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K-Ar AGES FROM THE CIMA VOLCANIC FIELD, EASTERN MOJAVE DESERT, CALIFORNIA

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INTRODUCTION

The Cima volcanic field, one of several alkaline to subalkaline basalt fields in southwest North America, is located in the eastern Mojave Desert, California, 120 km southwest of Las Vegas, Nevada (fig. 1). The field is located on the crest and flanks of several large pediment domes that truncate Precambrian metamorphic rocks, Paleozoic metasedimentary rocks, Mesozoic plutonic rocks (predominantly the Cretaceous Teutonia Quartz Monzonite), and Tertiary terrigenous clastic rocks (Hewett, 1956). The fact that the erosional environment on these pediment domes has protected the lava flows from significant fluvial modification and subsequent burial by younger flows makes the Cima volcanic field an ideal natural laboratory for the study of geomorphic and geologic processes of landscape evolution in arid to semiarid climates (Dohrenwend and others, 1984a). Potassium-argon ages on the Cima lava flows have been used to develop the necessary chronology for geochemical and morphological analyses of rock varnish (Dorn, 1984); rates and trends of landform evolution in arid environments (Dohrenwend and others, 1984b); types and rates of geomorphic processes on lava flows (Wells and others, 1984); and cumulic soil development in eolian parent materials (McFadden and others, 1984).

The Cima volcanic field contains more than 40 cinder cones and associated flows that cover an area of approximately 150 km². The cinder cones, 50 to 155 m high and 400 to 915 m wide, range from undissected to deeply eroded composite vents with exposed feeder dikes and plugs. The lava flows, as much as 1.5 km wide and 9 km long, occur as two morphologically distinct types: thin (2 to 4 m) flows, elongate in planform, with low original surface relief and relatively low gradients; and thick (10 to 30 m) flows, equant in planform, with higher original relief and higher gradients. The younger elongate flows display many of the surficial forms that are characteristic of moderate-gradient pahoehoe and aa flows; the equant flows generally lack these surface forms.

Flow rocks contain varying amounts of clinopyroxene, olivine, and plagioclase phenocrysts in a medium- to fine-grained groundmass of plagioclase, clinopyroxene, olivine, opaque minerals, brown basaltic glass, and apatite. Phenocrysts range in size from 0.2 to 1.0 mm. Rims of iddingsite(?) are commonly found around the olivine phenocrysts, whereas the clinopyroxene and plagioclase appear to be fresh. The groundmass typically exhibits pilotaxitic to trachytic texture; however, some flow rocks have an intergranular texture. X-ray-fluorescence analyses and CIPW norm calculations of flow rocks from the Cima field show that the flows range in composition from hawaiite to basanite (table 1). Many of the flows contain abundant xenoliths of dunite, gabbro, and granite, and xenocrysts of plagioclase. The granitic xenoliths are lithologically similar to the underlying Cretaceous Teutonia Quartz Monzonite and are probably derived from this source.

ANALYTICAL METHODS

Fifty-three whole-rock potassium-argon dates have been determined for the Cima volcanic field. Sampling-site locations are described below and are approximately located in figures 1 and 2. Samples from selected flows were thin sectioned and examined to determine their suitability for dating. To reduce the possibility of contamination by excess argon, suitable samples were cut into 3- to 5-mm-thick sections to facilitate removal of xenoliths and xenocrysts. The remaining material was then crushed, sieved, and treated with HCl and HF in an ultrasonic bath to remove surface-weathering alteration products, interstitial carbonate, and zeolites. Acid-treated samples were rinsed in an ultrasonic bath of distilled water, dried, and split for analysis. Duplicate potassium analyses were performed by flame photometry using a lithium internal standard following procedures described by Carmichael, Hample, and Jack (1968). Argon extractions and isotopic analyses were performed at the University of California, Berkeley, using standard isotope dilution methods and a 10-cm Reynolds-type gas-source mass spectrometer according to procedures described by Dalrymple and Lanphere (1969). The decay constants used in the age calculations are those recommended by Steiger and Jager (1977): $\lambda_\epsilon + \lambda_{\epsilon'} = 0.581 \times 10^{-10}\ yr^{-1}$; $\lambda_\beta = 4.962 \times 10^{-10}\ yr^{-1}$; and $^{40}K/\Sigma K = 1.167 \times 10^{-4}$. The reported precision is $\pm 2\sigma$. All samples were collected by Brent D. Turrin unless otherwise noted.

