DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Recognition of the Peach Springs Tuff, California and Arizona, using heavy mineral suites

by

Sharon Gusa

Open-File Report 86-522

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey editorial standards and nomenclature.

U.S. Geological Survey
345 Middlefield Road M/S 975
Menlo Park, California 94025

1986

INTRODUCTION

The Peach Springs Tuff of Young and Brennan (1974) is a voluminous ash-flow tuff of early Miocene age that has been identified in western Arizona and the Mojave Desert of southeastern California. The tuff was recognized and described in the areas of Peach Springs and Kingman, Arizona, on the western Colorado Plateau by Young (1966), and Young and Brennan (1974). Glazner and others (1986) and Wells and Hillhouse (1986) have recently proposed that the Peach Springs Tuff may correlate with ash-flow tuff occurring to the west across the Mojave Desert as far as the area of Barstow, California. If the correlation is correct, the Peach Springs Tuff would be the only Miocene unit of wide areal extent in this region and would cover an area of approximately 35,000 km^2. Thus, the Peach Springs Tuff would be invaluable for use as a stratigraphic marker and for determining the timing and amount of Tertiary crustal extension. However, ashflow tuffs are commonly difficult to correlate due to lateral and vertical variations in welding, mineralogy, and chemistry, complex depositional mechanisms, and other complicating factors (Hildreth and Mahood, 1985). Proposed identification of the Peach Springs Tuff over this extensive area has been based primarely on field relations such as its lower Miocene stratigraphic position, and phenocryst assemblage which includes abundant sanidine and lesser amounts of biotite, hornblende, plagioclase and sphene. Additional criteria used for correlation include phenocryst composition and paleomagnetic directions (Glazner and others, 1986, Wells and Hillhouse, 1986). Inconsistent K-Ar dates from localities of the Peach Springs Tuff and its proposed equivelents have left nagging uncertainties regarding this correlation. The source of the tuff is unknown. Additionally, correlation of some localities has been uncertain because of limited and widely scattered outcrop preservation, and the varied stratigraphic relations of the tuff within the numerous isolated Tertiary stratigraphic sections. This report presents the results of a study of relative abundances of heavy minerals to characterize and distinguish ashflow deposits in the region. We conclude that the Peach Springs Tuff can be easily and quickly identified by heavy-mineral suites, and the results confirm the correlation by Glazner and others (1986) of the Peach Springs Tuff with ash-flow tuff in the central Mojave Desert.

METHODS

Thirty-one samples of tuff were collected from widely distributed locations (fig. 1) and from several stratigraphic levels. Samples averaging 2 kgs were crushed and sieved and the (-60)-(+140) mesh-size fraction was separated using methylene iodide with a specific gravity of 2.83. The heavy separates were studied in oil under petrographic microscope, using optical properties to aid mineral identifications. Visual estimates of the relative percentages of minerals were made under binocular microscope using a comparative reference diagram. This semiquantitative technique proved adequate for distinguishing different tuffs; more quantitative techniques using line counts and proportional weights could be used for more detailed studies. Heavy mineral suites from the Peach Springs Tuff at Kingman (sample numbers 1, 2, and 3, figs. 1 and 2) were used as a basis of comparison for other samples correlated with the Peach Springs. Various other tuffs from the region were also analyzed to determine if they could be distinguished from the Peach Springs Tuff on the basis of heavy minerals.

