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W.M. Phillips, M.A. Korosec, H.W. Schasse, J.L. Anderson, and R.A. Hagen

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K-Ar AGES OF VOLCANIC ROCKS IN SOUTHWEST WASHINGTON

WILLIAM M. PHILLIPS
MICHAEL A. KOROSEC
HENRY W. SCHASSE
Division of Geology and Earth Resources, Department of Natural Resources, Olympia, WA 98504

JAMES L. ANDERSON
Center for Earth Sciences, University of Southern California, Los Angeles, CA 90007

RANDY A. HAGEN
Department of Geology, University of Oregon, Eugene, OR 97403

The K-Ar age determinations reported here support geologic mapping and compilations undertaken for production of the southwest quadrant of the Washington state geologic map (Walsh and others, in press). Age assignments are basically from the COSUNA time scale (Salvador, 1985); the age of the Eocene-Oligocene boundary is that of Montanari and others (1985) and Prothero and Armentrout (1985). Geochemical classification of volcanic rocks follows Zanettin (1984). Additional K-Ar ages for rocks in southwest Washington are presented in Evarts and others (in preparation), Vance and others (in press), Frizzell and others (1985), Hammond (1980), and Laursen and Hammond (1974, 1979).

GEOLOGIC BACKGROUND

Sampled rocks were collected primarily from the southern Cascade Mountains of Washington (fig. 1). In this region, the Cascades consist dominantly of upper Eocene through lower Miocene, pyroxene-phyric andesitic to dacitic lava flows, tuffs, and volcaniclastic sedimentary rocks. Quartz-phyric dacitic tuffs of late Oligocene through early Miocene age are locally present. Flows of the middle to upper Miocene Columbia River Basalt Group, which originated in southeast Washington and adjacent Idaho and Oregon, form important stratigraphic markers where present. The volcanic rocks have been folded about northwest- to north-trending axes and intruded by numerous Miocene dioritic to granodioritic plutons. Pliocene hypabyssal, possibly subvolcanic, intrusive activity is present in the Columbia River Gorge.

Quaternary volcanic activity has produced imposing andesitic to dacitic stratovolcanoes (Mount Rainier, Mount Saint Helens, and Mount Adams) in this part of the Cascade Range; a Pliocene to Quaternary polygenetic volcanic complex is also present at Goat Rocks (fig. 1). Quaternary basaltic lava-flow fields characterized by shield volcanoes, cinder cones, and fissure systems are present at Indian Heaven. The Simcoe Mountains area contains Pliocene through early Pleistocene back-arc volcanic rocks characterized by voluminous olivine basalt flows with lesser amounts of basaltic andesite and rhyolite.

Most of our K-Ar age determinations are from the upper Eocene to lower Miocene volcanic section. These strata, which range from 2 to more than 5 km in aggregate thickness, commonly lack areally extensive marker beds or fossiliferous horizons and hence are difficult to correlate regionally. The K-Ar age determinations have served as a major factor in the division of the Cascade volcanic section into time-lithology units for the 1:250,000-scale state geologic map.

PROCEDURES

Rock alteration resulting from deep burial, contact metamorphism near intrusives, or hydrothermal systems is widespread in the southern Washington Cascades and complicates the interpretation of K-Ar ages. Because of alteration and the typical presence of glass or the products of devitrification of glass in the groundmass of hypocrystalline rocks, all our samples required treatment with dilute HF and/or HNO_3.

