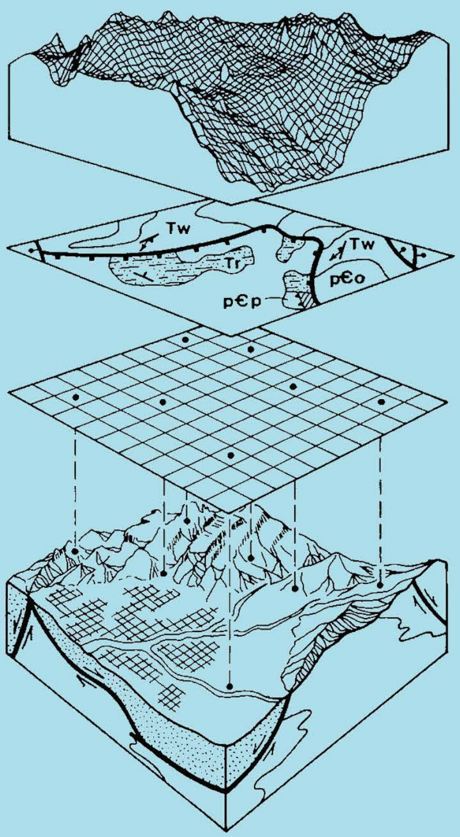
FRONTIERS IN GEOLOGY AND ORE DEPOSITS OF ARIZONA AND THE SOUTHWEST

Arizona Geological Society and the University of Arizona 1986 Symposium



FIELD TRIP GUIDEBOOK
#5

Stratigraphy, Structure, and Gold Mineralization Related to Calderas in the Superstition Mountains, Central Arizona

March 18-19, 1986

Leader: M. Sheridan (A.S.U.)

ARIZONA GEOLOGICAL SOCIETY
TUCSON, ARIZONA

Cover preparation by Beverly Morgan, modified from J. Mehulka and P. Mirocha, AGS Digest Volume XVI

ARIZONA GEOLOGICAL SOCIETY
P.O. BOX 40952, UNIVERSITY STATION
TUCSON, ARIZONA 85719

To: Field Trip Participants

Welcome to Arizona and the 1986 Arizona Geological Society Symposium "Frontiers in Geology and Ore Deposits of Arizona and the Southwest." As field trip chairman I would like to wish you an enjoyable and informative conference and a worthwhile field trip experience.

The field trip committee set out many months ago to provide field exposure to a broad spectrum of geological disciplines. The results include trips to recent precious-metal discoveries, areas of new and developing stratigraphic and structure concepts, industrial mineral resources, lithologic features significant to the petroleum potential in the Southwest, geologic hazards in the community, and an opportunity to attend trips from previous Arizona Geological Society meetings. We hope you find your chosen field trip as exciting as we intended.

At this time of very limited support from industry, it is especially important to acknowledge the personal efforts of so many. I include in those the planning and follow through of the field trip committee, the many hours of preparation by the trip leaders, and the commitment of the trip coordinators to a smooth-running trip. A special thanks goes to Maggie Morris of the University of Arizona Conference Department for the transportation, lodging, and meal arrangements.

Please enjoy the Southwest and remember this week of field trips and meetings as a step toward the frontiers of the future.

Best regards,

Parry D. Willard
Field Trip Chairman

Field Trip Committee

Annon Cook
Norm Lehman
Beverly Morgan
Jon Spencer
Erick Weiland
Joe Wilkins Jr.
Jan Wilt

ITINERARY

FIELD TRIP 5

STRATIGRAPHY, STRUCTURE, AND GOLD MINERALIZATION RELATED TO CALDERAS IN THE SUPERSTITION MOUNTAINS, CENTRAL ARIZONA

Leader:	Michael F. Sheridan (ASU)
Coordinators:	Diane Marozas (U of A)

Tuesday, March 18, 1986

7:00 am	Depart from University of Arizona, front of Student Union
9:30 am	Meet leaders at Apache Trail Junction
9:45 am	Old Wasp mine tour, Goldfield district
12:00 noon	Lunch* at Golden Hillside mine
12:30 pm	Golden Hillside mine tour
3:15 pm	Government Well stop. Examine geology along eastern margin of Goldfield caldera
4:15 pm	First Waterhole Canyon—low-angle faulting, caldera-related or tectonic?
6:30 pm	Arrive and check in at Grand Hotel,* Apache Junction, Ariz., (602-982-7411)
7:30 pm	Steak dinner,* Grand Hotel