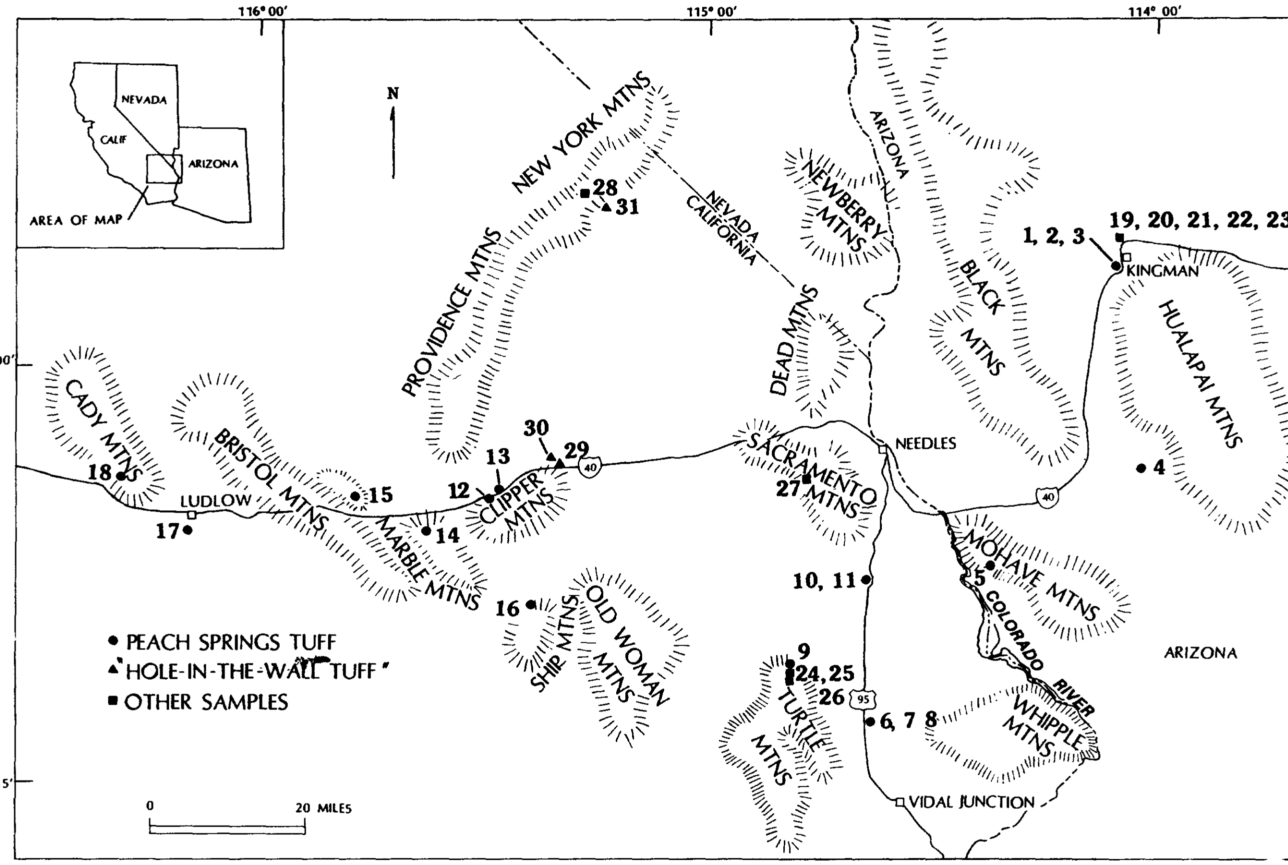

Figure 1. Sample location map.

SAMPLES STUDIED

Thirty-one samples of tuffs were collected within the study area (fig. 1). Detailed sample descriptions and localities are contained in an appendix. Samples 1, 2 and 3 from Kingman, Arizona, represent the Peach Springs Tuff as described and identified by Young (1966) and Young and Brennan (1974), and provide a basis of comparison for other putative correlations with it. Samples 1, 2, and 3 were collected from three different stratigraphic positions within the Peach Springs Tuff to determine if mineral content changes vertically within the tuff. Sample number 3 is from the basal nonwelded tuff, sample 2 from an intermediate nonwelded tuff, and sample 1 is from the upper welded part of the tuff.