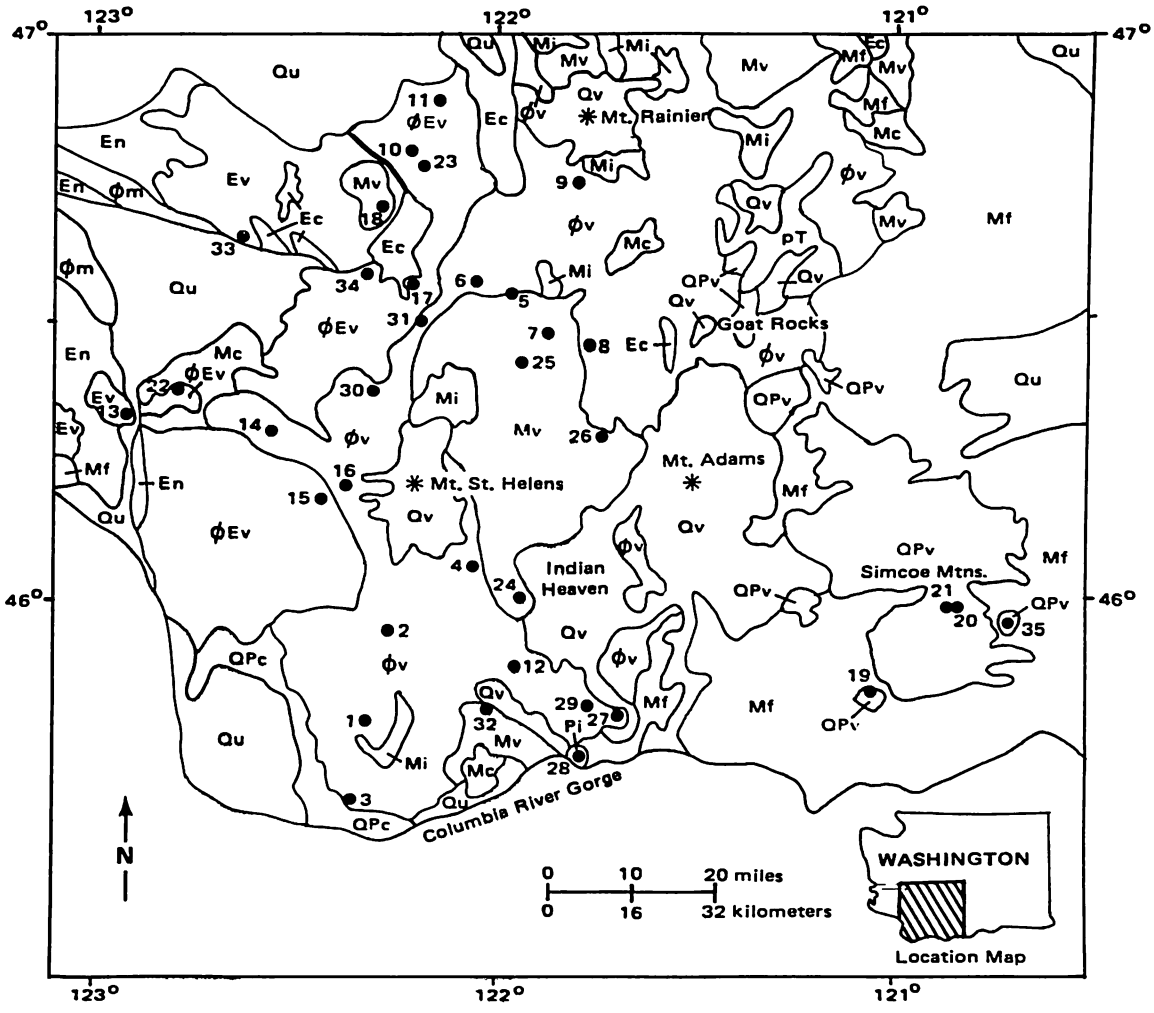
Major and minor element concentrations were determined for all our samples except sample 35 by x-ray fluorescence. These data are presented in table 1. Volcanic rocks were named on the basis of the geochemical data following the classification of Zanettin (1984).

Samples were processed for K-Ar determinations by one of three laboratories. Samples 1 through 18 and sample 35 were run by Krueger Enterprises, Inc., Geochron Laboratories Division. For these samples, the whole rock was crushed and sieved through 80 and 200-mesh-size (0.180–0.075 mm) sieves. Material between 80 and 200 mesh was treated with dilute HF and HNO_3 to remove alteration products and/or glass. Argon measurements were made by isotope dilution, and argon analyses were performed on a MS-10-type mass spectrometer. Potassium was measured by flame photometry. Analytical uncertainties for the calculated ages were based on both the estimated standard deviation of precision for the sample (Cox and Dalrymple, 1967) and extensive replication experiments at the laboratory (Hal Krueger, personal communication, 1986).

Samples 19 through 30 were processed at the College of Oceanography, Oregon State University under the direction of Kristine R. McElwee. Whole-rock samples were crushed and sieved through 10 and 30-mesh-size (2.00–0.6 mm) sieves. Material between 10 and 30 mesh was ultrasonically cleaned in distilled water, then treated with dilute HF and HNO_3 to remove alteration products and/or volcanic glass. Sample 22 is a plagioclase separate prepared by removing the non-feldspar components of the rock with standard magnetic and heavy-liquid methods. The plagioclase was then washed in dilute HF for 10 minutes, followed by ultrasonic cleaning in distilled water. Argon measurements were made by isotope dilution, and argon analyses were performed by an AEI MS-10S mass spectrometer. Potassium concentrations were determined by atomic absorption. Analytical uncertainties for the calculated ages were based on the estimated standard deviation of precision (Cox and Dalrymple, 1967).

