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# GEOLOGY, GEOCHRONOLOGY AND GEOCHEMISTRY OF THE PICACHO PEAK AREA, PINAL COUNTY, ARIZONA[1]

by

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## Abstract

Picacho Peak, a prominent landmark of southeastern Arizona, is a tilted and faulted remnant of an early Miocene trachytic volcanic complex. The alkaline volcanic rocks can be divided into two groups by appearance, chemistry and age. The trachyandesites (K/Na approx. 1, Fe/Mg approx. 1, $K_2O + Na_2O > 7\%$) of the main ridge yield K-Ar ages around 22.4 m.y. The purple-red ultrapotassic trachytes (K/Na >> 10, Fe/Mg >>10, $K_2O > 10\%$) yield an age of 20.7 m.y. Oxide variation diagrams show that both types could have come from eruptions at different times from the same differentiating magma body. The ultrapotassic trachytes are similar in composition to some trachytes associated with African and European carbonatites. However, no unequivocal carbonatites have been identified in this part of the Basin and Range province. These volcanics are part of an alkaline rock series only recently recognized in Arizona.

The ridge is bounded by a series of N 60° W-trending vertical faults which are approximately parallel to the strike of the beds. Northeast dips of 30° to 60° indicate that the beds are rotated toward the older crystalline rocks of the Picacho Mountains which lie on the side of a fault zone buried in the pass between the two mountain blocks. This fault may be part of a structure in the Tucson area that separates Tertiary rocks on the south and west from older crystalline rocks on the north and east. Faulting and tilting of the Picacho Peak sequence took place between 15 and 20 m.y. ago. This was followed by rifting which resulted in the formation of a complex system of subsidence structures in the southern Basin and Range province. Minor sedimentary units intercalated between flows indicate penecontemporaneous erosion and deposition in the area. These units are temporally correlative with part of the Pantano-Rillito Formations of the Tucson Basin. The chrysocolla found in fractures is believed to be related to a mineral-

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izing episode later than the Laramide primary copper mineralization found in adjacent areas.

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## Introduction

Picacho Peak, a narrow, 5 km long ridge oriented N 60° W, is set in the eastern part of the desert portion of the southern Basin and Range physiographic province. It is a prominent landmark along the Interstate 10 freeway about 65 km (40 miles) northwest of Tucson. The peak and its slopes are a state park with excellent, well-maintained roads and trails. Its dark volcanic rocks stand in marked contrast to the light-colored gneisses of the nearby Picacho Mountains to the north. The tan-gray apron of alluvial material which surrounds it is readily identified on ERTS imagery and high-altitude aerial photographs (Fig. 1). Structurally, both Picacho Peak and the Picacho Mountains are prominences on a bedrock ridge which extends southward under alluvium to the Samaniego Hills (Hardt and Cattany, 1965). This ridge separates the deep, anhydrite-filled Picacho basin (Peirce, 1974 and this Digest) on the west from the Avra basin on the east. Although the name Picacho Peak applies only to the highest point, in this paper we will use this name to include the entire ridge.

Prior to the K-Ar dating reported here, which establishes a Miocene age for the volcanic rocks, only subjective estimates could be made for the age of the Picacho Peak volcanic sedimentary sequence. Picacho Peak resembles, in form, the volcanic necks in the Hopi Butte area of the Colorado Plateau. Previously, Feth (1951) thought the central spire to be a Quaternary basalt plug in older volcanics; Wilson (1962) described the peak as a Tertiary intrusive and mapped it as such on the Pinal County geologic map (Wilson and Moore, 1959); Briscoe (1967) interpreted the rocks to be Cretaceous based on correlation with the Silver Bell formation in the Silver Bell Mountains to the south.

## Geology and Geochronology

The gross lithologic, textural, and structural features of Picacho Peak were first described by Feth (1951). Briscoe (1967), who later mapped the area and described the rocks in detail, concluded that the ridge was neither an olivine basalt plug as Feth described nor an intrusive as Wilson (1962) thought, but rather a concordant series of extrusive rocks, intercalated with conglomeratic sediments and tuffaceous units which dip 30° to 60° NE. We concur with Briscoe.

Flow contacts are indistinct in most places, and displacement by the numerous faults in the Picacho Peak prevents accurate determination of flow thicknesses, but estimates of 6 to 30 m seem reasonable. Some zones are massive, while others are agglomeratic with the autobrecciation characteristic of many andesitic rocks in southern Arizona. Fine textures range from aphanitic to porphyritic with few phenocrysts exceeding 5 mm in length. Some rocks are vesicular with quartz, calcite, or epidote filling some vesicles.

All of the rocks are fractured; some are closely jointed, but the rocks are intensely brecciated in fault zones. The appearance of the brecciation is enhanced on weathered surfaces, particularly on the promontory located north of the summit spire. The fractures are apparently "healed" so that the rock does not disaggregate and large breccia

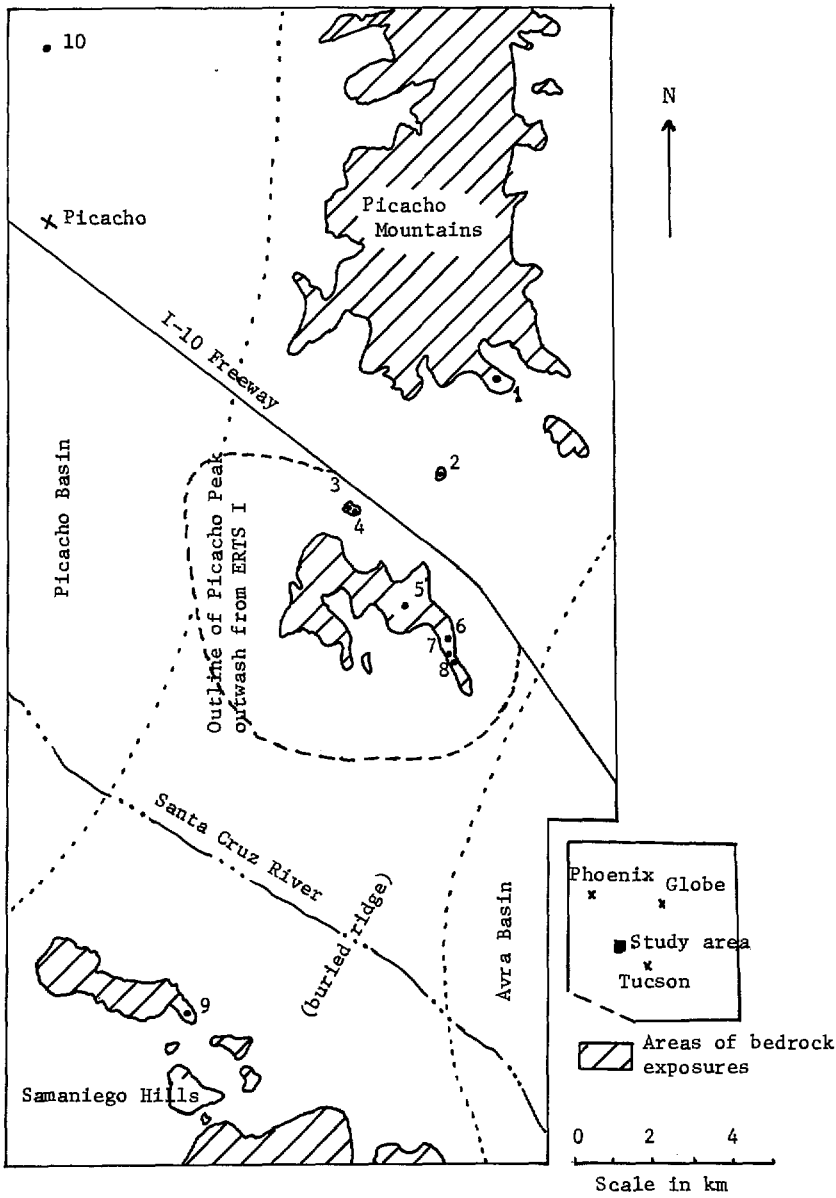


Figure 1. Sample location and index map. Numbers 1 to 10 indicate location of samples listed in Tables 1 to 3 with dotted lines indicating the outline of buried ridge.—Modified from Briscoe (1967), Feth (1951), Hardt and Cattany (1965), D. E. Peterson (1962), and D. L. Peterson (1968).

boulders are capable of rolling hundreds of meters. Intersecting grooved and slickensided surfaces attest to the tectonic deformation of this rock.

The base of the volcanic-sedimentary sequence is not exposed in the Picacho Peak area. Sedimentary units intercalated between some flows are poorly sorted with clasts up to 25 cm in diameter in a purple-red groundmass. Some clasts are well rounded, but most are angular to sub-angular. Well-sorted sand lenses are notable but sparse. Clasts consist of pink feldspar granite, tan phyllite, and some volcanic rock similar to that which is exposed in the ridge. Some gneissic metamorphic rock is also seen, but none which is similar to the augen gneisses of the Picacho Mountains. The conglomerate layers imply that eruptions were separated by time intervals long enough for erosion and contemporaneous deposition. Briscoe (1967) named the thickest unit the Wymola conglomerate, which he thought to be the oldest exposed member of the Picacho Peak sequence. The Wymola may be related to the Pantano-Rillito conglomerates of the Tucson area.

The volcanic rock units can be divided into two groups distinctive in appearance, chemistry, and age. Rocks of the main ridge form a heterogeneous group with varying colors, but some appear porphyritic in hand specimen. Rocks of the pass between Picacho Peak and the Picacho Mountains are purple red, aphanitic, and show both massive and agglomeratic textures. These rocks, which probably constitute a single flow unit, form the dark hill immediately north of Picacho Peak, the isolated hill in the middle of the pass, and the cap on a low ridge of gneiss which extends southeast from the Picacho Mountains. Briscoe (1967) and Feth (1951) suggested that the two dark hills were cones or vents based on the agglomeratic texture and vesicularity of the rocks, but structural inferences make this interpretation unlikely. The outcrop on the ridge crest appears to be in fault contact with the underlying sheared and recrystallized gneisses along a gently undulating shallow-dipping plane.