Nineteen samples of tuff that had been assigned to or suspected to be the Peach Springs Tuff, based on field relations, were analyzed for comparison with samples 1, 2 and 3 from the Kingman locality. These include samples of tuff from the central Mojave Desert (west side of the area in fig. 1) proposed to be the Peach Springs Tuff by Glazner and others (1986). Most of the samples contain abundant chatoyant blue sanidine. Of these, seven samples are nonwelded pumice from the base of the tuff, 11 samples are from the welded zone, and one, a sanidine-rich vitrophyre dike from the New York Mountains (sample 28), was collected as a possible intrusive equivalent of the Peach Springs Tuff. At two locations (Pyramid Butte and Snaggletooth, California) samples were collected from more than one horizon within the deposit to determine whether or not the tuff is vertically zoned.

Other Miocene ashflow tuffs in the region were also analyzed to determine whether or not they can be distinguished from the Peach Springs Tuff by their heavy mineral content. Five stratigraphic intervals in a 20-meter-thick section of ashflow and airfall tuff underlying the Peach Springs Tuff were sampled at Kingman (samples 19, 20, 21, 22, and 23), two of which (samples 21 and 22) are in the Cook Canyon Tuff of Buesch and Valentine (1986). Other tuffs sampled include the informally designated "Hole-in-the-Wall tuff" of McCurry (1982; samples 29, 30 and 31,), and a tuff in the Turtle Mountains (sample 26) dated at 20.0 Ma by Howard and others (1982).