Several independent lines of evidence support the accuracy of the potassium-argon ages from the Cima field. Paleomagnetic polarity determinations were measured for nearly all the Quaternary flows. In all cases, polarity determinations are in agreement with the latest revision of the paleomagnetic time scale of Harland and others (1983). Flows as old as 0.70 m.y. with normal polarity and flows as young as 0.75 m.y. with reversed polarity have been identified in the Cima field. This indicates an accuracy of 0.02 to 0.03 m.y. (± 4%) for age dates in the 0.7 m.y. range. Moreover, the potassium-argon ages are also in accord with progressive changes in flow surface morphology and soil development (Wells and others, 1984; McFadden and others, 1984). In addition, duplicate age determinations were performed on several flows to assess the stated estimated precision (±). Replicate argon extractions and isotopic analyses were done on four randomly selected samples (MC1a [3.86 ± 0.12, 3.83 ± 0.12 m.y.]; MC14 [0.16 ± 0.04, 0.17 ± 0.04 m.y.]; MC41 [0.27 ± 0.10, 0.26 ± 0.12 m.y.]; MC111 [0.47 ± 0.05, 0.45 ± 0.04 m.y.]) and for three sample pairs collected from different locations on the same flow (MC19 and MC90 [0.13 ± 0.06, 0.14 ± 0.04 m.y.]; MC6 and MC41 [0.33 ± 0.05, 0.265 m.y.*]; and MC87 and MC111 [0.50 ± 0.03, 0.460 m.y.*]). Age determinations were performed at different K-Ar laboratories, MC6 at Stanford University and MC41 at the University of California Berkeley; *mean of two analyses. The consistency of