Analytical techniques are presented in Appendix A and analytical data in Tables 1, 2, and 3. Normative mineralogies were computed using the molecular proportions method of Niggli rather than the weight percentage CIPW method (Barth, 1962). The aphanitic texture and fine-grained groundmass precluded modal analyses based on mineralogy.

Chemical analyses show a large content of alkali oxides, none less than 7%, which is sufficient to classify these as alkaline rocks for our purposes. All have $SiO_2$ and $Al_2O_3$ contents similar to andesite ($SiO_2$ 55%-67%, $Al_2O_3$ 16%-18%) but the content of $Na_2O + K_2O > CaO$ in the volcanic rocks of the south ridge classifies them as trachyandesite and the large amount of $K_2O$ in the purple-red volcanic rock north of Picacho Peak classifies that as an ultrapotassic trachyte. Trachyte, the extrusive equivalent of syenite, yields less than 10% normative plagioclase. Carmichael, Turner, and Verhoogen (1974) classify any rock with $K_2O/Na_2O$ values greater than 3 as ultrapotassic; the ratio of Picacho Peak ultrapotassic trachyte is greater than 10.

K-Ar ages were determined on four specimens (one a hornblende mineral separate and three whole-rock samples) collected from the approximately 1,000 m thick volcanic sedimentary sequence (No. 5-8, Fig. 1) exposed on the southeast ridge of Picacho Peak (Fig. 2). Ages range from 22.4 to 22.6 m.y. (Table 1), but this span is less than the smallest experimental error on any one age so that these numbers cannot be used to establish a chronology within this sequence. The 20 m.y. date determined on an ultrapotassic trachyte from the outcrop in the pass north of Picacho Peak (No. 2, Fig. 1) shows it to be younger than the rest of the volcanic sequence.

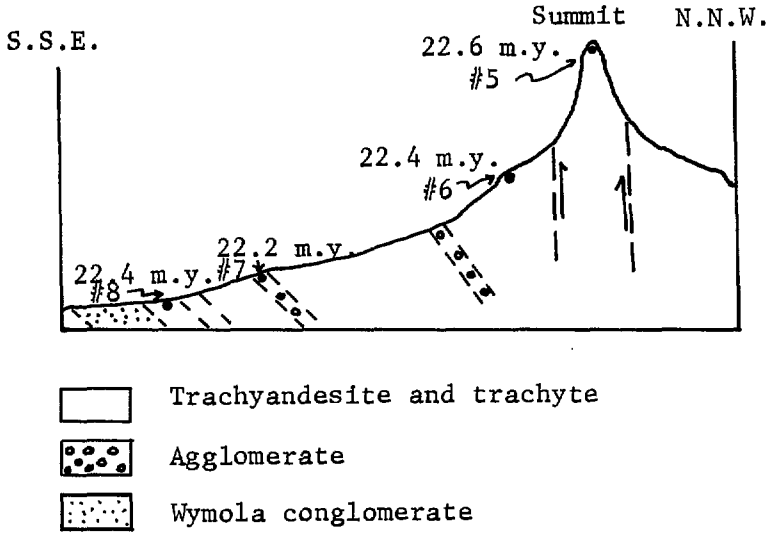


Figure 2. Schematic geologic section of the southeastern part of the Picacho Peak range modified after Briscoe (1967) and selected K-Ar ages. Numbers in parentheses indicate sample numbers listed in Tables 1 to 3.

TABLE 1

K-Ar DATA ON SAMPLES FROM PICACHO PEAK AREA, PINAL COUNTY, ARIZONA

| UAKA sample no. | Description and location | Percent K | Radiogenic argon-40 in x $10^{-12}$ moles/gm | Percent atmospheric argon-40 | Age in m.y. |
|---|---|---|---|---|---|
| 75-96 (5) | Whole rock, trachyte near Picacho Peak summit, altitude 1025 m. It overlies apparently fluidized granitic material. Lat 32° 38' 07" N, Long 111° 26' 00" W. | 6.73 | 268.0<br>263.4 | 5.7<br>6.0 | 22.60 ± 0.48 |
| 75-27 (8) | Whole rock, trachyandesite interbedded between two Wymola conglomerate units, southeastern part of the range, elevation 588 m. Lat 32° 37' 35" N, Long 111° 23' 30" W. | 2.84 | 112.2<br>110.1 | 16.1<br>16.4 | 22.39 ± 0.47 |
| 75-28 (6) | Whole rock, trachyandesite from top, southeastern ridge, elevation 716 m. Lat 32° 37' 56" N, Long 111° 23' 31" W. | 3.00 | 117.4<br>117.2 | 6.5<br>6.4 | 22.35 ± 0.47 |
| 75-85 (7) | Hornblende, hornblende trachyandesite with thick agglomerate unit, elevation 634 m, on the same slope as UAKA-75-28 and 75-27. | $0.79_5$ | 31.0<br>30.8 | 41.5<br>42.2 | 22.21 ± 0.50 |
| 75-29 (2) | Whole rock, massive ultrapotassic trachyte from a small isolated hill about 39 m, high in the pass between Picacho Peak and Picacho Mountain ranges. Lat 32° 39' 50" N, Long 111° 23' 26" W. | 9.58 | 359.5<br>354.5<br>337.2<br>334.4 | 46.9<br>47.1<br>41.2<br>41.6 | 20.72 ± 0.50 |
| 73-141 (9) | Biotite, Sasco andesite flow overlying brecciated andesite, youngest unit in Sasco area, northern end of Silverbell Mountains. Lat 32° 32' 55" N, Long 111° 27' 53" W. | 6.79 | 261.9<br>260.5 | 25.4<br>26.4 | 21.55 ± 0.45 |

Table 1, continued:

| UAKA sample no. | Description and location | Percent K | Radiogenic argon-40 in x $10^{-12}$ moles/gm | Percent atmospheric argon-40 | Age in m.y. |
|---|---|---|---|---|---|
| 73-140 (10) | Whole rock, drill chips, ultrapotassic trachyte, near the top of 185 m thick volcanic sequence, 2341-2345 m below sea level. The volcanic sequence is underlain and overlain by conglomerates. The upper conglomerate is overlain by 1825 m anhydrite and 710 m clay with minor anhydrite and halite, sand and gravel *(Peirce, 1974)*. Exxon's wildcat drill hole at Picacho Basin. Lat 32° 45' N, Long 111° 30' W. | 8.26 | 217.5<br>216.6 | 29.0<br>28.5 | 15.08 ± 0.34 |
| 74-87 (10) | Whole rock, drill chips, ultrapotassic trachyte near base of volcanic sequence, 2430-2442 m below sea level, same drill hole as UAKA-73-140. | 8.76 | 225.5<br>222.5 | 36.7<br>37.5 | 14.66 ± 0.34 |

Numbers is parentheses refer to sample numbers in Tables 2 and 3, Figures 1 and 2.

Constants used: $\lambda_e = 0.575 \times 10^{-10}\ yr^{-1}$

$\lambda_\beta = 4.905 \times 10^{-10}\ yr^{-1}$

$\lambda = 5.480 \times 10^{-10}\ yr$

$^{40}K/K = 1.18 \times 10^{-4}$ atom ratio

The sequence of trachyandesite flows and agglomerates found in Picacho Peak resembles in gross lithology and texture the volcanic sequence in the Samaniego Hills north of the Silver Bell Mountains as described by Eastwood (1970). An age of 21.5 m.y, determined on the youngest andesite in the Samaniego Hills (No. 9, Fig. 1) suggests that volcanism there was contemporaneous with the Picacho Peak volcanism.

Ages of 14.7 and 15.1 m.y. were determined on drill chips from a 185 m thick ultrapotassic volcanic unit penetrated at a depth of 2,800 m in the Exxon Picacho Basin well (No. 10, Fig. 1) located 16 km north-northwest of the summit spire of Picacho Peak. This rock apparently represents another episode of alkaline volcanism after a quiescence of about 5 m.y. Clasts of gneiss occur in the conglomeratic units above and below this rock and it can be inferred that basin deepening began after its eruption (Peirce, this Digest). The basin-fill sediments show little or no evidence of tilting and contain an 1,825 m thick sequence of anhydrite with intercalated shales (Peirce, 1974).

Basin deepening is the second of two distinct tectonic episodes which controlled the structure of Picacho Peak. This block-faulting event created the N 10° E oriented "range" which extends northward under the alluvium from the Samaniego Hills to and including the Picacho Mountains. The boundary faults which separate this structural block from the basins on either side are not exposed on the surface, but their approximate locations have been defined by geophysical methods (Hardt and Cattany, 1965; D. E. Peterson, 1962; D. L. Peterson, 1968). Peirce (1974) determined a minimum structural relief of about 4,000 m between similar crystalline rocks of the Picacho Basin and the Picacho Mountains. Some of the minor faults within Picacho Peak strike parallel to this trend and may be related to this tectonism.

The west-northwest trend of the Picacho Peak ridge was determined by an earlier tectonic event. The ridge is bounded by a series of N 60° W-trending vertical faults, some of which form the vertical faces on both sides of the ridge. Strike of the beds is approximately parallel to this direction, and the 30° to 60° NE dips suggest that the Picacho Peak block has been rotated toward the Picacho Mountains with most of the structural boundary buried beneath the alluvium in the pass. The intense brecciation of the rock on the northeast side of the ridge may have been caused by movement along this boundary.

The age determined on the drill-hole volcanic unit indicates that the basin-forming event is younger than 15 m.y. Rotation of the Picacho Peak block is inferred to have occurred between 15 and 20 m.y. ago. The boundary between Picacho Peak and the Picacho Mountains lies on the trend of an enigmatic "fault" which can be projected northwestward from the Tucson area, as last seen on the southwest end of the Catalina Mountains (extension of the Catalina fault?). Tertiary volcanic rocks on the southwest side of this feature are structurally lower than the presumably older crystalline rocks on the northeast side. Tilting and brecciation of the Picacho Peak sequence may have been caused by movement along this "fault."