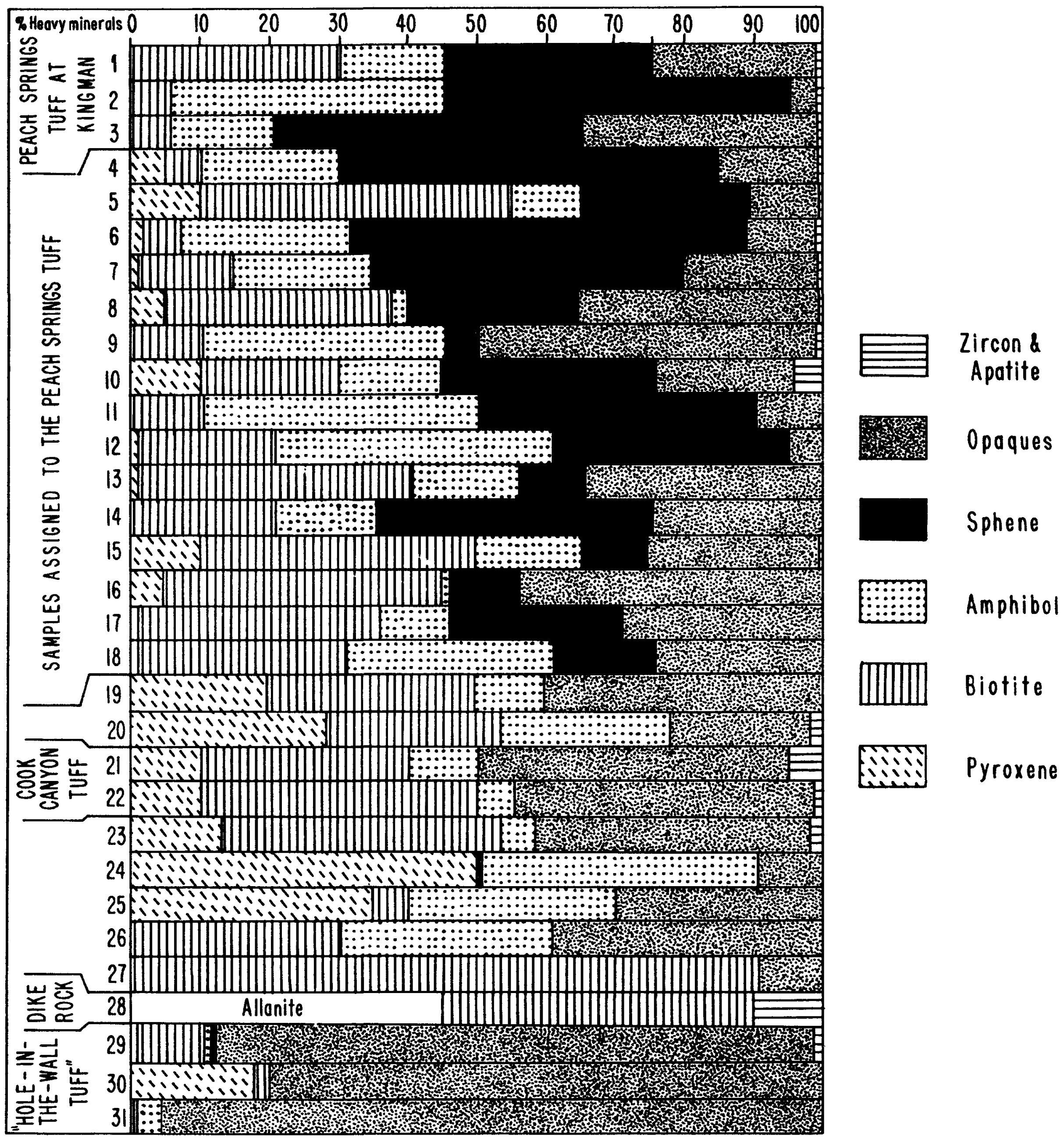

Figure 2. Relative abundances of heavy minerals in ash-flow tuffs and a dike rock from the Mojave Desert area. The Peach Springs Tuff of Young and Brennan (1974) at Kingman compares favorably with other samples here assigned to the Peach Springs Tuff, and is considered to differ from the various other ash-flow tuffs and the dike rock. Samples 19, 20, and 23-27 are unnamed tuffs.

RESULTS

Relative percentages of heavy minerals in the samples are shown in table 1. Heavy-mineral histograms for each sample are shown in figure 2.

The abundance of sphene (10-55%) is the most distinctive heavy-mineral characteristic of the Peach Springs Tuff (Figure 2). Heavy-mineral suites from samples of all other tuffs analyzed in this study contain less than 1% sphene. Other characteristics of the Peach Springs Tuff are relatively low pyroxene content, very low percentages of both apatite and zircon in most samples, and abundant, but varied biotite, amphibole and opaque minerals. Fifteen of the nineteen samples that had been correlated with the Peach Springs Tuff closely resemble the Peach Springs samples from the Kingman locality in their heavy mineral content, and can confidently be identified as the same unit (samples 4-18, fig. 2). Additionally, the Peach Springs Tuff samples show no conspicuous or consistent variation in heavy mineral content, either laterally or vertically.

Four samples that were tentatively correlated with the Peach Springs Tuff based on field evidence were found to differ significantly from it in heavy mineral content. The dike from the New York Mountains (sample 28) was thought to be related to the Peach Springs Tuff, and therefore a possible clue to the location of its source. However, this dike is unlike the Peach Springs Tuff because the heavy-mineral suite contains no pyroxene, amphibole, sphene, or opaque minerals, but does contain 45% allanite. Pumice samples 24 and 25 from the Turtle Mountains were also suspected to be pumice from the base of the Peach Springs Tuff, but differ from the overlying Peach Springs Tuff (sample 9) and other Peach Springs Tuff samples by the absence of sphene, abundance of pyroxene, and low biotite content. A tuff in the Sacramento Mountains (sample 27), suspected to be the Peach Springs Tuff on the basis of field relations, differs from the Peach Springs Tuff in that its heavy mineral suite contains 90% biotite and no sphene. The heavy mineral suites of all other samples proposed to be the Peach Springs Tuff resemble the heavy minerals of the Peach Springs Tuff of Young and Brennan at Kingman (samples 1,2 and 3), and confirm the correlation of Glazner and others (1986).

Samples of the "Hole-in-the-Wall tuff" (samples 29, 30 and 31) are distinguished from the Peach Springs Tuff by their lack of sphene, lower amphibole content and very abundant opaque minerals (80-90%, figure 2). The remaining samples are distinguished from the Peach Springs Tuff by the absence of sphene, and the lower percentage of opaque minerals distinguishes them from the Hole-in-the-Wall tuff".