Wednesday, March 19, 1986

7:30 am	Check out and depart from Grand Hotel
8:15 am	Canyon Lake overlook, First Water tuffs, and lavas
9:15 am	Canyon Lake welded tuff (rheomorphism?)
11:30 am	Mesquite Flat breccias and lahars
12:15 pm	Lunch* at Mormon Flat Dam road
12:45 pm	Mormon Flat Dam road, caldera faults and rhyolite vents
3:15 pm	Fish Creek overlook, northeast rim of Tortilla caldera
4:30 pm	Return to Apache Junction; then travel to Tucson
7:00 pm	Arrival in Tucson with stops at Holiday Inn (Broadway) and University of Arizona

*Included in fees.

Drivers: Diane Marozas

Field boots required. If possible, bring hard hat and safety glasses for mine tours.

FIELD TRIP 5

STRATIGRAPHY, STRUCTURE, AND GOLD MINERALIZATION RELATED TO CALDERAS IN THE SUPERSTITION MOUNTAINS, CENTRAL ARIZONA

March 18–19, 1986

Leader: Michael F. Sheridan (Arizona State University)

Coordinator: Diane Marozas (University of Arizona)

Arizona Geological Society Digest Volume XVI, 1986

STRATIGRAPHY, STRUCTURE, AND GOLD MINERALIZATION RELATED TO CALDERAS IN THE SUPERSTITION MOUNTAINS

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INTRODUCTION

This paper presents a resume of the stratigraphy, structure, and gold mineralization that can be seen during a field excursion along the Apache Trail. The volcanic rocks of this area belong to the huge Superstition Volcanic Field that covers hundreds of square kilometers in central Arizona (Fig. 1). The Apache Trail traces a path along the margins of at least three calderas or volcano-tectonic depressions (Sheridan and others, 1970; Sheridan, 1978). Hence, the stratigraphy and structures visible from the road are complex.

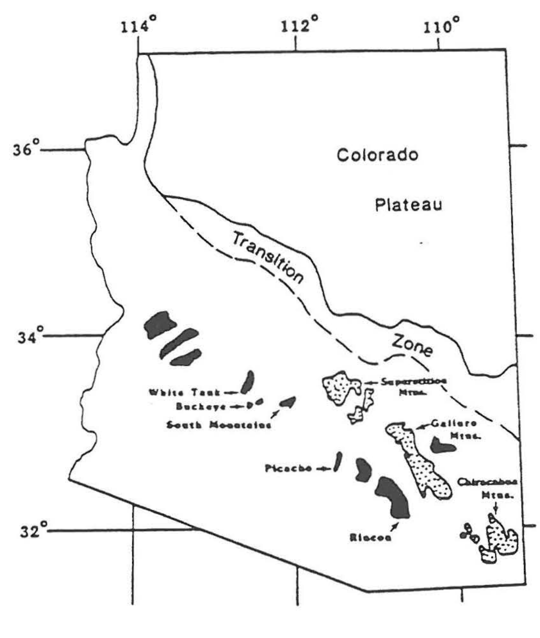

Figure 1. Index map showing the location of the Superstition Mountains, other large silicic volcanic fields (stippled pattern) and metamorphic core complexes (in black).

This field trip will spend part of a day examining the geology of the mines and prospects in the Goldfield District, a few kilometers north of Apache Junction. A day and a half will be spent examining the principal rock units and important structures in the area. Special attention will be paid to features that are characteristic of caldera margins.

Information on the geology of the area comes from many sources including several Arizona State University Geology theses that have been completed on the rocks from the Superstition Volcanic field. Most of the studies to date have been topical and a general synthesis of the entire volcanic field does not exist. A brief synthesis of the stratigraphic units, from the top of the section downward, follows. Along the Apache Trail the oldest units are to the southwest and the youngest units are to the northeast. An exception is the Horse Mesa area where the oldests units are exposed at the western edge of the volcanic field. Not all of the units described below are exposed in roadcuts.