Disseminated copper mineralization found in some fracture zones accounts for the numerous prospect pits. Briscoe (1967) suggested that this chrysocolla as well as the specular hematite and barite found along fracture zones was a result of hydrothermal alteration that is time related to emplacement of the ore to the south at Silverbell. Our new age determinations rule this out. The origin of this mineralization is obscure; it appears exotic or related to an early Miocene episode, contemporaneous with the extrusion of Picacho Peak volcanic sequence or postdating it.

It is, however, definitely not related to Laramide primary copper mineralization of the adjacent areas.

## Geochemistry and Petrology

Whole-rock analyses reveal the chemical differences between the trachyandesites of the ridge and the ultrapotassic trachytes of the pass. The grouping is evident from the variation diagrams (Figs. 3-7). The dense red rock collected from the summit (No. 5, Fig. 1) is similar in age to the trachyandesites, similar in color and texture to the ultrapotassic trachytes and chemically intermediate between the two groups.

In all of the thin sections, the feldspar phenocrysts and microlites are "dirty," being filled either with blebs of glass or flakes of sericite. Except for the hornblende phenocrysts in the hornblende trachyandesite, none of the mafic minerals can be readily identified. Opaque minerals are pervasive, occurring in tiny grains. Carbonate, up to 15 volume percent in some rocks, occurs in interstitial grains, in vesicles, and in fractures. Some rocks have partially digested inclusions of indeterminate origin. Groundmass microlites in the trachyandesite are generally larger than those of the ultrapotassic trachytes.

High $K_2O$ contents and the altered appearance of the rocks suggest that they have been subjected to "potassic" alteration. If this is true, this alteration is contemporaneous with and a phase of rock genesis. The remarkable uniformity of mineral separate and whole-rock ages in the trachyandesite group (Fig. 2) apparently precludes alteration of an existing volcanic pile at a time significantly later than their eruption. A pervasive alteration would have affected the granite clasts in the conglomerate units, but Briscoe (1967) found them to be clean and unaltered.

Figure 3 shows a linear trend of oxide variation versus solidification index. Solidification index, the percentage of MgO in the A-M-F (alkali-magnesia-total iron) ternary composition, was defined by Kuno (1954) as a measure of the liquid remaining in a differentiating magma body. The solidification index ranges between 0 and 2.5 for the ultrapotassic trachytes and between 17 and 20 for the trachyandesites. The systematic decrease of $Na_2O$ and MgO and increase of $K_2O$ with decreasing solidification index (Figs. 3, 4) suggest that the ultrapotassic trachytes could have been derived by differentiation of the magma which produced the trachyandesites.

$K_2O/Na_2O$ and total iron as $Fe_2O_3/MgO$ values vary considerably from a near unity value for trachyandesite to greater than 10 in the potassic trachytes (Fig. 5). The variation of these ratios is due to partitioning of the oxides in the rock-forming minerals in the magma chamber (Figs. 5, 6, 7) and their relative positions in the differentiated sequence.

Normative femic minerals constitute 8 to 12 percent of ultrapotassic trachytes and 16 to 22 percent in trachyandesites (Tables 2, 3; Fig. 7). Feldspars are alkaline with orthoclase predominating in the ultrapotassic trachytes and albite in trachyandesites (Figs. 6, 7). Trachyandesite contains more than 50 percent normative alkali feldspar and normative plagioclase ranges between $Ab_{65}$ to $Ab_{91}$. The discontinuity of the variation diagrams and distinct domains of the samples may be due to incomplete sampling of the flows. For example, Halva (1961) analyzed a flow with 6.1% $K_2O$ which we have not resampled. Considerably more CaO and MgO is present in the trachyandesites than the trachytes. $SiO_2$ and $Al_2O_3$ vary within limited ranges, and there is sufficient amount of each to combine with the alkalis to form feldspars.

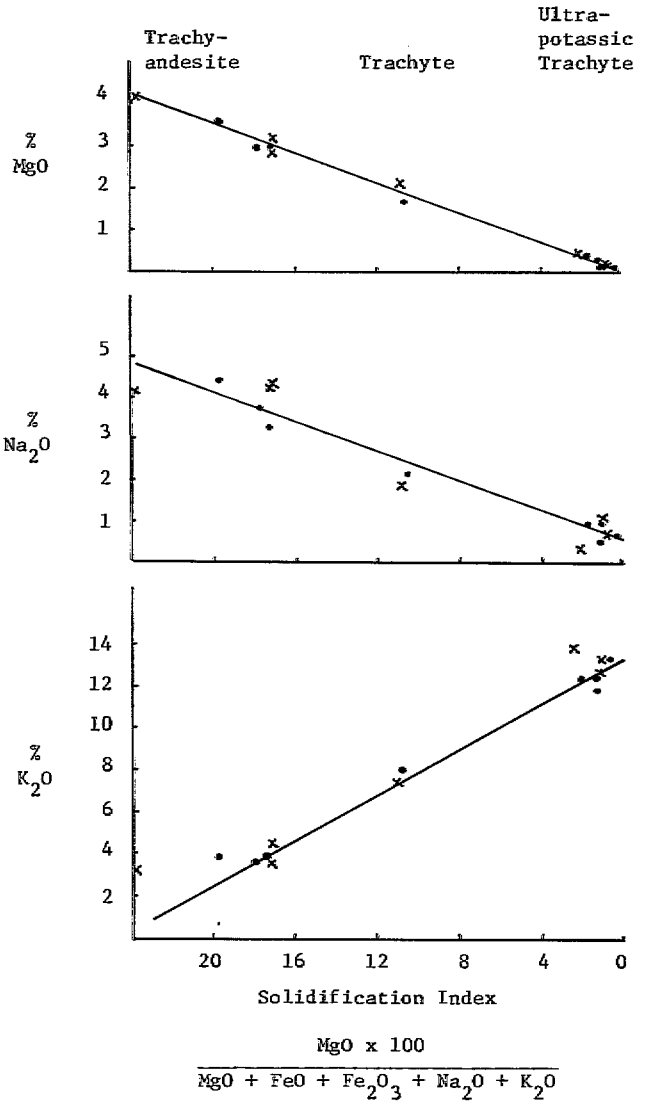


Figure 3. Variation of weight percent MgO, $Na_2O$, and $K_2O$ as a function of solidification index or S.I. (100 x MgO/(MgO + FeO + $Fe_2O_3$ + $Na_2O$ + $K_2O$) . The systematic decrease of MgO and $Na_2O$ and increasing of $K_2O$ with S.I. indicates a differentiation trend. The three rock types have different domains. Picacho Peak samples are represented by solid circles and literature values by x. This notation will be used in all figures.

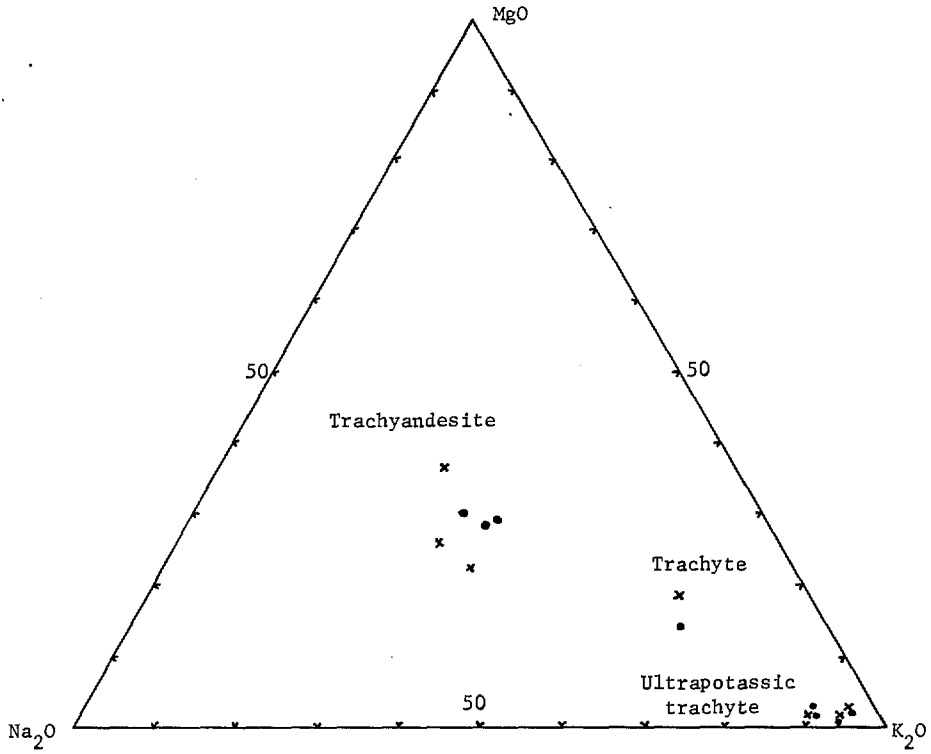


Figure 4. Ternary diagram showing a systematic increase in $K_2O$ with depletion of MgO and $Na_2O$ in the volcanic sequence.