Teledyne Isotopes processed samples 31 through 34. Whole-rock samples were crushed and sieved through 20 and 40 mesh-size (0.85–0.425 mm) sieves. Material between 20 and 40 mesh was treated with dilute HF to remove alteration products and/or volcanic glass. Argon measurements were made by isotope dilution, and argon analyses were performed on a MS-10-type mass spectrometer. Potassium concentrations were determined by flame photometry. Analytical uncertainties for the calculated ages are based upon the estimated standard deviation of precision (Cox and Dalrymple, 1967).

Constants used for all of the calculations are $\lambda_\beta = 4.962 \times 10^{-10}$ yr^{-1}, $\lambda_\epsilon = 0.581 \times 10^{-10}$ yr^{-1}, and $^{40}K/K_{total} = 1.167 \times 10^{-4}$ atom percent (Steiger and Jager, 1977).



EXPLANATION

Qu	Quaternary deposits, undifferentiated
Qv	Quaternary andesitic to dacitic pyroclastic flows, basalt to basaltic andesite lava flows, and volcaniclastic sediments
QPc	Quaternary-Pliocene continental sedimentary rocks
QPv	Quaternary-Pliocene basaltic to andesitic lava flows, dacite and rhyolite domes, and tuffs
Pi	Pliocene intrusive rocks
Mf	Middle to upper Miocene Columbia River Basalt Group flood basalt lava flows and interbedded continental sedimentary rocks
Mc	Lower to middle Miocene continental sedimentary rocks
Mv	Lower to middle Miocene andesite and basaltic andesite lava flows, andesitic to dacitic tuffs, dacite plugs and flows, and volcaniclastic sedimentary rocks
Mi	Miocene granitic to dioritic intrusive rocks
φm	Oligocene tuffaceous marine sedimentary rocks
φv	Oligocene andesite and basaltic andesite lava flows, tuffs, and volcaniclastic sedimentary rocks
φEv	Oligocene-Eocene basaltic-andesite and andesite lava flows, tuffs, and volcaniclastic sedimentary rocks
Ec	Eocene continental sedimentary rocks
En	Middle to upper Eocene near-shore marine sedimentary rocks
Ev	Middle to upper Eocene basalt and basaltic andesite lava flows
pT	Pre-Tertiary sedimentary and igneous rocks
●15	K-Ar sample locality

FIGURE 1. Generalized geologic map of southwestern Washington showing location of K-Ar age determination samples (modified from Walsh and others, in press).

TABLE 1. Geochemical data for K-Ar samples.