ROCK UNITS

Mesquite Flat breccia (Tmb). This unit (Rettenmaier, 1984; Stuckless and Sheridan, 1971) consists of lahars with bed thickness on the scale of centimeters to meters. Locally it contains thin ash-flow tuffs or coarse breccias. It has a tan to yellowish color and forms a prominent cliff along Canyon Lake. Large (dm) lithic clasts are set in a matrix of volcanic ash.

Younger basalt lava (Tyb). Both above and below the Tmb are thin (a few meters) bluish basalt flows (Suneson, 1976). Where this unit is weathered redish altered olivine phenocrysts are visible in hand specimens. The composition is that of an alkali olivine basalt.

Canyon Lake Tuff (Tct). This rhyolitic unit is a welded tuff composed of at least two cooling units (Stuckless and Sheridan, 1971). Locally in Bulldog Canyon it contains multiple vitrophyres and exhibits rheomorphic folds in thick sections. The base is nonwelded and vitric, but generally the degree of devitrification and vapor-phase alteration is high. Non-welded parts are yellowish due to zeolites, but the devitrified part is gray to redish. Phenocrysts (quartz, plagioclase, sanidine, and biotite) are fairly abundant (15 to 20%) and flattened pumice can be recognized in some samples. The age is 15 m.y.

Rhyolite of First Water Canyon (Tfr). This unit was formerly included in the Geronimo Head Formation (Stuckless, 1969; Stuckless, 1971; Stuckless and Sheridan (1971), but it has now been separated because it is older than the sequence exposed at Geronimo Head. It is a thick (more than 1,000 m) deposit of tuffs and lavas of phenocryst-poor rhyolite (Fodor, 1969; Suneson, 1976). The tuffs are yellow and generally exhibit thin bedding. The lavas are commonly glassy and range from black (obsidian), to gray (perlite), to redish (devitrified). The pyroclastic units consist of breccias, surge deposits, ash-flow tuffs, and pumice fall beds. Numerous eruptive centers occur throughout the area. The age is 16 m.y.(Stuckless and Sheridan, 1971).

The Geronimo Head formation more properly applies to a group of slightly younger domes and tuff-rings termed the Peters Canyon complex (Prowell, 1984). These domes and the ones to the north near Coronado Mesa (Isagholian, 1983) were the source for the Mesquite Flat Breccia lahars and tuffs. Several small rhyolitic dome complexes that have similar compositions and ages extend in a belt toward the southeast through Music Mountain as far as Pickettpost Mountain (Peterson, 1966).

Rhyodacite of Apache Gap (Tard). This unit (Stuckless and Sheridan, 1971) consists of a lava that is rich in phenocrysts (about 25%) and local pyroclastic breccias. The lava is black where it is glassy, but it may consist of a gray perlite matrix where hydrated or have a salt-and-pepper appearance where devitrified. Flow banding is locally common in the vicinity of vents. The associated tuffs and breccias may be ash flows, surges, or lahars. Locally a thin basalt flow lies between the base of the lava and the underlying tuff. Most exposures of the lava exhibit strong evidence of maga mixing with this basalt. The age of this unit is 20 to 21 Ma.

Bronco Butte Lahar (Tbl). This epiclastic volcanic breccia on Horse Mesa is about 60 m thick (Malone, 1972). It appears to grade into the dacite lava that caps the ridge near Bronco Butte, and hence may be equivalent to lahars that underlie the rhyodacite of Apache Gap (20 Ma age) in other parts of the Superstition Mountains. It is pale yellow in color, stratified, and contains inclusions of dacite and basalt.

Older Rhyolite lava and ashes (Torl, Tora). This sequence near Horse Mesa (Malone, 1972) consists of a basal rhyolite lava flow (Torl) that is overlain by ash-flow tuffs and lahars (Tora). The total thickness is 130 - 150 m. The lava is gray, aphyric, and devitrified. The pyroclastic deposits are pale yellow and contain pumice lapilli and blocks of dacite xenoliths.