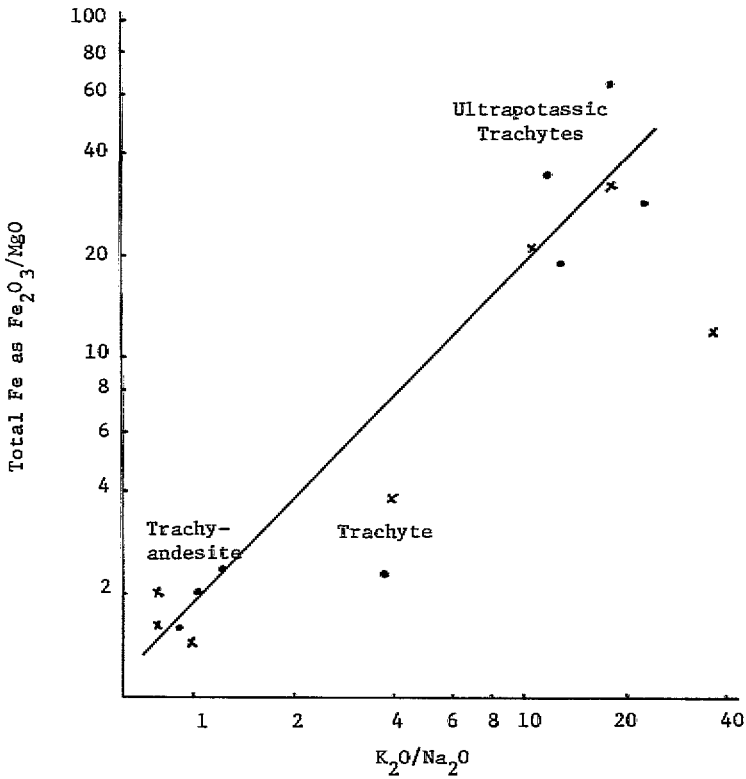


Figure 5. Systematic variation of total iron as $Fe_2O_3/MgO$ and $K_2O/Na_2O$ values suggest a differentiation trend due to fractional crystallization and removal of plagioclase and ferromagnesian minerals by crystal settling or filter pressing.

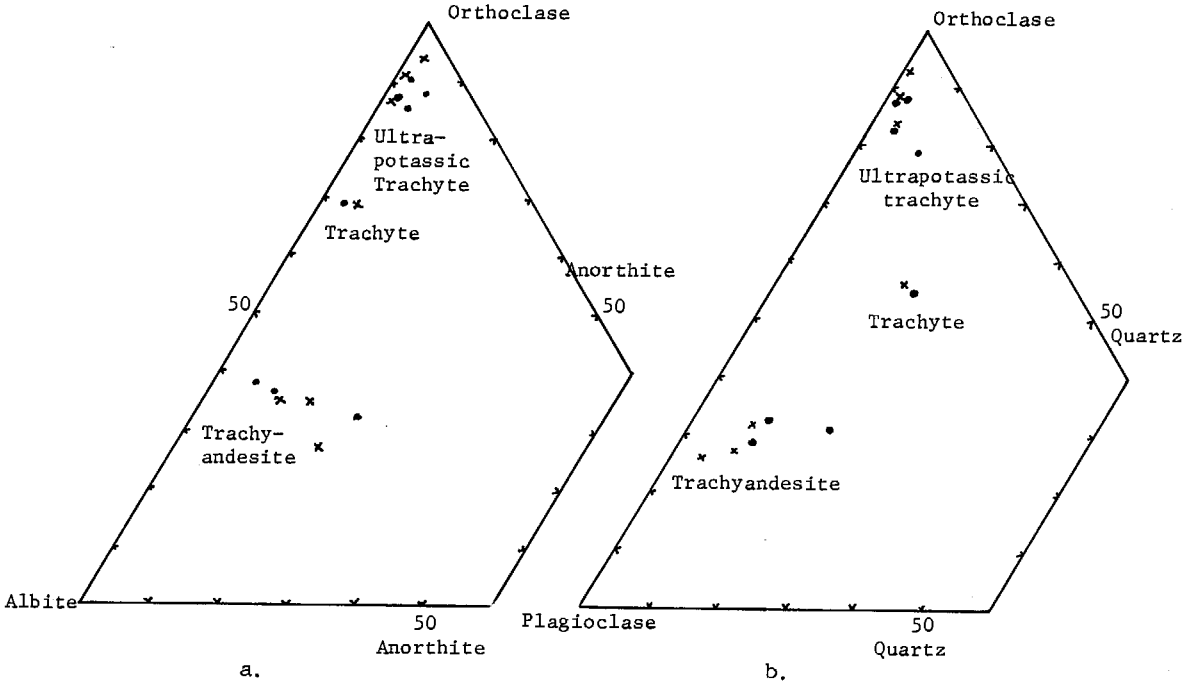


Figure 6. Ternary diagram showing some normative salic constituents computed using molecular proportions method:

a. Orthoclase predominates in ultrapotassic trachyte and albite in trachyandesite.

b. Plagioclase is the major constituent in trachyandesite. Normative quartz content is low in all samples.

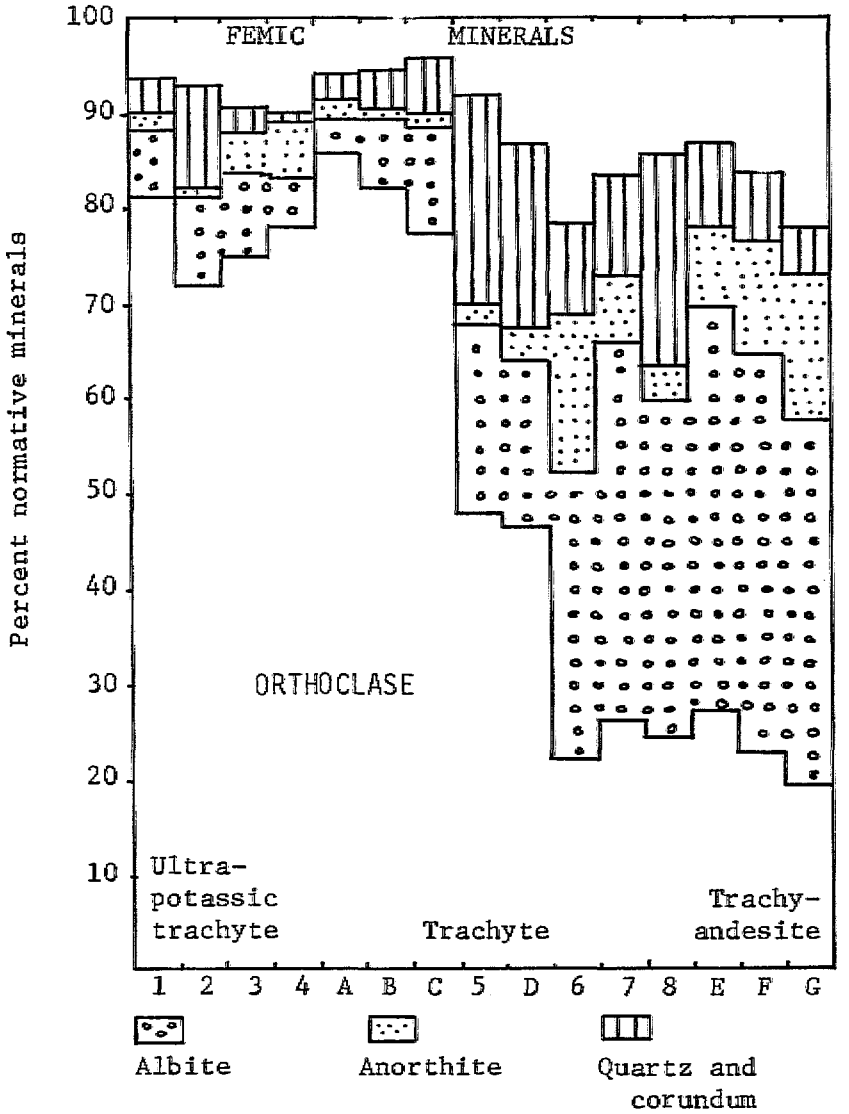


Figure 7. Diagrammatic representation of normative constituents calculated according to molecular proportions method. The numbers indicate sample numbers listed in Tables 2 and 3.

None of the rocks is undersaturated with silica. Compositions of the ultrapotassic trachytes are remarkably similar to rocks found in association with carbonatites (Table 2) (Sutherland, 1965, 1967; Garson, 1965) in the rift valleys of Africa and Europe. The trachyandesites are similar to rocks of nearby areas in Arizona (Table 3).

## Petrogenesis

Ultrapotassic rocks are rare, usually found in areas of extensional tectonics and/or associated with carbonatites (Carmichael and others, 1974; Sorensen, 1974). The southern Basin and Range province, described by Cook (1965) as a typical continental rift zone, is a reasonable geologic setting for alkaline rocks. Pakiser and Zeitz (1965) described the anomalous nature of this region relative to the provinces which surround it in terms of thinner crust (20 to 30 km), lower seismic velocities in the mantle immediately beneath the crust and higher heat flow.

Atwater (1970) proposed a plate tectonic model for the evolution of western North America which involves mid-Tertiary subduction under Arizona that ceased about the time of eruption of the Picacho Peak volcanics. These rocks may be the last differentiates of a magma body generated along or above this subduction zone. As the Picacho Peak volcanics apparently predate the basin-forming episode which is the crustal expression of extensional tectonics in Arizona during the Basin and Range orogeny, they may be related to the beginning of rifting in this area.

A remarkable compositional similarity between the Picacho Peak rocks and those found in association with carbonatites can be seen from Figures 3 through 7. Sanders (1974) suggested the possibility of a carbonatite complex in the Vulture Mountains approximately 200 km northwest of Picacho Peak in the same geologic province, but the evidence is equivocal. No carbonatite rocks have yet been found at Picacho Peak.

The petrogenesis of the ultrapotassic rocks is a complex problem. Eruptive alkaline rocks have been studied extensively in the African rift system but no satisfactory model for their origin has been proposed. Inferences concerning the origin of the ultrapotassic rocks can be drawn from studies of the other, more sodic, alkaline rocks.