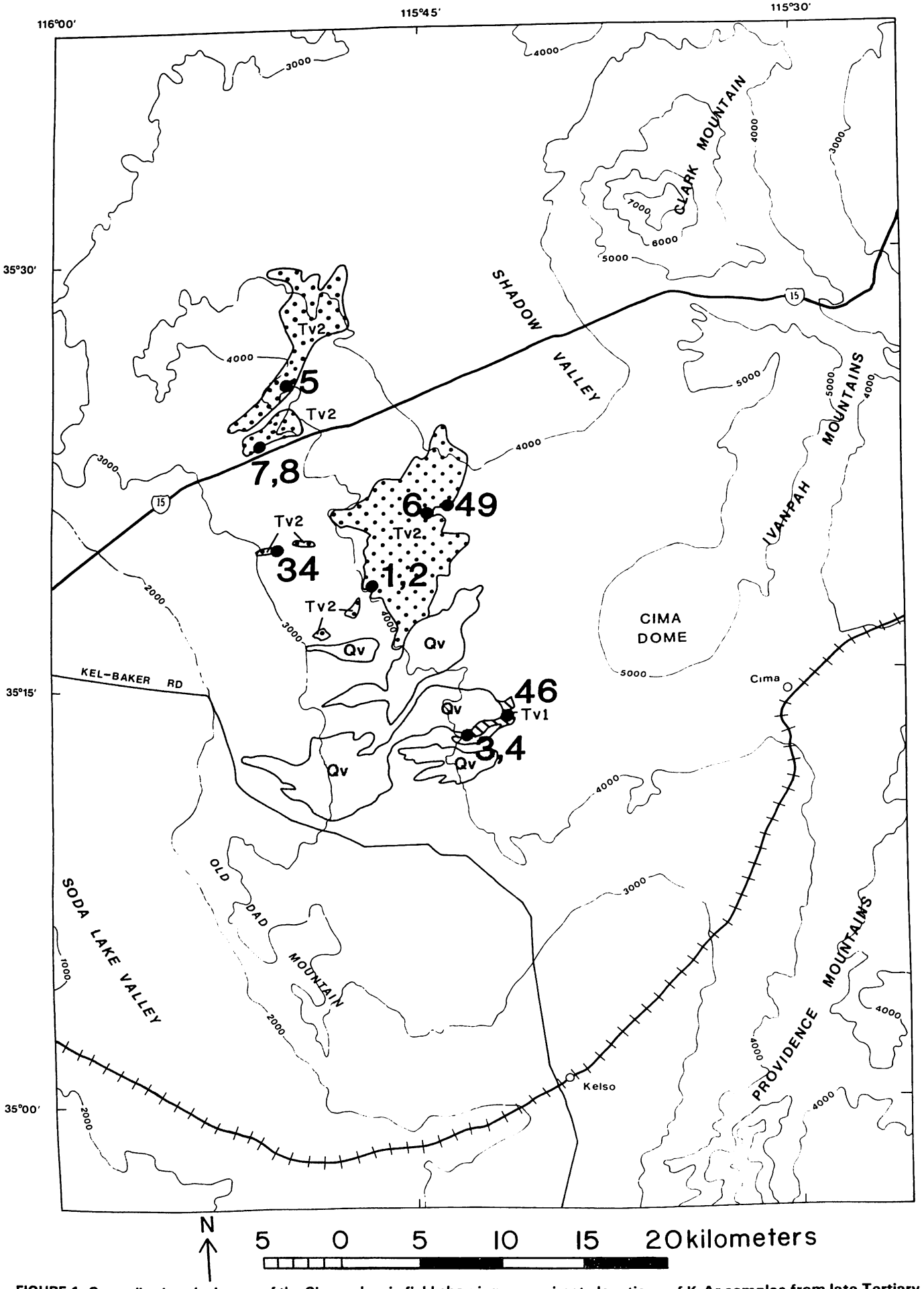

FIGURE 1. Generalized geologic map of the Cima volcanic field showing approximate locations of K-Ar samples from late Tertiary lava flows. Tv_1 = Miocene volcanic rocks; Tv_2 = Pliocene volcanic rocks; Qv = Quaternary volcanic rocks. Numbers correspond with the list of sampling-site location descriptions (see text).

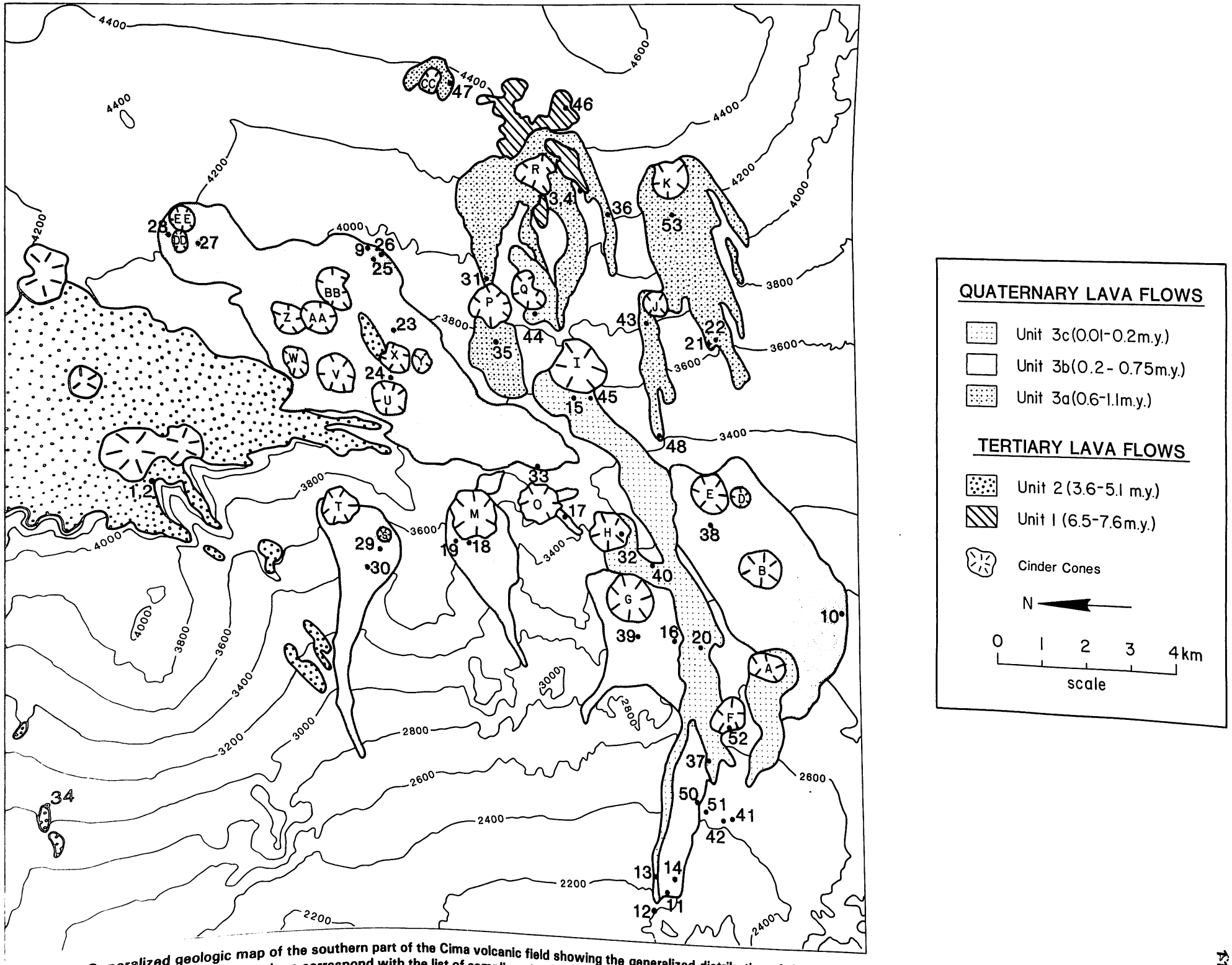

FIGURE 2. Generalized geologic map of the southern part of the Cima volcanic field showing the generalized distribution of the various ages of late Cenozoic volcanic rocks and the approximate locations of K-Ar samples. Numbers correspond with the list of sampling-site location descriptions; letters refer to volcanic vents (see text).