Sample	ID	SiO_2	AL_2O_3	TiO_2	FeO*	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5
1	KK0904855	54.51	15.89	1.64	11.69	0.18	8.68	4.09	0.24	2.92	0.16
2	BP0816851	52.13	17.39	1.08	9.70	0.17	10.44	5.92	0.30	2.75	0.14
3	MM0903851	52.99	15.35	1.92	13.10	0.21	8.60	4.34	0.46	2.81	0.23
4	MK8586	53.18	18.27	1.54	9.76	0.16	8.94	4.39	0.61	2.87	0.25
5	MK85817	58.75	15.81	1.09	8.21	0.16	8.20	4.20	0.40	3.00	0.16
6	MK85814	59.76	18.52	1.05	7.13	0.14	7.13	2.07	0.55	3.44	0.20
7	MK8578	60.50	16.75	1.25	8.29	0.14	6.73	2.27	1.09	2.80	0.20
8	MK98415	56.44	17.02	1.27	8.65	0.13	8.72	4.23	0.36	3.00	0.21
9	CC0827851	52.04	16.76	1.27	9.65	0.17	10.96	5.56	0.67	2.69	0.24
10	TW061985D	64.00	17.02	1.03	5.40	0.10	5.15	1.72	2.27	2.94	0.35
11	CC0712852	66.27	13.86	0.84	5.28	0.11	5.02	2.54	2.65	3.14	0.30
12	MK8597	52.79	17.06	2.13	10.98	0.18	8.92	4.28	0.85	2.51	0.31
13	BP0604851	50.63	14.03	3.80	13.34	0.20	9.36	4.78	0.49	2.86	0.51
14	MK8589	61.04	16.22	1.14	7.25	0.11	6.43	3.32	1.36	2.93	0.20
15	BP0814851	55.99	16.51	1.58	9.25	0.15	8.45	4.08	0.50	3.17	0.31
16	BP0814856	53.62	16.92	1.08	9.24	0.14	9.53	6.47	0.24	2.58	0.16
17	HS0515852	62.62	15.84	1.37	7.80	0.15	4.69	1.85	1.65	3.56	0.49
18	HSRH14623	59.96	17.82	0.95	7.18	0.13	6.95	3.16	0.50	3.15	0.19
19	JA84057	51.02	15.60	2.91	12.24	0.16	8.43	5.60	0.92	2.66	0.46
20	JA84015	55.16	16.93	1.99	9.16	0.13	7.61	4.43	1.44	2.83	0.32
21	JA84017	77.36	12.37	0.11	1.43	0.01	0.04	0.00	4.67	3.98	0.03
22	BP1004842	59.32	16.24	1.12	7.55	0.14	6.96	3.63	1.41	3.43	0.22
23	HS0612851	63.33	16.70	0.93	5.64	0.10	6.15	2.66	1.22	3.09	0.18
24	MK85546	57.21	18.58	1.09	8.03	0.23	7.95	2.99	0.53	3.20	0.19
25	MK85635	68.04	14.79	0.92	5.50	0.11	3.74	1.07	2.41	3.20	0.22
26	MK85627	57.37	19.19	1.12	7.56	0.14	7.75	2.29	1.05	3.26	0.25
27	MK85523	65.97	17.43	0.61	4.19	0.08	5.57	1.71	0.95	3.32	0.16
28	MK8551	67.35	17.08	0.49	3.87	0.08	4.95	1.48	0.92	3.62	0.16
29	MK88412	53.20	17.93	1.45	9.16	0.16	9.81	4.19	0.56	3.28	0.25
30	BP0619851	55.25	16.14	1.06	8.32	0.15	9.16	6.45	0.86	2.44	0.18
31	BP0516851	54.10	17.64	1.51	9.04	0.16	9.27	4.62	0.42	2.97	0.27
32	MM0904851	53.33	16.55	2.31	11.58	0.18	8.08	4.25	0.76	2.66	0.30
33	HS0116853	56.06	16.88	1.43	9.97	0.15	7.96	3.61	0.47	3.24	0.22
34	HS0117851A	57.52	17.57	1.29	7.79	0.12	7.81	3.48	0.90	3.21	0.31

Analyses by XRF, Department of Geology, Washington State University.
All analyses normalized to 100% on a volatile-free basis.
FeO* = Total iron as FeO.

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SAMPLE DESCRIPTIONS

1. *KK0904855* K-Ar
Basaltic-andesite lava flow, Øv (45°46'58"N, 122°17'25"W; Squaw Butte, Clark Co., WA). Aphyric to microphyric; holocrystalline and trachytic; plagioclase, clinopyroxene, and opaque minerals. *Analytical data:* K_2O = 0.346%, K_2O = 0.342%; $^{40}Ar^*$ = 1.475 × 10^{-11} moles/gm, $^{40}Ar^*$ = 1.330 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 22.4%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 13.1%.
(whole rock) 28.1 ± 2.7 m.y.

2. *BP0816851* K-Ar
Pyroxene basalt lava flow or sill, Øv (45°56'00"N, 122°14'41"W; Canyon Creek, Clark Co., WA). Porphyritic with sparse phenocrysts of plagioclase and clinopyroxene; plagioclase is broken and partially replaced by a zeolite; holocrystalline groundmass is trachytic and fine-grained with intergranular microlites of elongate plagioclase, clinopyroxene, and opaque minerals. *Analytical data:* K_2O = 0.427%, K_2O = 0.424%; $^{40}Ar^*$ = 1.65 × 10^{-11} moles/gm, $^{40}Ar^*$ = 1.63 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 39.5%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 35.8%.
(whole rock) 26.6 ± 2.3 m.y.