Extrusive rocks similar in composition to the Picacho trachyandesites have been described from various areas of the Afro-Arabian rift systems. Mohr (1971) proposed fractionation and/or partial melting without crustal contamination for the origin of trachyandesites on the Ethiopian plateaus. He noted these rocks to have higher $K_2O/Na_2O$ values than associated basalts or rhyolites. Fusion or assimilation of normal crust is ruled out in the origin of the slightly undersaturated peralkaline lavas of Mount Suswa in Kenya (Nash, Carmichael, and Johnson, 1969). Williams (1970) opposed these views in his model for the trachytes and ignimbrites associated with major Pliocene faulting of the Gregory rift in Ethiopia. He considered unlikely their generation from a differentiating basalt or phonolite magma and proposes, instead, their generation by selective fusion of upper mantle or lower crust.

The limited amount of data available at this writing precludes a definitive model for the origin of the Picacho Peak rocks. As a preliminary model, differentiation of a basaltic andesite magma by fractional crystallization and removal of plagioclase and ferromagnesian minerals by crystal settling or filter pressing fits the currently available data. The ages suggest that the magma body became enriched in potassium and

TABLE 2

ANALYSES AND NORMS OF ULTRAPOTASSIC TRACHYTES

| | Picacho Peak | | | | | Africa | | Europe |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Mean | A | B | C |
| $SiO_2$ | 59.1 | 60.9 | 59.7 | 56.4 | 59.1 | 58.4 | 57.7 | 60.1 |
| $TiO_2$ | 1.1 | 1.2 | 1.0 | 1.2 | 1.1 | 0.3 | 1.3 | 0.3 |
| $Al_2O_3$ | 17.1 | 16.7 | 16.5 | 16.4 | 16.7 | 17.8 | 18.0 | 18.6 |
| $Fe_2O_3$(total Fe) | 7.00 | 7.61 | 7.50 | 7.50 | 7.40 | 5.09 | 5.78 | 3.75 |
| MnO | 0.11 | 0.13 | 0.18 | 0.17 | 0.15 | 0.42 | 0.06 | 0.09 |
| MgO | 0.11 | 0.22 | 0.40 | 0.26 | 0.25 | 0.43 | 0.18 | 0.18 |
| CaO | 0.75 | 0.43 | 2.00 | 2.60 | 1.44 | 0.80 | 0.39 | 0.57 |
| $Na_2O$ | 0.74 | 0.99 | 0.96 | 0.54 | 0.81 | 0.38 | 0.74 | 1.21 |
| $K_2O$ | 13.31 | 11.80 | 12.43 | 12.48 | 12.50 | 13.90 | 13.26 | 12.63 |
| Volatiles | 0.73 | 0.80 | 1.37 | 2.25 | 1.29 | 1.16 | | 2.80 |
| Solidification Index | 0.5 | 1.1 | 1.9 | 1.2 | 1.2 | 2.2 | 0.9 | 1.0 |
| Normative Plagioclase | $Ab_{78}$ | $Ab_{89}$ | $Ab_{68}$ | $Ab_{47}$ | $Ab_{67}$ | $Ab_{63}$ | $Ab_{87}$ | $Ab_{88}$ |
| NORMS | | | | | | | | |
| Orthoclase | 81.8 | 71.7 | 74.8 | 77.7 | 76.2 | 85.6 | 81.9 | 77.2 |
| Albite | 6.9 | 9.1 | 8.8 | 5.1 | 7.5 | 3.6 | 6.9 | 11.2 |
| Anorthite | 1.9 | 1.1 | 4.1 | 5.8 | 3.5 | 2.1 | 1.0 | 1.5 |
| Quartz | 2.4 | 8.5 | 2.8 | 1.1 | 3.7 | 1.0 | 1.7 | 3.4 |
| Corundum | 0.9 | 2.2 | - | - | 0.6 | 1.6 | 2.4 | 2.7 |
| Femic Minerals | 6.7 | 7.2 | 9.5 | 10.1 | 8.2 | 6.1 | 5.7 | 3.9 |

1. Ultrapotassic trachyte, remnant overlying the crest of a span of metamorphic rocks in the southern part of the Picacho Mountains, about 2 km northeast of #2.

2. Ultrapotassic trachyte, inselberg in the Picacho Pass, same as UAKA-75-29 of Table 1.

3. Ultrapotassic trachyte, about 0.15 cubic meter fragment in autobrecciated zone, small hill north of Picacho Peak.

4. Ultrapotassic trachyte, flow unit near the top of the hill. Samples 3 and 4 are from the same hill.

A. SUT 213--Potash trachyte, west side, Toror Hills, Uganda *(Sutherland, 1965)*.

B. Feldspathic breccia, Nkalonje complex, Malawi *(Garson, 1965)*.

C. Potash trachyte, K-21, Kaiserstuhl carbonatite complex, Rhine graben, West Germany *(Sutherland, 1967)*.

TABLE 3

ANALYSES AND NORMS OF TRACHYTES AND TRACHYANDESITES

| | Trachyte | | Trachyandesites | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Picacho Peak | Canada | Picacho Peak | | | | Southern Arizona | | |
| | 5 | D | 6 | 7 | 8 | Mean | E | F | G |
| $SiO_2$ | 67.2 | 61.2 | 56.1 | 61.8 | 60.4 | 59.4 | 61.6 | 56.2 | 60.1 |
| $TiO_2$ | 1.1 | 0.8 | 0.9 | 0.8 | 1.0 | 0.9 | 0.8 | 1.1 | 1.0 |
| $Al_2O_3$ | 16.3 | 15.7 | 17.9 | 16.4 | 16.7 | 16.7 | 16.4 | 17.0 | 15.8 |
| $Fe_2O_3$(Total Fe) | 3.90 | 7.60 | 7.14 | 5.56 | 5.87 | 6.19 | 3.74 | 6.67 | 5.56 |
| MnO | 0.08 | 0.15 | 0.05 | 0.07 | 0.05 | 0.06 | 0.08 | 0.11 | 0.10 |
| MgO | 1.70 | 2.08 | 2.97 | 3.55 | 2.95 | 3.16 | 2.59 | 4.17 | 2.76 |
| CaO | 0.95 | 1.38 | 6.45 | 2.75 | 1.40 | 3.53 | 3.36 | 6.08 | 4.75 |
| $Na_2O$ | 2.13 | 1.86 | 3.28 | 4.40 | 3.74 | 3.81 | 4.62 | 4.17 | 4.55 |
| $K_2O$ | 8.11 | 7.52 | 4.00 | 4.03 | 3.92 | 3.98 | 4.48 | 3.20 | 3.52 |
| Volatiles | 2.54 | | 3.63 | 1.75 | 2.81 | 2.73 | | | |
| Solidification Index | 10.7 | 10.9 | 17.4 | 19.8 | 17.9 | 19.1 | 17.2 | 23.8 | 17.2 |
| Normative Plagioclase | $Ab_{89}$ | $Ab_{83}$ | $Ab_{65}$ | $Ab_{85}$ | $Ab_{91}$ | $Ab_{77}$ | $Ab_{83}$ | $Ab_{71}$ | $Ab_{78}$ |
| NORMS | | | | | | | | | |
| Orthoclase | 47.8 | 46.2 | 21.9 | 26.1 | 24.2 | 24.4 | 26.9 | 19.2 | 22.4 |
| Albite | 19.1 | 17.4 | 30.1 | 39.4 | 35.1 | 29.6 | 42.2 | 38.0 | 41.6 |
| Anorthite | 2.4 | 3.6 | 16.4 | 6.8 | 3.6 | 9.1 | 8.5 | 15.3 | 11.9 |
| Quartz | 18.2 | 15.6 | 7.9 | 8.8 | 16.4 | 14.7 | 7.8 | 3.5 | 7.2 |
| Corundum | 3.3 | 3.7 | 3.0 | 2.0 | 5.7 | 4.5 | 1.0 | 1.3 | - |
| Femic Minerals | 8.7 | 13.5 | 20.7 | 16.8 | 14.8 | 17.7 | 13.4 | 22.6 | 16.6 |

5. Trachyte, near summit of Picacho Peak, same as UAKA-75-96.

6. Trachyandesite, same as UAKA-75-28.

7. Trachyandesite, same as UAKA-75-85.

8. Trachyandesite, same as UAKA-75-27.

D. Average of three trachytes, Brent Crater, Ottawa-Bonnecheve graben of St. Lawrence rift system *(Currie and Shafiqullah, 1967)*.

E. Biotite latite, Samaniego Hills, Silverbell Mountains, RLE-29-68 *(Eastwood, 1970)*.

F. Andesite, Tumamoc Hill, Tucson Mountains, RLE-9-68 *(Eastwood, 1970)*.

G. Hornblende andesite, Roskruge Mountains, RLE-15-68 *(Eastwood, 1970)*.

depleted in sodium and magnesium over the 2 m.y. between eruptions of the trachyandesites and the ultrapotassic trachytes.

The Picacho Peak rocks are part of a series of alkaline rocks only recently recognized in Arizona. Major and trace element analyses as well as isotope studies are currently being conducted by this laboratory to fit the genesis of these rocks into the framework of Basin and Range evolution.

## Conclusions

Picacho Peak is a tilted remnant of a trachytic volcanic complex which probably extruded more than 1,000 m of flows and agglomerates between 20 and 23 m.y. ago. The presence of conglomerate layers between some volcanic flows attests to penecontemporaneous erosion and deposition in the area. The present attitude of the flows may have resulted from the same forces that caused movement along a fault zone between Picacho Peak and the Picacho Mountains between 15 and 20 m.y. ago. The trachyandesites and ultrapotassic trachytes appear to be among the last rocks erupted in the waning stages of a mid-Tertiary volcanic magmatic pulse (Damon, 1971). Both rock types could have originated by eruptions at different times from the same differentiating magma body.

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## Appendix A

K-Ar analytical data on five volcanic units from the Picacho Peak are presented in Table 1. Analytical techniques used for isotope dilution analysis of argon and wet chemical analysis of potassium are described by Livingston and others (1967) and Damon, Shafiqullah, and Leventhal (1974), with this modification: whole rocks are ground to -100 mesh and +150 mesh, glass and altered mineral separated by flotation on a heavy liquid (specific gravity 2.50 to 2.55), and the carbonate removed by leaching in 0.5 N phosphoric acid.