TABLE 1. X-ray fluorescence analyses and CIPW norm calculations for basaltic lava flows from the Cima volcanic field. Oxides are given in weight percent, trace elements are in ppm. FeO* equals FeO_{total}. Results are normalized to 100. X-ray fluorescence analyses are by Joachim Hampel.

	MC1a	MC3	MC5a	MC12	MC20	MC21	MC25	MC29	MC32	MC37	MC43
SiO_2	50.1	50.9	50.9	47.4	48.1	47.1	48.3	47.4	47.1	47.9	47.3
TiO_2	2.5	2.3	2.2	2.4	2.3	2.3	2.4	2.4	2.5	2.5	2.4
Al_2O_3	17.6	17.0	17.6	16.5	16.7	16.0	16.6	16.8	16.1	17.0	16.7
FeO*	10.6	10.0	10.1	9.8	10.0	9.9	9.5	10.2	10.6	10.5	9.3
MnO	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
MgO	3.7	4.6	3.5	7.6	6.2	8.4	7.4	7.4	7.6	6.1	8.2
CaO	8.0	7.8	7.4	9.0	9.1	9.5	8.9	9.1	8.6	8.4	8.8
Na_2O	4.8	4.4	5.0	4.4	4.5	4.1	3.8	4.1	4.5	4.5	4.3
K_2O	1.8	2.1	2.3	2.0	2.1	1.8	2.1	1.8	2.1	2.2	2.1
P_2O_5	0.7	0.7	0.8	0.7	0.8	0.7	0.8	0.6	0.7	0.7	0.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ni	29	72	38	121	88	129	126	105	109	120	120
Rb	33	39	41	42	47	38	39	42	42	45	46
Sr	601	545	641	607	609	555	704	636	636	650	565
Y	37	36	38	29	32	30	26	30	30	33	31
Zr	343	323	394	306	305	283	308	316	316	339	309
Nb	36	40	43	48	45	41	44	45	45	48	45
Ba	270	321	356	376	389	336	426	290	335	365	338
La	32	34	35	38	32	27	38	31	31	39	32
V	197	182	198	245	246	270	220	257	275	219	241
Cr	21	43	42	175	95	244	188	175	139	110	138
Or	10.8	12.2	13.3	11.9	12.3	10.8	12.6	10.6	12.4	12.7	12.5
Ab	33.6	34.7	34.4	18.8	21.4	17.3	23.4	20.5	18.5	22.6	17.9
An	21.1	20.8	18.7	19.0	19.4	20.0	21.8	22.0	17.5	19.8	20.0
Di	11.4	10.6	10.4	16.9	16.8	18.4	13.3	15.4	16.5	13.7	15.3
Ol	9.1	10.8	8.9	13.5	11.4	14.8	14.2	14.1	14.1	12.5	14.6
Mt	3.9	3.7	3.7	3.6	3.7	3.7	3.5	3.8	3.9	3.9	3.5
Il	4.7	4.4	4.2	4.6	4.4	4.3	4.5	4.5	4.8	4.8	4.5
Ap	1.6	1.7	2.0	1.6	1.8	1.5	2.0	1.4	1.7	1.7	1.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

these multiple age determinations indicates that the stated 2σ precision values are accurate assessments of analytical reproducibility.

SAMPLE DESCRIPTIONS

1. *MC1* K-Ar
Basalt (35.3078°N,115.7755°W, 1320 m; lowest flow head of 100–150-m-deep canyon W side of high basalt-capped mesa ~1.0 km WSW of Club Peak, ESE of Granite Spring; Granite Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.954%; $^{40}Ar^*$ = 13.17 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.684. *Comment:* Magnetic polarity not determined.
(whole rock) 3.88 ± 0.09 m.y.

2. *MC1a* K-Ar
Basalt (35.3078°N,115.7755°W, 1350 m; uppermost flow head of 100–150-m-deep canyon W side of high basalt-capped mesa ~1.0 km WSW of Club Peak, ESE of Granite Spring; Granite Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.432%, 1.432%; $^{40}Ar^*$ = 9.602 × 10^{-12} mol/g, 9.516 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.661, 0.662. *Comment:* Magnetic polarity not determined.
(whole rock) 3.86 ± 0.12 m.y.
(whole rock) 3.83 ± 0.12 m.y.