3. *MM0903851* K-Ar
Basaltic-andesite lava flow, Øv (45°37'31"N, 122°19'35"W; Washougal River valley, Clark Co., WA). Porphyritic with scattered, medium-grained phenocrysts of plagioclase and opaque minerals; holocrystalline, trachytic groundmass with opaque minerals, plagioclase, clinopyroxene, and chlorite. *Analytical data:* K_2O = 0.605%, K_2O = 0.601%; $^{40}Ar^*$ = 2.308 × 10^{-11} moles/gm, $^{40}Ar^*$ = 2.563 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 32.9%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 20.1%.
(whole rock) 27.9 ± 1.9 m.y.

4. *MK8586* K-Ar
Pyroxene basaltic andesite lava flow, Øv (46°02'30"N, 122°02'03"W; SE shore of Swift Reservoir, Skamania Co., WA). Porphyritic with coarse-grained phenocrysts of clinopyroxene and

plagioclase; inclusions of hypersthene-bearing phaneritic rock; holocrystalline, very fine-grained, intergranular groundmass of opaque minerals, plagioclase, clinopyroxene, and patches of chloritic alteration. *Analytical data:* K_2O = 0.756%, K_2O = 0.729%; $^{40}Ar^*$ = 3.073 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.063 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 54.3%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 56.0%.

(whole rock) 28.5 ± 1.8 m.y.

5. *MK85817* K-Ar
Pyroxene andesite lava flow, Mv (46°32'11"N, 121°57'36"W; N of Randle, Lewis Co., WA). Porphyritic with abundant phenocrysts of plagioclase and clinopyroxene; hypocrystalline groundmass with intersertal plagioclase, clinopyroxene, opaque minerals, and dark brown glass. *Analytical data:* K_2O = 0.493%, K_2O = 0.482%; $^{40}Ar^*$ = 1.085 × 10^{-11} moles/gm, $^{40}Ar^*$ = 1.18 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 15.0%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 17.6%.

(whole rock) 16.1 ± 1.8 m.y.

6. *MK85814* K-Ar
Two-pyroxene andesite lava flow, Øv (46°33'30"N, 122°02'27"W; Kiona Creek, Lewis Co., WA). Porphyritic with coarse- to medium-grained phenocrysts of zoned plagioclase, clinopyroxene, and hypersthene; hypocrystalline, intersertal groundmass with brownish alteration products, opaque minerals, and plagioclase. *Analytical data:* K_2O = 0.695%, K_2O = 0.687%; $^{40}Ar^*$ = 2.738 × 10^{-11} moles/gm, $^{40}Ar^*$ = 2.665 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 44.1%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 45.9%.

(whole rock) 27.0 ± 1.8 m.y.

7. *MK8578* K-Ar
Andesite flow(?) flow, Mv (46°28'33"N, 121°51'37"W; Lone Tree Mountain, Lewis Co., WA). Porphyritic with abundant, medium-grained plagioclase, clinopyroxene, and minor hypersthene; holocrystalline, subhedral-granular groundmass of plagioclase, opaque minerals, and fuzzy patches of greenish birefringent mineral. *Analytical data:* K_2O = 1.22%, K_2O = 1.148%; $^{40}Ar^*$ = 3.488 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.76 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 54.8%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 63.8%.

(whole rock) 22.1 ± 1.3 m.y.

8. *MK98415* K-Ar
Basaltic-andesite, Øv (46°02'30"N,121°44'40"W; Bishop Mountain, Lewis Co., WA). Porphyritic with abundant, medium- to coarse-grained phenocrysts of plagioclase, clinopyroxene, trace hypersthene, and patches of green, pleochroic chlorite; holocrystalline, very altered groundmass of euhedral opaque minerals, microcrystalline quartz, plagioclase, and brown or green chlorite. *Analytical data:* K_2O = 0.496%, K_2O = 0.455%; $^{40}Ar^*$ = 2.238 × 10^{-11} moles/gm, $^{40}Ar^*$ = 1.773 × 10^{-11} moles/gm, $^{40}Ar^*$ = 2.22 × 10^{-11} moles/gm, $^{40}Ar^*/^{40}Ar$ × 100 = 13.7%; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 29.7%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 22.7%.

(whole rock) 30.1 ± 2.2 m.y.

9. *CC0827851* K-Ar
Olivine(?) basalt lava flow, Mv (46°43'40"N, 121°47'43"W; Lookout Mountain, Lewis Co., WA). Porphyritic with coarse-grained phenocrysts of inclusion-rich plagioclase, altered olivine(?), and clinopyroxene; holocrystalline, fine-grained groundmass with intergranular plagioclase, clinopyroxene, opaque minerals, and fuzzy patches of alteration products. *Analytical data:* K_2O = 0.824%, K_2O = 7.792%; $^{40}Ar^*$ = 2.250 × 10^{-11} moles/gm, $^{40}Ar^*$ = 2.205 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 40.5%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 59.9%.