SAMPLE	FORMATION	PYROXENE	BIOTITE	AMPHIBOLE	APATITE	ZIRCON	SPHENE	OPAQUE	ALLANITE
1	TYPE PST	<1	30	15	<1	<1	30	24	0
2	TYPE PST	<1	5	40	<1	<1	50	5	0
3	TYPE PST	<1	5	15	<1	<1	45	35	0
4	PST	5	5	20	<1	<1	55	15	0
5	PST	10	45	10	0	<1	25	10	0
6	PST	2	5	25	0	1	57	10	0
7	PST	1	14	20	<1	<1	45	20	0
8	PST	5	33	2	<1	<1	25	35	0
9	PST	<1	10	35	<1	<1	5	50	0
10	PST	10	20	15	1	3	31	20	0
11	PST	<1	10	40	0	0	40	25	0
12	PST	1	20	40	<1	<1	34	5	0
13	PST	1	40	15	<1	<1	10	34	0
14	PST	<1	20	15	0	<1	40	25	0
15	PST	10	40	15	<1	<1	10	25	0
16	PST	5	40	1	0	<1	10	45	0
17	PST	1	35	10	<1	<1	25	30	0
18	PST	1	30	30	<1	<1	15	25	0
19	UNNAMED	20	30	10	4	<1	<1	36	0
20	UNNAMED	28	25	25	2	<1	0	20	0
21	CCT	10	30	10	5	0	<1	45	0
22	CCT	10	40	5	2	<1	<1	43	0
23	UNKNOWN	13	40	5	2	<1	<1	40	0
24	UNKNOWN	50	<1	40	<1	<1	<1	10	0
25	UNKNOWN	35	5	30	<1	<1	<1	30	0
26	UNKNOWN	<1	30	30	<1	<1	0	40	0
27	UNKNOWN	0	90	0	<1	<1	<1	10	0
28	DIKE	0	45	0	2	8	0	0	45
29	HWT	1	10	<1	<1	1	1	86	0
30	HWT	18	2	0	0	<1	<1	80	0
31	HWT	0	1	3	0	<1	<1	95	0

Table 1. Relative abundances of various heavy minerals in the Peach Springs Tuff of Young and Brennan (1974) at Kingman, Arizona, (TYPE PST) compared with other samples assigned to the Peach Springs Tuff (PST) and with other tuffs. HWT = "Hole-in-the-Wall tuff" of McCurry (1982), CCT = Cook Canyon tuff of Buesch and Valentine (1986), DIKE = vitrophyre dike.

CONCLUSIONS

Semiquantitative determination of the heavy-mineral assemblage can be used as a relatively quick and simple guide for correlating or distinguishing ash-flow tuffs in the region. The combination of heavy minerals with stratigraphy, total phenocryst mineralogy, paleomagnetic data, and radiometric dating can be diagnostic. In whole-rock samples of the Peach Springs Tuff, we found no obvious differences between heavy minerals in basal pumice that probably was derived from the top of the magma chamber, and overlying welded layers, presumably derived from lower parts of the magma chamber. Any possible differences in distribution of crystal phases in the parent magma chamber of the Peach Springs Tuff would have to be sought in more detailed sampling of pumices. The lack of obvious lateral mineralogical zoning gives no clue as to the location of the source area of the tuff, which remains unknown. An important result of this study is that heavy mineral suites support the correlation of blue-sanidine tuff from the central Mojave Desert with the Peach Springs Tuff (Glazner and others, 1986). Additionally, some samples that were previously thought to be the Peach Springs Tuff were found to be unrelated to that unit. Heavy-mineral suites are potentially useful as a correlation tool in other areas, particularly where structure is complex or where numerous ash-flow deposits of similar ages are difficult to distinguish.

ACKNOWLEDGEMENTS

Barbara John and R. V. Fisher suggested the approach. Jane Nielson, Keith Howard, David Miller and Allen Glazner provided samples. Reviews by Vic Seiders, Andrei Sarna-Wojcicki, and Robert L. Christiansen greatly improved the manuscript. This study is a contribution of the Pacific to Arizona Crustal Experiment (PACE) of the U. S. Geological Survey, a multidisciplinary study of crustal structure and evolution in the southwestern United States.