Superstition Tuff (Tst). This thick (more than 600 m) welded tuff makes up the main part of Superstition Mountain, where it fills a caldera (Stuckless, 1969; 1971; Stuckless and Sheridan, 1972). It is generally strongly welded and devitrified and contains about 25% phenocrysts of quartz, sanidine, plagioclase, and biotite. Flattened pumice are easily recognized in most samples. Its age is 22 to 25 Ma. The Apache Leap tuff (Peterson, 1961; 1968; 1969) has a similar appearance and composition but it is somewhat younger (about 20 Ma).

Latites of Fish Creek (Tfl) (Malone, 1972) and Latites of Government Well (Hillier, 1978). These units occur in stratigraphically equivalent positions in the western and eastern parts of the Apache Trail, respectively. They consist of lahars, breccias, and lavas of intermediate (latite) composition (Kilbey, 1986). Because they formed central volcanoes, their thickness is variable (from 600 m down to the thickness of a single flow) and depends on the distance from the vent. Generally these rocks are rich in phenocrysts, especially large plagioclase and hornblende crystals. Pyroxene is a minor phenocryst phase. This unit has an age between 25 and 29 m.y.

Older basalt (tob). This unit consists of several thin basalt flows and local scoria cones. The basalts are black to gray and contain olivine phenocrysts that are cobmonly altered to iddingsite. Most of these lavas are highly altered and contain amygdules filled with calcite or chalcedony. In the Goldfield area the oldest unit may be a basaltic andesite, but all other analyzed lavas have an alkali olivine basalt composition.

Interbedded with the basalts in the Goldfield Mining District are a number of latitic to rhyolitic tuffs (Kilbey, 1986). Some of these units are coarse breccias with huge (meter diameter) boulders of granite supported by an ash matrix. Surge beds and welded units are also present in these tuffs.

Whitetail Conglomerate (Two). This unit consists of coarse-grained red beds. The thickness of this units depends on previous topography; it is thickest in paleovalleys and is absent on paleohills. The unit is thick-bedded and mainly contain clasts of granite. Locally a few limestone boulders are present.

Precambrian granite (Pgcr). This rock is the basement of the area. It is deeply weathered and hence has a thick development of gruss on its surface. The rock contains subequal amounts of large quartz, plagioclase, and K-spar crystals with lesser amounts of biotite and hornblende. The age of this rock is about 1.4 b.y. (Stuckless and Naeser, 1972). A local pluton of diorite exists to the south of the Goldfield Mountains and a complex Precambrian stratigraphy of several sedimentary and metamorphic units occurs to the south of the Superstition Mountains.