(whole rock) 19.1 ± 1.4 m.y.

10. *TW061985D* K-Ar
Andesite flow or sill, ØEv (46°45'53"N, 122°11'09"W; NW of Elbe, Pierce Co., WA). Porphyritic, with abundant medium-grained phenocrysts of plagioclase, equant opaque minerals, hypersthene, and clinopyroxene; plagioclase is zoned with inclusions of an opaque mineral; groundmass is hypocrystalline and trachytic with plagioclase, opaque minerals, brown glass, and zeolites. *Analytical data:* K_2O = 2.499%, K_2O = 2.628%; $^{40}Ar^*$ = 11.93 × 10^{-11} moles/gm, $^{40}Ar^*$ = 12.42 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 71.1%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 59.3%.

(whole rock) 32.7 ± 1.5 m.y.

11. *CC0712852* K-Ar
Dacite flow, ØEv (46°53'00"N,122°08'10"W; Lynch Creek area, Pierce Co., WA). Porphyritic with medium-grained phenocrysts of hypersthene, plagioclase, and clinopyroxene; plagioclase is fractured with birefringent, reddish mineral along cracks; holocrystalline, intergranular and trachytic groundmass of plagioclase, clinopyroxene, opaque minerals, and zeolites. *Analytical data:* K_2O = 2.768%, K_2O = 2.641%; $^{40}Ar^*$ = 14.07 × 10^{-11} moles/gm, $^{40}Ar^*$ = 13.83 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 82.6%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 82.1%.

(whole rock) 35.5 ± 1.6 m.y.

12. *MK8597* K-Ar
Clinopyroxene basaltic-andesite lava flow, Mv (45°51'45"N,121°55'25"W; S of Big Butte, Skamania Co., WA). Porphyritic to seriate with plagioclase, clinopyroxene, and opaque mineral phenocrysts; plagioclase is fractured with opaque and birefringent minerals along fractures; groundmass is hypocrystalline with opaque minerals, plagioclase, clinopyroxene, and a small amount of inclusion-rich brown glass. *Analytical data:* K_2O = 1.158%, K_2O = 1.177%; $^{40}Ar^*$ = 3.508 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.535 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 53.8%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 53.5%.

(whole rock) 20.8 ± 1.2 m.y.

13. *BP0604851* K-Ar
Basalt lava flow, Ev (46°19'10"N,122°54'34"W; Toutle River bridge, Cowlitz Co., WA). Porphyritic with rare, medium-grained plagioclase and clots of green, isotopic material; fine-grained, holocrystalline, euhedral-granular groundmass of plagioclase, opaque minerals, clinopyroxene, and calcite. *Analytical data:* K_2O = 0.643%, K_2O = 0.671%; $^{40}Ar^*$ = 3.643 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.485 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 46.6%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 44.1%.

(whole rock) 37.3 ± 2.2 m.y.

14. *MK8589* K-Ar
Andesite lava flow, Øv (46°17'21"N,122°33'11"W; Signal Peak, Cowlitz Co., WA). Porphyritic with abundant, medium-grained hypersthene, plagioclase and clinopyroxene phenocrysts; hypocrystalline groundmass of opaque minerals and greenish patches of birefringent mineral and euhedral zelites (devitrified glass?). *Analytical data:* K_2O = 1.324%, K_2O = 1.329%; $^{40}Ar^*$ = 6.195 × 10^{-11} moles/gm, $^{40}Ar^*$ = 6.845 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 65.1%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 70.1%.
(whole rock) 33.9 ± 1.7 m.y.

15. *BP0814851* K-Ar
Two-pyroxene basaltic-andesite lava flow, ØEv (46°10'17"N,122°25'00"W; quarry W of Big Bull Mountain, Cowlitz Co., WA). Porphyritic with phenocrysts of plagioclase, hypersthene, and clinopyroxene; hypocrystalline groundmass with trachytic, intersertal texture composed of dark brown glass, tabular plagioclase, and equant clinopyroxene. *Analytical data:* K_2O = 0.646%, K_2O = 0.648%; $^{40}Ar^*$ = 3.050 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.505 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.690 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 49.3%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 23.1%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 50.6%.
(whole rock) 36.3 ± 2.2 m.y.