REFERENCES

Buesch, D.C., Valentine, G.A., 1986, Peach Springs Tuff and volcanic stratigraphy of the southern Cerbat Mountains: Geolgoical Society of America Guidebook and Volume, Cenozoic stratigraphy, structure and mineralization in the Mojave Desert. 82nd Annual Meeting, Los Angleles, Calif., March 25-28, 1986, pp. 7-13.

Carr W.J., Dickey, D.D., and Quinlivan, W.D., 1980, Geologic map of the Vidal NW, Vidal Junction, and parts of the Savahia Peak Quadrangles, San Bernardino County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map, I-1126, scale 1:24,000.

Glazner, A.F., Nielson, J.E., Howard, K.A., and Miller, D.M., 1986, Correlation of the Peach Springs Tuff, a large-volume Miocene ignimbrite sheet in California and Arizona: Geology, v. 14, p. 840-843.

Hildreth, W., and Mahood, G., 1985, Correlation of ash-flow tuffs: Geological Society of America Bulletin, v. 96, no. 7, pp. 968-974.

Howard, K.A., Stone, P., Pernokas, M.A., and Marvin, R.F., 1982, Geologic and geochronologic reconnaissance of the Turtle Mountains area, California: West border of the Whipple Mountains detachment terrane: in Frost, E.G. and Martin, D.L., eds., Mesozoic-Cenozoic Tectonic Evolution of the Colorado River Region, California, Arizona, and Nevada (Anderson-Hamilton Volume) pp. 341-354

McCurry, Michael, 1982, The geology of a late Miocene silicic volcanic center in the Woods and Hackberry Mountians area of the eastern Mojave Desert, San Bernardino County, California, in Frost, E.G. and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada (Anderson-Hamilton volume): San Diego, Cordilleran Publishers, p. 433-439.

Wells, R.E., and Hillhouse, J.W., 1986, Paleomagnetism of the Peach Springs Tuff and correlative outcrops from Barstow, California to the Colorado Plateau, Arizona: Geolgical Society of America Abstracts with Programs, v. 18, n.5, p. 421.

Young, R.A., 1966, Cenozoic geology along the edge of the Colorado Plateau in northwestern Arizona: Dissertation Abstracts, Section B, v. 27, no. 6, p. 1994.

Young, R.A., and Brennan, W.J., 1974, Peach Springs Tuff: Its bearing on structural evolution of the Colorado Plateau and development of Cenozoic drainage in Mohave County, Arizona: Geological Society of America, v. 85, p. 83-90.

APPENDIX- Location and handsample descriptions of each sample analyzed.

Defined Peach Springs Tuff Samples

Samples 1, 2 and 3. 35°10'31"N latitude, 114°04'27"W longitude. Collected by J. Nielson and S. Gusa from a road cut about 3 miles west of Kingman, Arizona, on Interstate highway 40. Samples from this locality are from the Peach Springs Tuff as defined by Young (1966), and Young and Brennan (1974), and serve as a basis for comparison for correlating other tuffs with the Peach Sprigs Tuff. An internal stratigraphy of the Peach Springs Tuff is well exposed here. Samples were collected from each of three units to determine if heavy mineral content changes vertically within the tuff. Sample 1 is from the highest part of the tuff, about 25 meters above the base, sample 2 from an intermediate unit, and Sample 3 is from the basal unit

Sample 1 is from a massive, resistant, cliff-forming light purple welded, lithic-rich, pyroxene-biotite-sanidine tuff that exhibits the typical outcrop appearance of the Peach Springs Tuff. Located 30 meters above the base of the Peach Springs Tuff.

Sample 2 is from a light tan, nonwelded, pumice and lithic-rich, biotite-pyroxene-sanidine tuff. Located 2 meters above the base of the deposit.

Sample 3 represents the basal deposit of the Peach Springs Tuff. It is pink, coarse-grained, well sorted, nonwelded, finely stratified lithic-rich biotite-sanidine tuff. Located 0.5 meters above the base.