3. *MC2* K-Ar
Basalt (35.2145°N,115.7025°W, 1300 m; head of 80-m-deep canyon 1.3 km SW of vent R and 2.5 km SE of Aikens Quarry; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.655%; $^{40}Ar^*$ = 18.61 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.562. *Comment:* Magnetic polarity not determined.
(whole rock) 6.47 ± 0.18 m.y.

4. *MC2a* K-Ar
Basalt (35.2145°N,115.7025°W, 1250 m; lowest flow at head of 80-m-deep canyon 1.3 km SW of vent R and 2.5 km SE of Aikens Quarry; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.174%; $^{40}Ar^*$ = 15.40 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.628. *Comment:* Magnetic polarity not determined.
(whole rock) 7.55 ± 0.17 m.y.

5. *MC3* K-Ar
Basalt (35.4198°N,115.8409°W, 1235 m; SE margin flow-capped mesa ~0.6 km S of Solomons Knob and 100 m S of jeep road; Solomons Knob 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.637%; $^{40}Ar^*$ = 12.74 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.423. *Comment:* Magnetic polarity not determined.
(whole rock) 4.48 ± 0.15 m.y.

6. *MC4* K-Ar
Basalt (35.3449°N,115.7435°W, 1270 m; N side of canyon, ~0.8 km W of Cow Cove, 2 m above wash at fork in dry wash; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.926%; $^{40}Ar^*$ = 15.93 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.577. *Comment:* Magnetic polarity not determined.
(whole rock) 4.76 ± 0.17 m.y.

7. *MC5* K-Ar
Basalt (35.3891°N,115.8615°W, 1070 m; uppermost flow eroded flow margin on S-facing escarpment of flow-capped mesa, ~0.6 km N of Interstate 15; Solomons Knob 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.906%; $^{40}Ar^*$ = 14.06 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.657. *Comment:* Magnetic polarity not determined.
(whole rock) 4.24 ± 0.17 m.y.

8. *MC5a* K-Ar
Basalt (35.3891°N,115.8615°W, 1070 m; lowermost flow eroded flow margin on S-facing escarpment of flow-capped mesa, ~0.6 km N of Interstate 15; Solomons Knob 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.782%; $^{40}Ar^*$ = 15.86 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.587. *Comment:* Magnetic polarity not determined.
(whole rock) 5.12 ± 0.16 m.y.

9. *MC6* K-Ar
Basalt (35.22598°N,115.7185°W, 1215 m; eroded flow margin W side Black Tank Wash ~250 m W of Aikens Quarry haul road, same flow as sample MC41; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.600%; $^{40}Ar^*$ = 0.918 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.109. *Comment:* Magnetic polarity normal.
(whole rock) 0.33 ± 0.05 m.y.

10. *MC11* K-Ar
Basalt (35.1638°N,115.8065°W, 890 m; eroded flow margin upper flow N side of Willow Wash, ~0.25 km N of Kel-Baker Highway; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 0.893%; $^{40}Ar^*$ = 0.865 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.199. *Comment:* Magnetic polarity normal.
(whole rock) 0.56 ± 0.08 m.y.

11. *MC12* K-Ar
Basalt (35.2040°N,115.8705°W, 680 m; eroded flow margin distal (NW) end of flow complex, ~30 m E of Kel-Baker Highway; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.463%; $^{40}Ar^*$ = 1.465 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.056. *Comment:* Magnetic polarity normal.
(whole rock) 0.58 ± 0.16 m.y.

12. *MC13* K-Ar
Basalt (35.2065°N,115.8735°W, 660 m; partly buried outcrop E bank of Willow Wash, ~100 m W of Kel-Baker Highway; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.605%; $^{40}Ar^*$ = 0.460 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.028. *Comment:* Magnetic polarity normal.
(whole rock) 0.17 ± 0.06 m.y.

13. *MC14* K-Ar
Basalt (35.2035°N,115.8665°N, 690 m; N margin uppermost flow, 410 m E of Kel-Baker Highway; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.758%, 1.758%; $^{40}Ar^*$ = 0.474 × 10^{-12} mol/g, 0.523 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.041, 0.057. *Comment:* Magnetic polarity normal.
(whole rock) 0.16 ± 0.04 m.y.
(whole rock) 0.17 ± 0.04 m.y.