For the whole-rock chemical analyses, the samples were leached with 0.5 N phosphoric acid to remove the carbonate from vesicles and microfractures. In this process, some primary interstitial carbonate may have been lost, especially from the ultrapotassic trachytes. $SiO_2$ was determined by colorimetric methods; $Al_2O_3$, $TiO_2$, total iron as $Fe_2O_3$, MnO, MgO, CaO, $Na_2O$, and $K_2O$ were determined using atomic absorption spectrophotometry. Loss on ignition was calculated from weight loss after heating the samples to 1000°C for 15 minutes. Analytical precisions are: $SiO_2$ $\pm$ 1%, $TiO_2$, $Al_2O_3$, total iron as $Fe_2O_3$, MgO, CaO, $Na_2O$, and $K_2O$ $\pm$ 2% of the concentrations reported in Tables 2 and 3.

## References

Atwater, T., 1970, Implications of plate tectonics for the Cenozoic tectonic evolution of western North America: Geol. Soc. America Bull., v. 81, p. 3513-3516.

Barth, T. F. W., 1962, Theoretical petrology: New York, John Wiley & Sons, 416 p.

Briscoe, J. A., 1967, The general geology of the Picacho Peak area: unpublished M.S. thesis, University of Arizona, Tucson, 52 p.

Carmichael, I. S. E., Turner, F. J., and Verhoogen, J., 1974, Igneous petrology: New York, McGraw-Hill Book Co., 739 p.

Cook, K. L., 1965, Rift system in the Basin and Range province, in Irvine, T. N., ed., The world rift system: Canada Geol. Survey Paper 66-14, p. 246-277.

Currie, K. L., and Shafiqullah, M., 1967, Carbonatite and alkaline igneous rocks in the Brent Crater, Ontario: Nature, v. 215, p. 725-726.

Damon, P. E., 1971, The relationship between late Cenozoic volcanism and tectonism and orogenic epeirogenic periodicity, in Turekian, K. K., ed., The late Cenozoic glacial ages: New York, John Wiley & Sons, p. 15-35.

Damon, P. E., Shafiqullah, M., and Leventhal, J. S., 1974, K-Ar chronology for the San Francisco volcanic field and rate of erosion of the Little Colorado River, in Geology of Northern Arizona, Part 1, Regional studies, Guidebook, Geol. Soc. America Rocky Mountain Section meeting, Flagstaff, p. 221.

Eastwood, R. L., 1970, A geochemical-petrological study of mid-Tertiary volcanism in parts of Pima and Pinal Counties, Arizona: unpublished Ph.D. dissertation, University of Arizona, Tucson, 212 p.

Feth, J. H., 1951, Structural reconnaissance of the Red Rock quadrangle: U.S. Geol. Survey Open-File Report, Tucson, Arizona.

Garson, M. S., 1965, Carbonatites in southern Malawi: Malawi Geol. Survey Bull, v. 15.

Halva, C., 1961, A geochemical investigation of basalts in southern Arizona: unpublished M.S. thesis, University of Arizona, Tucson, 88 p.

Hardt, W. F., and Cattany, R. E., 1965, Description and analysis of geohydrologic system in western Pinal County, Arizona: U.S. Geol. Survey Open-File Report, Tucson, Arizona

Kuno, H., 1954, Volcanoes and volcanic rocks: Tokyo, Iwanami and Co.

Livingston, D. E., Damon, P. E., Mauger, R. L., Bennett, R., and Laughlin, A. W., 1967, Argon-40 in cogenetic feldspar-mica assemblages: Jour. Geophys. Research, v. 72, p. 1361.

Mohr, P. A., 1971, Ethiopian rift and plateaus: some volcanic petrochemical differences: Jour. Geophys. Research, v. 76, p. 1967-1984.

Nash, W. P., Garmichael, I. S. E., and Johnson, R. W., 1969, The mineralogy and petrology of Mount Suswa, Kenya: Jour. Petrology, v. 10, p. 409-439.

Pakiser, L. C., and Zeitz, I., 1965, Transcontinental crustal and upper mantle structure: map of crustal thickness and crustal and mantle velocities: U.S. Program for the Internat. Upper Mantle Project, Project Report 1965, Natl. Acad. Sci.-Natl. Research Council, 119.

Peirce, H. W., 1974, Thick evaporites in the Basin and Range province, Arizona, in Googan, A. H., ed., Fourth symposium on salt: Cleveland, Northern Ohio Geol. Soc., Inc., v. 2, p. 47-55.

Peterson, D. E., 1962, Earth fissuring in the Picacho area, Pinal County, Arizona: unpublished M.S. thesis, University of Arizona, Tucson, 35 p.

Peterson, D. L., 1968, Bouguer gravity map of parts of Maricopa, Pima, Pinal and Yuma Counties, Arizona: U.S. Geol. Survey Geophys. map GP-615.

Sanders, D. E., 1974, Massive calcite in the Vulture Mountains near Wickenburg, Maricopa County, Arizona: unpublished M.S. thesis, Northern Arizona University, Flagstaff, 106 p.

Sorensen, H., 1974, The alkaline rocks: New York, John Wiley & Sons, 622 p.

Sutherland, D. S., 1965, Potash trachytes and ultra-potassic rocks associated with the carbonatite complex of Toror Hills, Uganda: Mineral Mag., v. 35, p. 363-378.

_____1967, A note on the occurrence of potassium-rich trachytes in the Kaiserstuhl carbonatite complex, West Germany: Mineral Mag., v. 36, p. 334-341.

Williams, L. A. J., 1970, The volcanics of the Gregory rift valley, East Africa: Bull. volcanol., v. 34, p. 439-465.

Wilson, E. D., 1962, A résumé of the geology of Arizona: University of Arizona, Arizona Bur. Mines Bull. 171, 140 p.

Wilson, E. D., and Moore, R. T., 1959, Geologic map of Pinal County, Arizona: University of Arizona, Arizona Bur. Mines.

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# GEOLOGY AND GEOCHRONOLOGY OF THE PICACHO PEAK RANGE, PINAL COUNTY, ARIZONA

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## ABSTRACT

K-Ar ages of the volcanic sequence intercalated with minor amounts of sediments in the Picacho Peak are between 20 and 23 m.y. Rock compositions vary from andesitic to ultrahigh potassic trachytes. They were probably extruded during the waning stages of the mid-Tertiary magmatic pulse. Post-extrusive tilting and high-angle faulting control the physiography of the range.

# INTRODUCTION

The Picacho Peak Range, site of the Picacho Peak State Park, is 35 miles north of Tucson near the I-10 Freeway. Prior to our geochronologic studies, previous workers could only make subjective age estimates for these rocks. Feth (1951) believed the central spire to be a Quaternary olivine basalt plug that intruded older sediments and volcanics. Wilson (1962) considered it to be a small Tertiary intrusive and mapped it as such on the Pinal County geologic map (Wilson and Moore, 1959). Briscoe (1967) mapped it as a sequence of Cretaceous volcanic rocks.

Our K-Ar age determinations show it to be of Miocene age.

## PHYSIOGRAPHY

Picacho Peak range is located in the desert section of the Basin and Range physiographic province in southern Arizona. It is a narrow steep sided ridge, about 5 km long, oriented in a N60°W direction. This obviously volcanic ridge is distinctly different from the light colored Precambrian gneisses of the Picacho Mountain, about 7 km to the north (Fig 1). The two highlands may be structurally related but the nature of this relationship is not clear. Some volcanic flow remnants lie on ridges of gneiss at the base of the Picacho Mountain. Recent alluvium surrounding the Picacho Peak consists of pebbles, cobbles, and boulders of volcanic material eroded from the range which give the area a tan-grey color, distinct from other areas seen in high altitude photographs and in field relations.

## GEOLOGY

The geology of the Picacho Peak Range has been discussed by Feth (1951) who described the gross lithological and textural features, and mapped by Briscoe (1967). Our observations support Briscoe's conclusions that the range is composed of a concordant volcanic eruptive sequence intercalated with sediments that dips 40° to 50° to the northeast. The central spire is neither an olivine basalt plug (Feth, 1951) nor an intrusive (Wilson, 1962).

The volcanic sequence consists of a series of intermediate to felsic flows, tuffs and agglomerates with some interbedded conglomerates and siltstones. The grey, maroon and red volcanics tend to weather dark brown to black. Some phases are vesicular with quartz, calcite and epidote filling the vesicles. Individual flows range from 6 m to 30 m thick and the red color on top of some of the flows presumably indicate oxidation during interflow weathering. The flows vary in texture from aphanitic to slightly porphyritic with high potash units being dark, aphanitic, massive, vesicular to scoriaceous. Most of the flows are strongly jointed, ~~presumably~~ resulted from ~~post-flow tectonic~~ episodes.

Hydrothermal solution carrying quartz, calcite, barite, and copper minerals penetrated the faults and fractures altered and mineralized the fault breccias and jointed volcanics. The range has a large number of prospect pits and adits along fault zones that carry sparse copper oxide, carbonate and sulfides with minor silver and specular hematite.

## GEOCHRONOLOGY

K-Ar analytical data on five volcanic units from the Picacho Peak are presented in Table 1. Analytical techniques used for isotope dilution analysis of argon and wet chemical analysis of potassium are described by Livingston *et al.* (1967) and Damon *et al.* (1974), with the following modification. Suitable whole rocks are ground to -100 mesh and +100 mesh, the glass and altered minerals separated by floatation on a heavy liquid (specific gravity 2.50 to 2.55) and the carbonate removed by leaching in 0.5 N phosphoric acid.