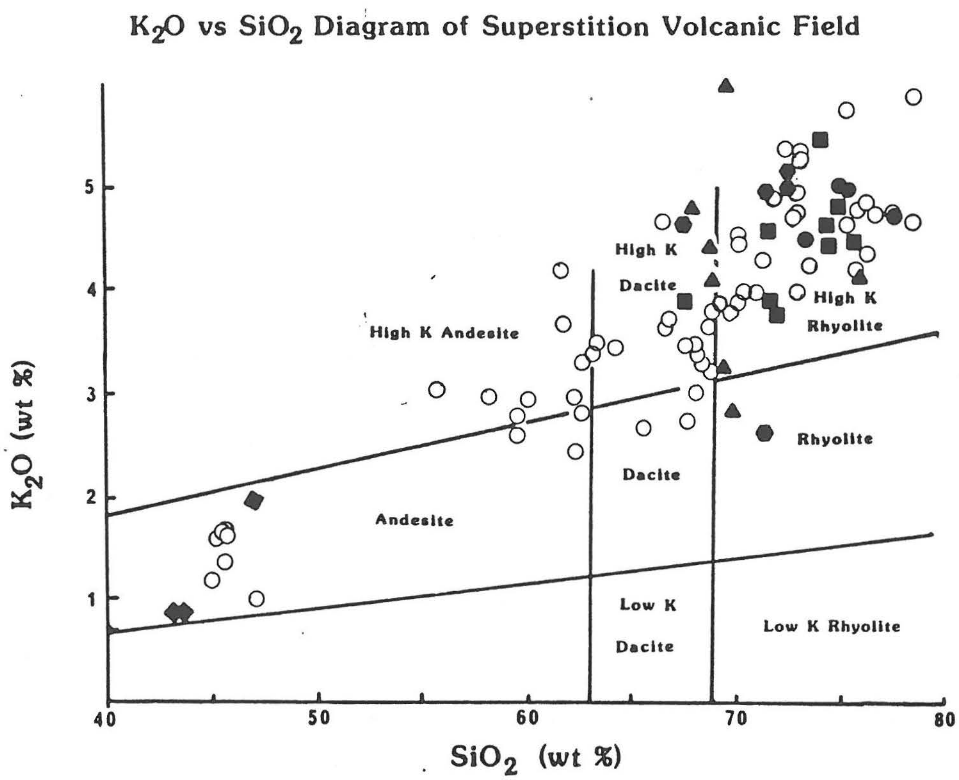

Figure 2. K_2O vs. silica diagram for volcanic rocks of the Superstition Volcanic Field. Classification after Ewart (1979). Open circles are rocks older that 16 Ma; closed symbols are rocks younger than 16 Ma.

CHEMICAL COMPOSITIONS

The rocks of the Superstition Mountains form a coherent chemical pattern on scatter diagrams that extends from basalts to high-silica, high-K rhyolites (Fig. 2). There is a pronounced silica gap in the compositional range that corresponds to andesites. Stuckless and Naeser (1972) parposed a different evolutionary paths for the high-silica rocks and for the intermediate types.

The least evolved rocks of the silica-rich trend could be called high-K andesites (Fig. 2) or latites (Fig. 3). The name latite is preferred because they typically contain 10 to 20% of normative quartz and have subequal amounts of alkali feldspar and plagioclase in the norms.

The rocks could be divided into two suites based on age and structural complexity. Rocks older than 16 Ma are generally strongly tilted whereas units younger than 16 Ma are usually only slightly deformed. Both series have similar extreme compositions and trends on variation diagrams (Fig. 2 and Fig. 3). The older series has a smaller compositional gap and intermediate compositions (latites) are more abundant. The older series eruptions appear to have been larger, forming regional ash-flow sheets, calderas, and composite volcanoes. The younger series erupted from local vents related to northwest-trending faults. Their vents commonly are surrounded by tuff-rings and contain flow-dome complexes. Hydromagmatism was more prevalent during the later period.