16. *BP0814856* K-Ar
Pyroxene basaltic-andesite lava flow, Øv (46°11'36"N, 122°21'12"W; NE of Big Bull Mountain, Cowlitz Co., WA). Sparsely porphyritic with phenocrysts of plagioclase and clinopyroxene; hypocrystalline groundmass with intersertal, trachytic texture; composed of dark brown glass, skeletal opaque minerals, plagioclase, clinopyroxene, and patches or clumps of clay and opaque minerals. *Analytical data:* K_2O = 0.380%, K_2O = 0.380%; $^{40}Ar^*$ = 1.740 × 10^{-11} moles/gm, $^{40}Ar^*$ = 1.883 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 29.7%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 47.7%.
(whole rock) 32.9 ± 2.6 m.y.

17. *HS0515852* K-Ar
Andesite lava flow, ØEv (46°33'28"N, 122°13'35"W; Minnie Creek area, Lewis Co., WA). Porphyritic, with abundant fine-grained phenocrysts of plagioclase, opaque minerals, and clinopyroxene; hypocrystalline, trachytic groundmass with opaque minerals, sparse plagioclase microlites, dark brown glass, and weakly birefringent, greenish-gray material. *Analytical data:* K_2O = 1.928%, K_2O = 1.987%; $^{40}Ar^*$ = 10.10 × 10^{-11} moles/gm, $^{40}Ar^*$ = 10.26 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 50.6%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 77.4%.
(whole rock) 35.8 ± 1.7 m.y.

18. *HSRH14623* K-Ar
Andesite lava flow Mv (46°33'22"N,122°16'56"W; Hiawatha Creek area, Lewis Co., WA). Porphyritic with abundant, medium-grained phenocrysts of plagioclase, hypersthene, opaque minerals, clinopyroxene, and anhedral clots of chlorite; hypocrystalline, trachytic groundmass of plagioclase, opaques, and brown glass. The age determination does not fit readily the regional stratigraphic framework and may be too young. *Analytical data:* K_2O = 0.668%, K_2O = 0.670%; $^{40}Ar^*$ = 2.222 × 10^{-11} moles/gm, $^{40}Ar^*$ = 2.270 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 16.0%, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 17.3%.
(whole rock) 23.2 ± 1.7 m.y.

19. *JA84057* K-Ar
Olivine basalt lava flow, QPv (45°50'05"N, 121°03'47"W; Klickitat River Canyon, Klickitat Co., WA). Olivine and plagioclase phenocrysts with hypocrystalline, intersertal groundmass of plagioclase, olivine(?), and dark brown glass. *Analytical data:* K_2O = 0.963%; $^{40}Ar^*$ = 3.999 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 67.1%.
(whole rock) 2.88 ± 0.05 m.y.

20. *JA84015* K-Ar
Olivine basaltic andesite flow or sill, QPv (45°49'56"N, 120°58'42"W; Indian Rock, Klickitat Co., WA). Porphyritic to seriate, olivine(?) and plagioclase phenocrysts; holocrystalline, fine-grained groundmass of clinopyroxene, plagioclase, olivine, and opaques; unaltered. *Analytical data:* K_2O = 1.542%; $^{40}Ar^*$ = 0.9374 × 10^{-11} moles/gm, $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 61.7%.
(whole rock) 4.22 ± 0.05 m.y.

21. *JA84017* K-Ar
Biotite rhyolite flow, QPv (45°58'47"N, 120°50'47"W; Indian Rock, Klickitat Co., WA). Plagioclase-biotite-phyric with microcrystalline groundmass of quartz, plagioclase, and hornblende(?). *Analytical data:* K_2O = 4.266%; $^{40}Ar^*$ = 2.496 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 84.5%.
(whole rock) 4.06 ± 0.05 m.y.

22. *BP1004842* K-Ar
Two-pyroxene andesite lava flow, ØEv (46°21'03"N, 122°48'42"W; Hollywood Gorge of Toutle River, Cowlitz Co., WA). Porphyritic with abundant, coarse- to medium-grained phenocrysts of plagioclase, clinopyroxene, and hypersthene; hypocrystalline groundmass of intersertal brown glass, plagioclase, opaque minerals, and clinopyroxene. *Analytical data:* K_2O = 0.243%; $^{40}Ar^*$ = 1.219 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 63.2%.
(plagioclase) 34.5 ± 0.5 m.y.

