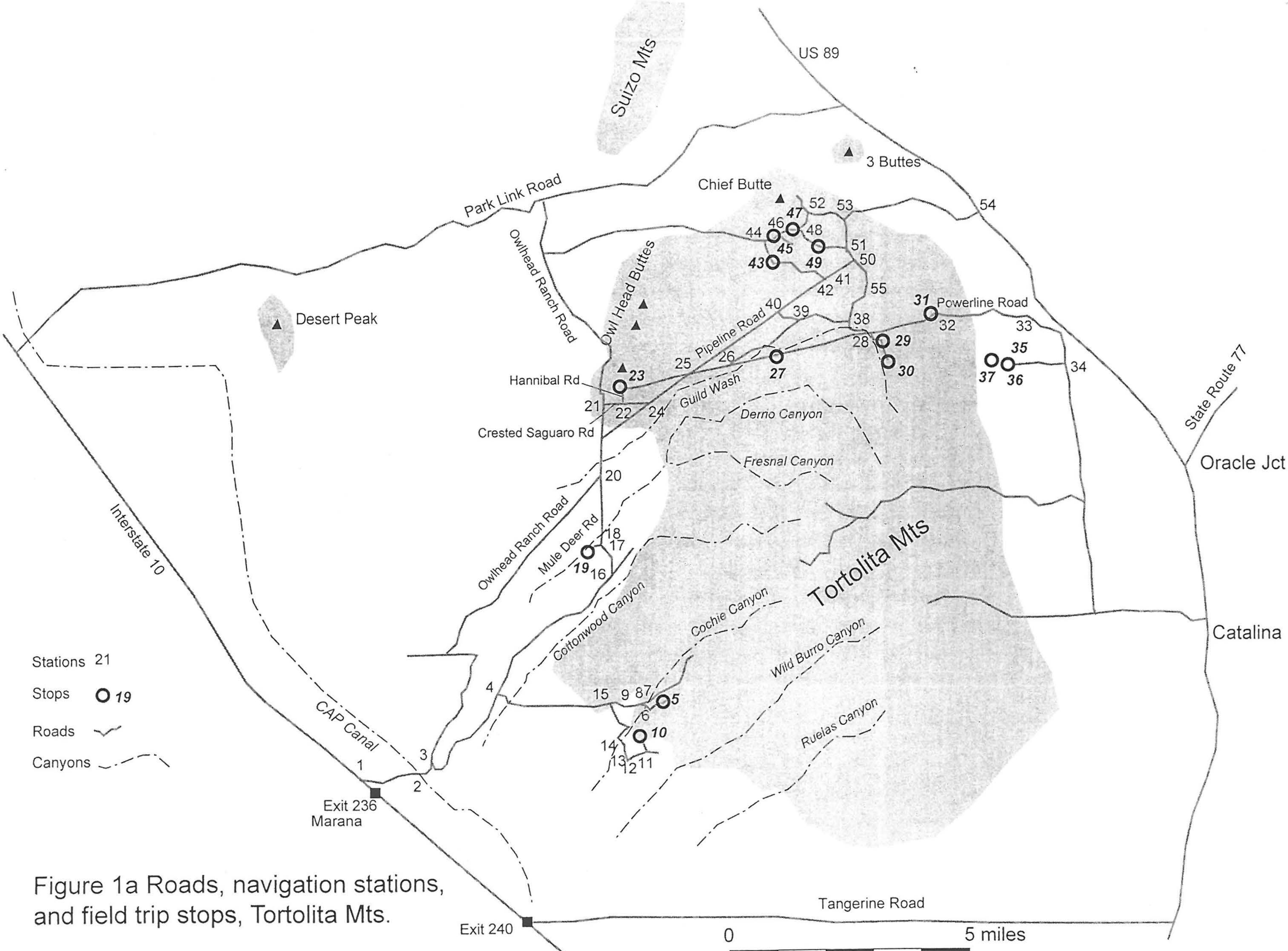



Figure 1a Roads, navigation stations, and field trip stops, Tortolita Mts.