## DISCUSSION

Table 1 shows the Picacho volcanic sequence to have been erupted about 22 m.y. ago. The base of the volcanic sequence is not exposed in the area. The Wymola conglomerate, thought to be the oldest by Briscoe (1967), is probably younger than the bulk of the volcanics because the major portion (80%) of the clasts are locally derived volcanic rocks similar to the Picacho lavas and a 20 m thick flow included between conglomerate beds yields an age somewhat younger than those of the Picacho sequence (Fig 2). Briscoe's interpretation probably resulted from structural complications in the southern part of the range.

The hornblende (UAKA-75-85) from an andesite cobble in the agglomerate unit interbedded between two fine-grained andesites (UAKA-75-28 and 75-27) yields an age of 22.21 ± 0.4 m.y. This sequence of andesite, tuff and agglomerate at the Picacho Peak resembles in gross lithology and texture (Feth, 1951; Briscoe, 1967) the volcanic sequence of Samaniego Hills, northern Silverbell Mountain studied by Eastwood (1970). Biotite from the youngest andesite in Samaniego Hills (UAKA-73-141) is 21.55 ± 0.45 m.y. Potassium contents of andesites of the two areas are similar and range between 2.8 and 3.5 weight percent.

Rock compositions vary from andesitic to trachytic in the Picacho area (Table 1). The dark, massive, resistent flows in the main spire of the peak are similar to those in an insulberg, about ~~130 feet~~ 40 m high, in the pass between the ranges, and also a remnant of volcanic flows overlying the crest of a ridge of metamorphic rocks in the southern part of the Picacho Mountains. They have high potassium contents and are purple to grey in color on fresh surfaces. They are composed of scoriaceous flow breccia units with calcite, quartz, zeolites and epidote filling the vesicles and with fine colloidal silica stringers. Although Briscoe (1967) and Feth (1951) considered them old spatter cones or vents, the K-Ar data suggest that they may represent last phases of eruption.

Incomplete chemical analysis of UAKA-75-29 (Table 2) shows high Al and K with low Mg, Ca and Na relative to average trachytes. Although silica was not determined, the rock probably has high normative orthoclase with ~~low~~ minor plagioclase and mafic minerals. The fine-grained, ultrapotassic rocks from the Picacho area consist of a mat of alkali feldspar microlites. The groundmass is aphanitic with minute rounded and partially digested inclusions. The interstitial mafic minerals include minute grains of magnetite and altered olivine. The K-feldspar laths have been sericitized. Irregular masses of calcite, partly replaced by quartz, are present. The vesicular units are the most altered. Vesicle fillings include zeolite, epidote, quartz, and calcite.

Ultrapotassic volcanic rocks in various parts of Arizona were first recognized as an offshoot of the K-Ar dating of these rocks. These differ from normal alkali trachytes in having a high $Al_2O_3$ and K/Na ratio greater than five. Such rocks are usually found in areas of extensional tectonics as well as in the same structural settings as carbonatites and kimberlites (Carmichael *et al.*, 1974). Damon (1971) and others pointed out that the Basin and Range may represent the continental equivalent of the East Pacific Rise where the crust is thin.

## CHRONOLOGY OF STRUCTURAL AND PHYSIOGRAPHIC EVOLUTION

The structural and physiographic evolution of the present Picacho Peak range is very complex. The following deductions may be made from the limited available data.

1. The volcanic sequence with a wide range in composition was erupted between 20 and 23 m.y. ago. The intercalated sediments and zones of weathering suggest interdispersed periods of weathering and erosion. The large granitic blocks near the summit indicate rifting of the basement rocks by viscuous highly potassic volcanics (more than 5% K), in contradiction to the conclusions of Briscoe (1967).

2. The area has experienced at least three periods of tectonism:

(a) Faulting and ~~regional~~ tilting.

Faulting:

The dominant structure of the Picacho Peak range strike northwest with the main range striking N60°W. High angle faults parallel this NW trend and control physiography. The other minor set of faults are almost perpendicular to these faults. The traces of the faults are often marked by fault breccia with slickensides and are cemented in places by silica (Briscoe, 1967). Feth (1951) recognized five step faults, two on the southwest and three on the northeast side of the range. These faults in the northeast are probably responsible for the pass between the two ranges. Traces of the bounding faults are often covered with alluvium and are only delineated by geophysical surveys. However, the fault zones bounding the high pinnacle are visible. The Bouguer gravity map (Peterson, 1962) shows a gravity low between the two ranges suggesting a downfaulting block

Tilting:

The volcanic sequence at the Picacho Peak range is tilted 40 to 50° to the northeast. A similar trend is noted in the Tertiary volcanics of northern Tucson and Silverbell Mountains in the south (Bickerman and Damon, 1966; Eastwood, 1970), and the Owlhead area of the northern Tortillita Mountains (Barter, 1962).

(b) North-South Faulting

The north-south trending faults are presumably much younger than the north-west striking faults and tilting ~~responsible for the asymmetric nature of the Picacho and Red Rock Basins. These~~ and may represent extensional tectonics during rifting. A contour map of hydrologic bed rock surface shows that the Lower Santa Cruz Basin is divided into two sections by a buried north-south trending ridge of hydrologic bed rock (Fig 1) from Picacho Peak to Samaniego Hill (Hardt and Cattany, 1965). This bed rock ridge consists mostly of the volcanics and separates the Picacho Basin to the northwest from the Red Rock Basin to the southeast. The Bouguer gravity map of Peterson (1962) also shows this as a relative gravity high between the two basins. ~~As well,~~ Geophysical studies indicate that the Picacho Basin trends north-south. The bed of the ephemeral Santa Cruz River crosses this buried ridge to the south-west of Picacho Peak. ~~It consists of~~ (a five mile wide zone of braided channels.)

Gravity anomaly configuration on the west side of the peak may represent a buried pediment sloping gently to the west for about 3 km. Peterson (1962) considered this steep gravity gradient representing the north-south trending boundary fault, separating the Picacho range from the downfaulted area. The thickness of the sedimentary cover to the east is not known because of the alluvial ~~cover~~ fan.

3. The high potassic rocks were extruded during the waning stages of the mid-Tertiary magmatic pulse (Damon, 1971). Then they were faulted, tilted, and eroded before the main east-west rifting and block faulting, which resulted in the formation of a complex system of subsidence structures. The basin fill sediments are flat-lying (Damon et al., 1973), and the volcanics have low initial $^{87}Sr/^{86}Sr$ ratios. The age, petrochemistry and petrogenesis of these high potassic lavas, along with their relationship to our Basin and Range tectonic model will be discussed in a subsequent paper.

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## REFERENCES

Barter, C.F., 1962. General geology of the Owl Head Butte area, Pinal County, Arizona: Unpublished M.S. thesis, University of Arizona, Tucson.

Bikerman, M., and P.E. Damon, 1966. K-Ar chronology of the Tucson Mountains, Pima County, Arizona: Geol. Soc. Amer. Bull., v. 77, p. 1225-1234.

Briscoe, J.A., 1967. The general geology of the Picacho Peak area: Unpublished M.S. thesis, University of Arizona, Tucson, 52 pp.

Carmichael, I.S.E., F.J. Turner, and J. Verhoogen, 1974. Igneous Petrology: McGraw-Hill Book Co., 739 pp.

Damon, P.E., 1971. The relationship between late Cenozoic volcanism and tectonism and orogenic epeirogenic periodicity, in: Conf. on The Late Cenozoic Glacial Ages, K.K. Turekian, ed., John Wiley & Sons, New York, p. 15-35.

Damon, P.E., M. Shafiqullah, and D.J. Lynch, 1973. Geochronology of block faulting and basin subsidence in Arizona: Geol. Soc. Amer. Abstracts with Programs, v. 5, p. 590.

Damon, P.E., M. Shafiqullah, and J.S. Leventhal, 1974. K-Ar chronology for the San Francisco volcanic field and rate of erosion of the Little Colorado River, in: Geology of Northern Arizona, Part 1, Regional Studies, Guidebook, Geol. Soc. Amer. Rocky Mtn. sec. mtg., Flagstaff, p. 221.

Eastwood, R.L., 1970. A geochemical-petrological study of mid-Tertiary volcanism in parts of Pima and Pinal Counties, Arizona: Unpublished Ph.D. dissertation, University of Arizona, Tucson, 212 pp.

Feth, J.H., 1951. Structural reconnaissance of the Red Rock Quadrangle: U.S. Geological Survey Open File Report, Tucson, Arizona.

Halva, Caroll, 1961. A geochemical investigation of basalts in southern Arizona: Unpublished M.S. thesis, University of Arizona, Tucson.

Hardt, W.F., and R.E. Cattany, 1965. Description and analysis of geohydrologic system in western Pinal County, Arizona: U.S. Geological Survey Open File Report, Tucson, Arizona.

Livingston, D.E., P.E. Damon, R.L. Mauger, R. Bennett, and A.W. Laughlin, 1967. Argon-40 in cogenetic feldspar-mica assemblages: Jour. Geophys. Res., v. 72, p. 1361.

Peterson, D.E., 1962. Earth fissuring in the Picacho area, Pinal County, Arizona: Unpublished M.S. thesis, University of Arizona, Tucson.

Wilson, E.D., and R.T. Moore, 1959. Geologic map of Pinal County, Arizona: Arizona Bureau of Mines, University of Arizona, Tucson.

Wilson, E.D., 1962. A resume of the geology of Arizona: Arizona Bureau of Mines Bull. 171, University of Arizona, Tucson.