Other Peach Springs Tuff Samples

Sample 4. 34°47'38"N latitude, 114°01'53"W longitude. Collected by J. Nielson and S. Gusa from Flattop mountain, near Yucca, Arizona. Light tan, glassy, sphene-hornblende-sanidine pumice from the basal nonwelded zone of the tuff.

Sample 5. 34°36'26"N latitude, 114°22'41"W longitude. Collected from the Mohave Mountains by J. Noller. Silicified purple tuff with flattened pumice, blue sanidine, minor hornblende, plagioclase (partly replaced by k-feldspar), sphene, and pyroxene. Contains abundant volcanic and granitic xenoliths.

Sample 6. 34°21'49"N latitude, 114°38'49"W longitude. Collected by J. Nielson and S. Gusa from Pyramid Butte, 39 miles south of Needles, California, near U.S. Highway 95. Light tan biotite-hornblende-sanidine pumice from the basal nonwelded part of the Peach Springs Tuff. The tuff was identified by Carr and others (1980). K-Ar whole-rock date on overlying basalt is 17.0 +/- 0.4 Ma, and on underlying basalt is 14.5 +/- 0.3 Ma (Carr and others, 1980)

Sample 7. 34°21'49"N latitude, 114°38'49"W longitude. Collected by J. Nielson and S. Gusa from the same location as sample 6, but is stratigraphically above sample 6. Light tan sphene-biotite-amphibole-sanidine pumice from the nonwelded basal part of the tuff.

Sample 8. 34°21'49"N latitude, 114°38'49"W longitude. Collected by J. Nielson from Pyramid Butte, California. Light tan, crystal-lithic tuff with large (to 10 cm long) blocky pumice fragments, some showing incipient welding. Phenocrysts are sanidine, plagioclase, hornblende, minor quartz and sphene.

Sample 9. 34°27'31"N latitude, 114°49'38"W longitude. Collected by J. Nielson from the Turtle Mountains, California. Pumice from reversly graded zone near the base of the Peach Springs Tuff deposit. Contains pumice blocks up to 35 cm long, and phenocrysts of sanidine, hornblende, plagioclase, quartz, and corroded sphene. The outcrop has no welded zone but is affected by vapor phase alteration throughout.

Sample 10. 34°35'57"N latitude, 114°39'11"W longitude. Collected by J. Nielson and S. Gusa from the Snaggletooth area, 20 miles south of Needles, California, near U.S. Highway 95. Light tan to white sphene-biotite-amphibole-sanidine pumice from the nonwelded basal part of the tuff.

Sample 11. 34°35'57"N latitude, 114°39'11"W longitude. Collected by J. Nielson from the welded zone overlying sample 10. Silicified amygdular tuff with reddish matrix. Dominant phenocrysts are sanidine, plagioclase and hornblende. Sphene is evident in hand sample.

Sample 12. 34°45'38"N latitude, 115°28'01"W longitude. Collected by D.M. Miller from the Clipper Mountains, California. Welded tuff containing hornblende, bioite, and sanidine.

Sample 13. 34°46'03"N latitude, 115°28'11"W longitude. Collected by J. Nielson from the Clipper Mountains, California. Pinkish-purple matrix of welded zone. Contains flattened pumice fragments less than 1 cm long. Sanidine, plagioclase, and minor hornblende are visible in hand sample.

Sample 14. 34°40'42"N latitiude, 115°38'48"W longitude. Collected by A. Glazner from the Marble Mountains, California. Light purple, welded, tuff containing hornblende, biotite, and sanidine. K-Ar sanidine date= 16.3 +/- 0.4 Ma (written communication, J.K. Nakata).

Sample 15. 34°45'30"N latitude, 115°47'28"W longitude. Collected by D.M. Miller from the capping volcanic unit in the Bristol Mountains, California. Pink, welded, pumiceous tuff that contains hornblende, biotite, sanidine and lithic fragments.