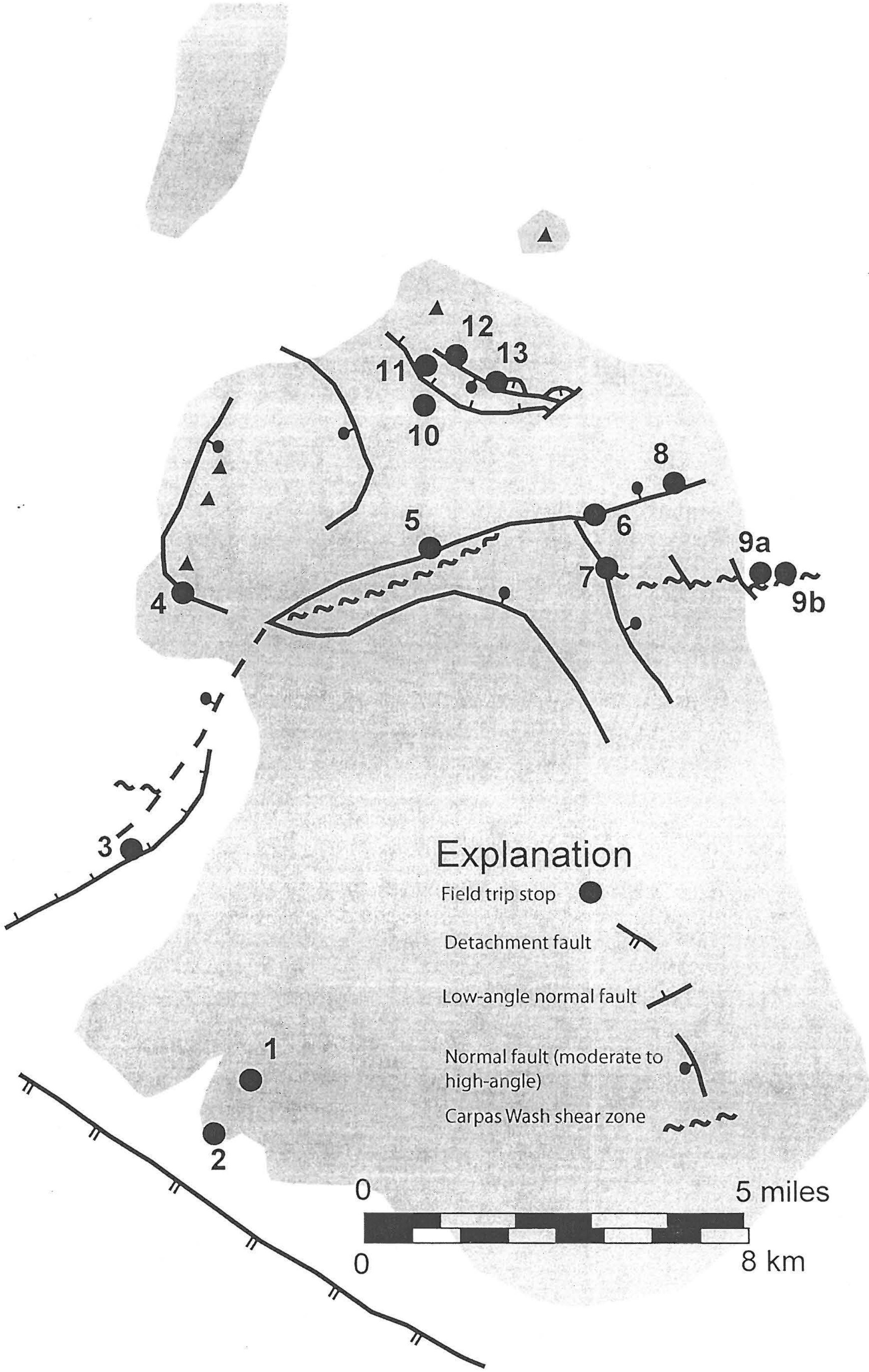



**Figure 1b** Principal faults and shear zones, Tortolita Mts