14. *MC16* K-Ar
Basalt (35.2015°N,115.8680°W, 700 m; degraded constructional high on flow surface, ~300 m E of Kel-Baker Highway; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.431%; $^{40}Ar^*$ = 0.771 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.029. *Comment:* Magnetic polarity normal.
(whole rock) 0.32 ± 0.09 m.y.

15. *MC19* K-Ar
Basalt (35.2175°N,115.7522°W, 1095 m; degraded flow levee 0.25 km W of crest of vent I tephra ring, 10 m W of jeep trail, same flow as MC90; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.535%; $^{40}Ar^*$ = 3.412 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.024. *Comment:* Magnetic polarity normal.
(whole rock) 0.13 ± 0.06 m.y.

16. *MC20* K-Ar
Basalt (35.2005°N,115.8095°W, 920 m; eroded distal flow margin, ~1.1 km SW of summit of vent G; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.701%; $^{40}Ar^*$ = 1.375 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.059. *Comment:* Magnetic polarity normal.
(whole rock) 0.46 ± 0.08 m.y.

17. *MC21* K-Ar
Basalt (35.2232°N,115.7808°W, 1080 m; eroded NW flow margin, ~0.67 km SSW of summit of vent O; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.562%; $^{40}Ar^*$ = 1.705 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.146. *Comment:* Magnetic polarity normal.
(whole rock) 0.63 ± 0.11 m.y.

18. *MC24* K-Ar
Basalt (35.2421°N,115.7872°W, 1095 m; degraded constructional high on eroded N flow margin 0.3 km W of summit of NW cone at vent M; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.574%; $^{40}Ar^*$ = 2.055 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.075. *Comment:* Magnetic polarity reversed.
(whole rock) 0.75 ± 0.22 m.y.

19. *MC25* K-Ar
Basalt (35.2450°N,115.7875°W, 1090 m; eroded S flow margin, ~0.3 km N of MC24; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.726%; $^{40}Ar^*$ = 1.168 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.026. *Comment:* Magnetic polarity normal.
(whole rock) 0.39 ± 0.08 m.y.

20. *MC26* K-Ar
Basalt (35.1955°N,115.8088°W, 900 m, outcrop S bank of shallow wash ~50 m E of jeep track and 460 m S of sample 20, Indian Spring 7.5′ quad., San

Bernardino Co., CA). *Analytical data:* K^+ = 1.783%; $^{40}Ar^*$ = 0.187 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.031. *Comment:* Magnetic polarity normal.

(whole rock) 0.06 ± 0.03 m.y.

21. *MC28* K-Ar

Basalt (35.1915°N,115.7372°W, 1110 m; eroded N margin of flow, ~5 m above modern wash and ~1.25 km SW of summit of vent J; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.676%; $^{40}Ar^*$ = 0.972 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.084. *Comment:* Magnetic polarity normal.

(whole rock) 0.33 ± 0.03 m.y.

22. *MC29* K-Ar

Basalt (35.1908°N,115.7381°W, 1125 m; eroded N margin of flow, ~20 m above modern wash and ~1.3 km SW of summit of vent J; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.325%; $^{40}Ar^*$ = 2.272 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.049. *Comment:* Magnetic polarity reversed.

(whole rock) 0.99 ± 0.07 m.y.

23. *MC36* K-Ar

Basalt (35.2592°N,115.7365°W, 1250 m; top of 10-m-high knob near distal edge of flow, ~1.4 km SSW of summit of vent BB; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.351%; $^{40}Ar^*$ = 0.781 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.016. *Comment:* Magnetic polarity normal.

(whole rock) 0.33 ± 0.16 m.y.

24. *MC37* K-Ar

Basalt (35.2570°N,115.7478°W, 1220 m; W bank fluvial channel cut through lava flow, ~450 m E of summit of vent U; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.591%; $^{40}Ar^*$ = 0.694 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.036. *Comment:* Magnetic polarity normal.

(whole rock) 0.25 ± 0.05 m.y.

25. *MC40* K-Ar

Basalt (35.2588°N,115.7185°W, 1220 m; eroded S margin flow ~8 m above flow surface of MC6 and MC41, 160 m W of Black Tank Wash and 1.3 km SE of summit of vent BB; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.517%; $^{40}Ar^*$ = 1.770 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.085. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.67 ± 0.13 m.y.

26. *MC41* K-Ar

Basalt (35.2575°N,115.7172°W, 1210 m; eroded flow margin W side Black Tank Wash, ~240 m W of quarry haul road, same flow as sample MC6; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.600%, 1.600%; $^{40}Ar^*$ = 0.743 × 10^{-12} mol/g, 0.722 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.020, 0.018. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.27 ± 0.10 m.y.
(whole rock) 0.26 ± 0.12 m.y.