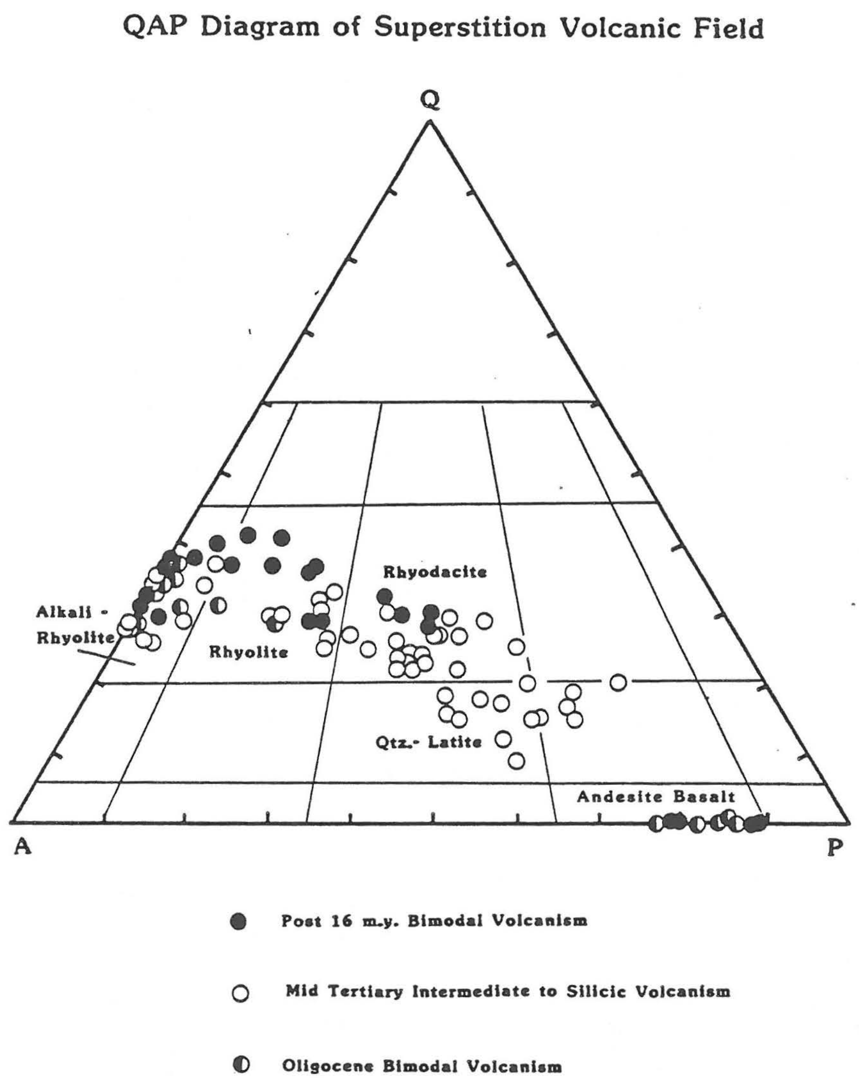

Figure 3. QAP diagram of rocks from the Superstition Volcanic Field. The diagram illustrates an early bimodal (basalt-rhyolite) volcanism, a later intermediate to silicic (latite-rhyodacite-rhyolite) volcanism, and a post 16 Ma bimodal (basalt-rhyolite) phase. Q (quartz), A (alkali feldspar), and P (plagioclase) are based on a recalculation of the chemical norms of analysed rocks.

STRUCTURES

The structural geology of the Superstition Mountains is very complex and only a brief introduction will be presented here. There are several series of faults of various ages that cut the volcanic rocks. The oldest set of faults trend to the northeast and parallel a basin in which the Whitetail Conglomerate accumulated. The Goldfield Mining District lies in this basin.

The next chronological set of faults are low angle (less than 50°) faults with well-developed slick faces. The traces of these faults are curvilinear and they occur in concentric sets. Sets of these faults are associated with each of the three postulated calderas (Sheridan, 1978) so that they are assumed to be slip surfaces along which large blocks slid into the collapsed areas. Another possible origin for these faults is due to thin-skin distension of the area due to regional extension.

A later set of faults has a N-S to northwest trend. These faults are high-angle normal types. These seem to be the loci for the volcanic vents of lavas younger than 16 Ma. They define a series of elongate horsts and graben in the northern part of the volcanic field.

GOLD MINERALIZATION

These facts suggest that the ore was originaly deposited as a placer or lag on the surface of the granite from which it was derived. This process continued for millions of years as the granite weathered prior to the Neogene orogeny. Formation of horsts and graben related to tumescence prior to the main volcanic pulse stripped the loose gold-bearing gravels which then accumulated as the Whitetail Conglomerate in low places in the topography.

The gold occurs as wires, sheets, and nuggets within quartz veins. Hydrothermal alteration of the host rock is limited to zones near the veins. The highest grade of ore is located at the intersection of mineralized veins. Because of the patchy nature of the ore grade, persistent mining has not been possible in modern times.

There are certain consistent relationships of the ore to structures and stratigraphy that bear on its genesis. The best showings of gold occur along fault contacts of the Whitetail Conglomerate with the older volcanic units such as the basalts or latites. The Whitetail rests on a rejuvenated surface of deeply weathered Precambrian granite. The best production has come from north-trending faults. These structures cut the low-angle arcuate fault that defines the outer margin of the Goldfield Caldera.

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The first phases of volcanism in this area capped the granite and conglomerate with basaltic and latitic lavas that formed low shields or composite cones with breccia aprons. The formation of the Goldfield Caldera at about 16 Ma caused large blocks to slide along low-angle faults bringing the gold-bearing conglomerate into contact with reactive country rocks. The normal faulting that immediately followed the caldera collapse provided near-vertical channels for the fluids to rise to the surface. The gold was transported out of the conglomerate and upward a short distance. It deposited with quartz in epithermal veins close to the surface.

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FIELD NOTES AND SKETCHES

[Original contains five sheets]