Sample 16. 34°33'24"N latitude, 115°23'49"W longitude. Collected by K. Howard from the northern Ship Mountains, California. Welded biotite-plagioclase--blue sanidine tuff. K-Ar date on sanidine= 17.5 +/- 0.4 Ma (J.K. Nakata, written communication, 1985).

Sample 17. 34°42'00"N latitude, 116°10'05"W longitude. Collected by A. Glazner three miles south of Ludlow, California. Light brown welded tuff containing hornblende, biotite, and sanidine phenocrysts.

Sample 18. 34°47'28"N latitude, 116°18'45" W longitude. Collected by A. Glazner from the northern Cady Mountains, California. Brownish purple, welded tuff that contains hornblende and sanidine.

Other Tuffs

Samples 19, 20, 21, 22, and 23. 35°12'36"N latitude, 114°03'24"W longitude. Collected by J. Nielson and S. Gusa from the road cut on Iterstate Highway 40 near the Stockton Hill Road exit near Kingman, Arizona. These samples are from a series of ashflow deposits that underlie the Peach Springs Tuff (Buesch and Valentine, 1986). Samples are listed from oldest to youngest.

Sample 19 is from the basal unit exposed on the road cut. Light gray to white, nonwelded, biotite-sanidine tuff.

Sample 20 is from a light pink, nonwelded tuff containing thin beds of lithic fragments.

Sample 21 is from a light tan, nonwelded, fine-grained, biotite pumice flow, at the base of the Cook Canyon Tuff of Buesch and Valentine (1986).

Sample 22 is from a dark tan, nonwelded, biotite-sanidine-hornblende pumice flow. This sample is from the upper part of the Cook Canyon Tuff of Buesch and Valentine (1986).

Sample 23 is from a light pink, nonwelded, lithic-rich biotite-sanidine-tuffaceous sandstone.

Samples 24 and 25 (two samples). 34°27'31"N latitude 114°49'38"W longitude. Collected by J. Nielson and S. Gusa from the northern Turtle Mountains, California. Pumice immediately below the Peach Springs Tuff. Sample 25 overlies sample 24.

Sample 26. 34°27'17"N latitude, 114°49'39"W longitude. Collected by K. Howard from the northern Turtle Mountains, Cailfornia. Welded, hornblende-biotite-plagioclase tuff, lacking sphene. K-Ar date on biotite from this sample = 20.0 +/- 0.7 Ma (Howard and others, 1982).

Sample 27. 34°46'48"N latitude, 114°46'48"W longitude. Collected by J. Nielson from Eagle Pass, Sacramento Mountains, California. Brownish purple, welded, biotite-sanidine rich tuff. Whole-rock chemistry of this sample differs from the Peach Springs Tuff (J. Nielson, unpublished data).

Sample 28. 39°19'15"N latitude, 115°16'53"W longitude. Collected by J. Nielson and S. Gusa from the New York Mountains, California. This is a sanidine-rich vitrophyre dike, considered in the field to resemble and possibly be related to the Peach Springs Tuff. K-Ar dating of biotite (J.K. Nakata, written communication, 1986) gave a date of 15.8 Ma, younger than most dates on the Peach Springs Tuff listed by Glazner and others (1986).

"Hole-in-the-Wall tuff" samples

Sample 29. 34°48'47"N latitude, 115°20'05" W longitude. Collected by K. Howard from the Blind Hills, California. Welded, crystal-rich, plagioclase- blue sanidine-tuff. K-Ar date on sanidine= 17.2 +/- 0.4 Ma (J.K. Nakata, written communication, 1985).

Sample 30. 34°49'20"N latitude, 115°20'45"W longitude. Collected by D.M. Miller from the Blind Hills, California. Tan, welded, tuff that contains biotite, pyroxene, and sanidine phenocrysts.

Sample 31. 35°17'15"N latitude, 115°13'35"W longitude. Collected by D.M. Miller from tuff stratigraphically overlying the Peach Springs Tuff in the New York Mountains, California. Welded tuff that contains biotite and sanidine phenocrysts.