27. *MC42* K-Ar

Basalt (35.2932°N,115.7182°W, 1315 m; degraded constructional high ~800 m SW of summit of vent EE, Button Mountain; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.582%; $^{40}Ar^*$ = 0.731 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.030. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.27 ± 0.07 m.y.

28. *MC43* K-Ar

Basalt (35.2998°N,115.7149°W, 1335 m; eroded margin lava pool N flank of vent DD; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.613%; $^{40}Ar^*$ = 0.904 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.118. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.32 ± 0.02 m.y.

29. *MC50* K-Ar

Basalt (35.2606°N,115.7920°W, 1080 m; eroded N flow margin, ~0.7 km W of summit of vent S; Granite Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.402%; $^{40}Ar^*$ = 1.843 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.122. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.70 ± 0.06 m.y.

30. *MC51* K-Ar

Basalt (35.2635°N,115.7965°W, 1050 m; N side shallow wash, ~550 m NW of sample MC50 and 1.1 km W of summit of vent S; Granite Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.530%; $^{40}Ar^*$ = 0.702 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.030. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.27 ± 0.05 m.y.

31. *MC55* K-Ar

Basalt (35.2365°N,115.7228°W, 1215 m; eroded N flow margin ~50 m E of Aikens Quarry haul road; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.590%; $^{40}Ar^*$ = 1.932 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.073. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.70 ± 0.06 m.y.

32. *MC56* K-Ar

Basalt (35.2095°N,115.7845°W, 1050 m; eroded S margin of ponded or rootless lava flow on S flank of vent H; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.524%; $^{40}Ar^*$ = 0.451 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.048. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.17 ± 0.04 m.y.

33. *MC58* K-Ar

Basalt (35.2270°N,115.7685°W, 1075 m; eroded W flow margin, ~15 m above modern wash and 0.6 km E of summit of vent O; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.909%; $^{40}Ar^*$ = 0.515 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.015. *Comment:* Magnetic polarity normal. *Collected by:* John C. Dohrenwend.

(whole rock) 0.16 ± 0.07 m.y.

34. *MC59* K-Ar

Basalt (35.3281°N,115.8495°W, 950 m; E end of elongate butte, ~40 m above adjacent pediment surface and 3.2 km WNW of Granite Spring; Granite

Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.429%; $^{40}Ar^*$ = 9.022 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.616. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 3.64 ± 0.16 m.y.

35. *MC61* K-Ar

Basalt (35.2345°N,115.7385°W, 1170 m; degraded constructional high near distal flow margin, ~0.8 km W of summit of vent P; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.431%; $^{40}Ar^*$ = 1.473 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.036. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 0.59 ± 0.12 m.y.

36. *MC62* K-Ar

Basalt (35.2095°N,115.7061°W, 1300 m; eroded S flow margin, ~8 m above modern pediment surface and 1.9 km SSW of summit of vent R; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.402%; $^{40}Ar^*$ = 2.068 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.295. *Comment:* Magnetic polarity reversed. *Collected by:* John C. Dohrenwend.

(whole rock) 0.85 ± 0.05 m.y.

37. *MC66* K-Ar

Basalt (35.1942°N,115.8385°W, 790 m; N flow margin ~1.2 km NW of summit of vent F; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.396%; $^{40}Ar^*$ = 0.573 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.073. *Comment:* Magnetic polarity indeterminate.

(whole rock) 0.24 ± 0.04 m.y.

38. *MC70* K-Ar

Basalt (35.1905°N,115.7815°W, 1025 m; degraded constructional high on flow surface, 0.7 km W of summit of vent E; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.356%; $^{40}Ar^*$ = 0.833 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.096. *Comment:* Magnetic polarity normal.

(whole rock) 0.35 ± 0.04 m.y.

39. *MC75* K-Ar

Basalt (35.2065°N,115.8115°W, 930 m; outcrop in shallow wash on flow surface, ~0.95 km W of summit of vent G; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.499%; $^{40}Ar^*$ = 0.565 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.065. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 0.22 ± 0.03 m.y.

40. *MC76* K-Ar

Basalt (35.2535°N,115.7932°W, 965 m; SE flow margin along NW side Black Tank Wash, 0.75 km S of summit of vent G; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.364%; $^{40}Ar^*$ = 0.350 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.022. *Comment:* Magnetic polarity indeterminate.

(whole rock) 0.15 ± 0.06 m.y.

41. *MC85* K-Ar

Basalt (35.1885°N,115.8505°W, 749 m; upper flow partly buried in Black Tank Wash near confluence with Willow Wash, ~2 km W of summit of vent F; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.564%; $^{40}Ar^*$ = 0.235 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.014. *Comment:* Magnetic polarity normal. This flow overlies the flow of MC86, and ~0.5 m of alluvial sand and gravel, mostly grus, appears to separate the two flows.