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TABLE 1

K-Ar DATA ON SAMPLES FROM PICACHO PEAK AREA,
RED ROCK QUADRANGLE, PINAL COUNTY, ARIZONA

Constants used:
$\lambda_e = 0.575 \times 10^{-10}\ yr^{-1}$
$\lambda_\beta = 4.905 \times 10^{-10}\ yr^{-1}$
$\lambda = 5.480 \times 10^{-10}\ yr$
$^{40}K/K = 1.18 \times 10^{-4}$ atom ratio

| UAKA Sample No. | Description and Location | Percent K | Radiogenic argon-40 in $\times 10^{-12}$m/g | Percent atmospheric argon-40 | Age in m.y. | Ref. |
|---|---|---|---|---|---|---|
| 75-28 (5) | Whole rock, andesite from southern part of the ridge top, elevation 2350'; Lat 32° 37' 56" N, Long 111° 23' 31" W. | 3.00 | 117.4<br>117.2 | 6.5<br>6.4 | 22.35 ± 0.47 | |
| 75-85 (6) | Hornblende, hornblende andesite with thick agglomerate unit, elevation 2080' on the same slope as UAKA-75-28 and 75-27. | $0.79_5$ | 31.0<br>30.8 | 41.5<br>42.2 | 22.21 ± 0.50 | |
| 75-27 (7) | Whole rock, dark grey aphanitic andesite interbedded between two Wymola Conglomerate units, southeastern part of the range, elevation 1930', Lat 32° 37' 35" N, Long 111° 23' 30" W. | 2.84 | 103.8<br>102.7 | 11.4<br>11.7 | 20.80 ± 0.44 | |
| 75-96 (3) | Whole rock, aphanitic dark grey trachyte near Picacho Peak summit, altitude 3360'. It overlies granitic blocks. Lat 32° 38' 07" N, Long 111° 26' 00" W. | 6.73 | 268.0<br>263.4 | 5.7<br>6.0 | 22.60 ± 0.48 | |
| 75-29 (2) | Whole rock, ultrapotassic grey, massive, aphanitic trachyte from a small isolated hill about 130' high in the pass between Picacho Peak and Picacho Mountain ranges. Lat 32° 39' 50" N, Long 111° 23' 26" W. | 9.58 | 337.2<br>334.4 | 41.2<br>41.6 | 20.09 ± 0.47 | |
| 73-141 (8) | Biotite, Sasco andesite flow overlying brecciated andesite, youngest unit in Sasco area, northern end of Silverbell Mountains. Lat 32° 32' 55" N, Long 111° 27' 53" W. | 6.79 | 261.9<br>260.5 | 25.4<br>26.4 | 21.55 ± 0.45 | |

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Constants used:
$\lambda_e = 0.575 \times 10^{-10}\ yr^{-1}$
$\lambda_\beta = 4.905 \times 10^{-10}\ yr^{-1}$
$\lambda = 5.480 \times 10^{-10}\ yr$
$^{40}K/K = 1.18 \times 10^{-4}$ atom ratio

| UAKA Sample No. | Description and Location | Percent K | Radiogenic argon-40 in $\times 10^{-12}$m/g | Percent atmospheric argon-40 | Age in m.y. | Ref. |
|---|---|---|---|---|---|---|
| 75-29a (1) | Whole rock, remnant of the volcanics overlying the crest of a spar of metamorphic rocks in the southern part of the Picacho Mountain, about 2 km northeast of UAKA-75-29. | 11.45 | | | | |
| (4) | Whole rock from the summit, Picacho Peak (Halva, 1961, p. 32). | 5.06 | | | | |

**Note:** Some of the numbers are approximate, subject to air argon calibration and final checking by P.E. Damon.

TABLE 2

PARTIAL CHEMICAL ANALYSIS OF AN ULTRA HIGH POTASSIC ROCK

(UAKA-75-29) FROM THE PICACHO AREA

| | Weight Percent |
|---|---|
| $SiO_2$ (est) | 60. |
| $Al_2O_3$ | 16.7 |
| FeO (Total Fe) | 7.6 |
| MgO | 0.6 |
| CaO | 0.6 |
| $Na_2O$ | 1.4 |
| $K_2O$ | 11.5 |
| K/Na ratio | 9.2 |

Figure 1. The numbers 1 to 8 indicate location of samples listed in Table 1 (modified after Feth, 1951; Hardt and Cahany, 1965; Briscoe, 1967). Dotted lines indicate outline of buried ridge.

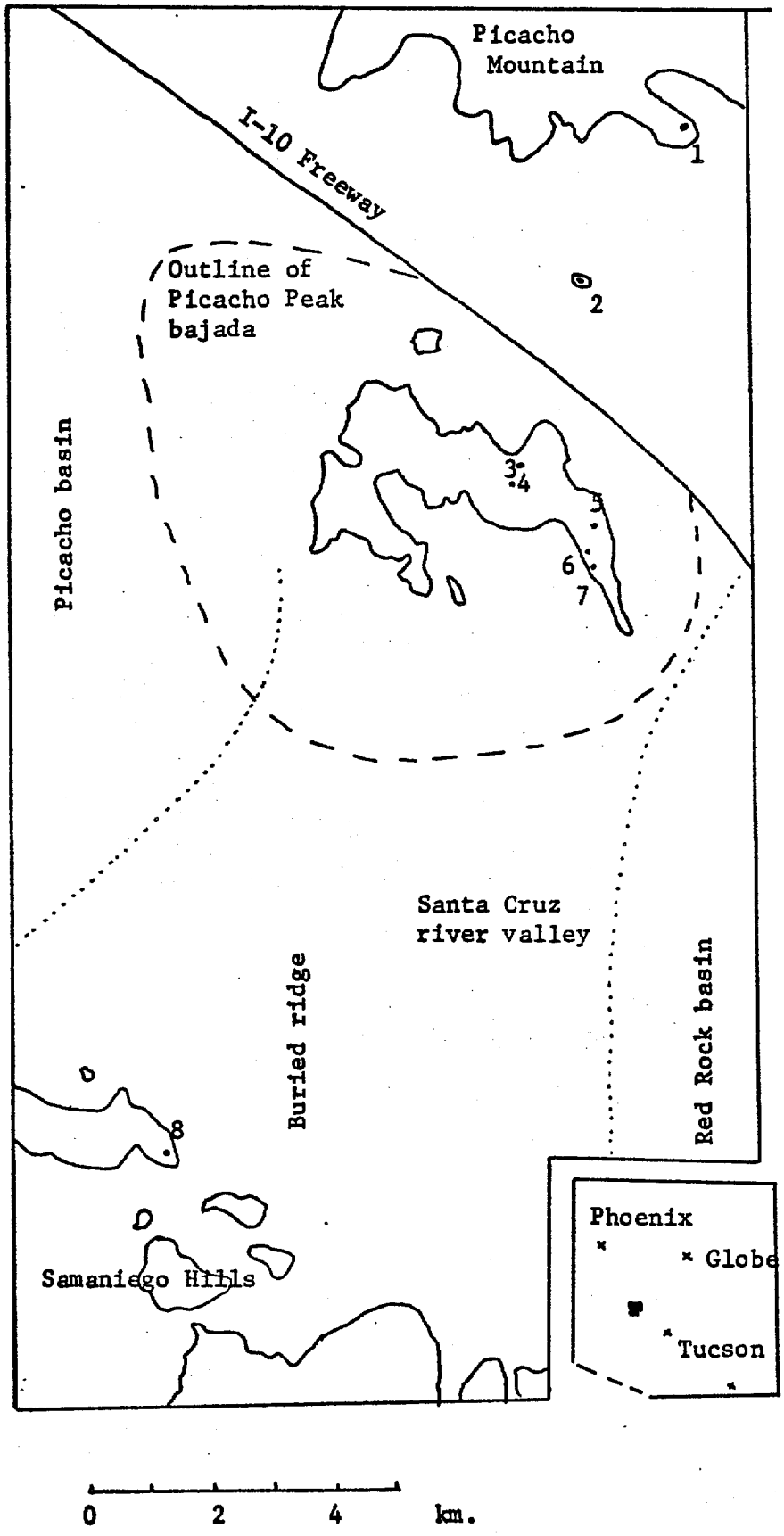
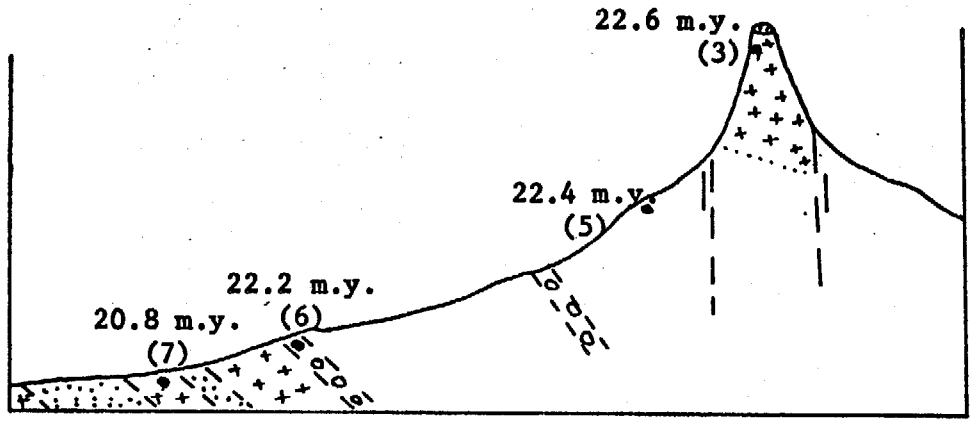
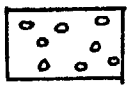

Picacho Mountain
I-10 Freeway
Outline of Picacho Peak bajada
Picacho basin
1
2
3
4
5
6
7
8
Santa Cruz river valley
Buried ridge
Red Rock basin
Samaniego Hills
Phoenix
Globe
Tucson
0
2
4
km.

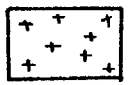
Figure 2. Schematic geologic section of the southeastern part of the Picacho Peak range showing rock types (Briscoe, 1967) and the K-Ar ages. Numbers in parentheses indicate samples listed in Table 1.



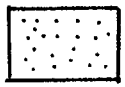
$K_{pb}$ Porphyritic vesicular basalt



$K_a$ Agglomerate



$K_{ab}$ Aphanitic basalt



$K_w$ Wymola conglomerate