(whole rock) 0.09 ± 0.07 m.y.

42. *MC86* K-Ar

Basalt (35.1895°N,115.8510°W, 751 m; lower flow in Black Tank Wash near confluence with Willow Wash, ~2 km W of summit of vent F; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.538%; $^{40}Ar^*$ = 0.341 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.036. *Comment:* Magnetic polarity normal.

(whole rock) 0.13 ± 0.03 m.y.

43. *MC87* K-Ar

Basalt (35.2025°N,115.7315°W, 1180 m; constructional high on flow surface ~0.5 km WNW of summit of vent J, same flow as sample MC111; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.639%; $^{40}Ar^*$ = 1.437 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.139. *Comment:* Magnetic polarity normal.

(whole rock) 0.50 ± 0.03 m.y.

44. *MC88* K-Ar

Basalt (35.2275°N,115.7315°W, 1170 m; constructional high on surface of flow from vent Q, ~0.7 km W of summit of vent Q; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.301%; $^{40}Ar^*$ = 0.744 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.080. *Comment:* Magnetic polarity normal.

(whole rock) 0.33 ± 0.04 m.y.

45. *MC90* K-Ar

Basalt (35.2159°N,115.7525°W, 1095 m; lava channel levee ~170 m S of MC19 and 50 m W of jeep track, same flow as MC19; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.582%; $^{40}Ar^*$ = 0.383 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.025. *Comment:* Magnetic polarity normal.

(whole rock) 0.14 ± 0.04 m.y.

46. *MC91c* K-Ar

Basalt (35.2191°N,115.6845°W, 1445 m; uppermost flow on 60-m-high E-W-trending ridge ~1.3 km ESE of summit of vent R; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.674%; $^{40}Ar^*$ = 20.11 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.648. *Comment:* Magnetic polarity not determined.

(whole rock) 6.92 ± 0.32 m.y.

47. *MC100* K-Ar

Basalt (35.2438°N,115.6745°W, 1343 m; eroded S flow margin, 500 m S of summit of vent CC and 100 m N of jeep track; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.257%; $^{40}Ar^*$ = 2.387 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.221. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 1.09 ± 0.08 m.y.

48. *MC111*

Basalt (35.2012°N,115.7615°W, 1040 m; distal K-Ar

flow margin ~3 km WNW of summit of vent J, same flow as sample MC87; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.558%, 1.558%; $^{40}Ar^*$ = 1.273 × 10^{-12} mol/g, 1.217 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.131, 0.157. *Comment:* Magnetic polarity normal.

(whole rock) 0.47 ± 0.05 m.y.
(whole rock) 0.45 ± 0.04 m.y.

49. *MC115* K-Ar
Basalt (35.3475°N,115.7305°W, 1260 m; eroded S margin of flow that caps the 15–20-m-high ridge on N side of Cow Cove; Cow Cove 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.202%; $^{40}Ar^*$ = 6.812 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.395. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 3.27 ± 0.13 m.y.

50. *MC121* K-Ar
Basalt (35.1949°N,115.8462°W, 760 m; eroded S flow margin ~2.3 km E of Kel-Baker Highway and 1.7 km WNW of summit of vent F; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.567%; $^{40}Ar^*$ = 0.416 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.037. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 0.15 ± 0.04 m.y.

51. *MC122* K-Ar
Basalt (35.1939°N,115.8479°W, 755 m; 1.5-m-diameter basaltic boulder on deeply dissected middle Pliestocene fan surface, ~200 m SW of sample MC121; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.615%; $^{40}Ar^*$ = 1.129 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.042. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 0.40 ± 0.24 m.y.

52. *MC123* K-Ar
Basalt (35.1891°N,115.8325°W, 810 m; constructional high of flow surface on flank of vent F, ~0.5 km W of summit of vent; Indian Spring 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.635%; $^{40}Ar^*$ = 1.452 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.138. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 0.51 ± 0.04 m.y.

53. *MC124* K-Ar
Basalt (35.1980°N,115.7049°W, 1322 m; constructional high on flow surface, ~550 m W of summit of vent K; Marl Mountains 7.5′ quad., San Bernardino Co., CA). *Analytical data:* K^+ = 1.307%; $^{40}Ar^*$ = 2.578 × 10^{-12} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 0.127. *Comment:* Magnetic polarity not determined. *Collected by:* John C. Dohrenwend.

(whole rock) 1.14 ± 0.12 m.y.

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