23. *HS0612851* K-Ar
Two-pyroxene andesite flow or sill, Mv (46°45'53"N, 122°11'09"W; quarry E of Elbe, Thurston Co., WA). Porphyritic with phenocrysts of plagioclase, clinopyroxene, and hypersthene; hypocrystalline groundmass of intersertal plagioclase and clinopyroxene microlites, opaque minerals, and brown glass. *Analytical data:* K_2O = 1.193%; $^{40}Ar^*$ = 3.576 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 43.7%.
(whole rock) 20.7 ± 0.3 m.y.

24. *MK85546* K-Ar
Two-pyroxene andesite lava flow, Mv (46°00'10"N, 121°53'20"W; SW of McClellan Meadows, Skamania Co., WA). Glomeroporphyritic with phenocrysts of plagioclase, clinopyroxene, hypersthene, and opaque minerals; hypocrystalline groundmass of yellow to green birefringent material and clay minerals (altered glass?), plagioclase, opaque minerals, and clinopyroxene. *Analytical data:* K_2O = 0.427%; $^{40}Ar^*$ = 1.229 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar$ × 100 = 47.9%.
(whole rock) 19.9 ± 0.4 m.y.

25. *MK85635* K-Ar
Pyroxene dacite lava flow, Mv (46°25'25"N, 121°55'13"W; NE of Iron Creek Butte, Lewis Co., WA). Porphyritic and glomeroporphyritic with plagioclase, clinopyroxene, and opaque mineral phenocrysts; hypocrystalline groundmass of plagioclase microlites and brown glass. *Analytical data:* K_2O = 2.214%; $^{40}Ar^*$ = 5.014 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 46.7%.
(whole rock) 15.7 ± 0.2 m.y.

26. *MK85627* K-Ar
Pyroxene andesite, Mv (46°15'05"N,121°41'15"W; NW of Table Mountain, Skamania Co., WA). Porphyritic with phenocrysts of plagioclase, clinopyroxene, and possibly hypersthene; holocrystalline, intergranular groundmass with chloritic alteration. *Analytical data:* K_2O = 1.088%; $^{40}Ar^*$ = 4.023 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 72.2%.
(whole rock) 25.5 ± 0.4 m.y.

27. *MK85523* K-Ar
Hornblende diorite porphyry stock, Pi (45°47'00"N, 121°40'25"W; Hauk Butte, Skamania Co., WA). Phaneritic; fine-grained, slightly porphyritic with subhedral granular texture; consists of zoned plagioclase, green hornblende, opaque minerals. *Analytical data:* K_2O = 0.964%; $^{40}Ar^*$ = 6.689 × 10^{-12} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 62.3%.
(whole rock) 4.8 ± 0.1 m.y.

28. *MK8551* K-Ar
Hypersthene-biotite-quartz diorite porphyry plug, Pi (45°43'07"N,121°45'35"W; Wind Mountain, Skamania Co., WA). Phaneritic; porphyritic with phenocrysts of zoned and twinned plagioclase and hypersthene altered to biotite; subhedral granular to anhedral granular, fine-grained groundmass with acicular hornblende and anhedral quartz. *Analytical data:* K_2O = 0.994%; $^{40}Ar^*$ = 7.083 × 10^{-12} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 46.6%.
(whole rock) 4.9 ± 0.01 m.y.

29. *MK8555* K-Ar
Pyroxene basaltic andesite flow, Mv (45°47'35"N, 121°43'55"W; NW of headwaters of Lost Creek, Skamania Co., WA). Porphyritic with abundant phenocrysts of plagioclase, clinopyroxene, and altered olivine(?); hypocrystalline, trachytic groundmass of plagioclase, clinopyroxene, opaque minerals, and glass. *Analytical data:* K_2O = 0.648%; $^{40}Ar^*$ = 1.212 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 34.7%.
(whole rock) 12.9 ± 0.3 m.y.

30. *BP0619851* K-Ar
Clinopyroxene basaltic andesite lava flow, Øv (46°21'44"N,122°17'31"W; tributary of Schultz Creek, Skamania Co., WA). Porphyritic with sparse plagioclase, clinopyroxene and altered olivine(?) phenocrysts; holocrystalline, intergranular groundmass of plagioclase, clinopyroxene, opaque minerals, and chloritic alteration products; K-Ar age appears to be too old in terms of regional stratigraphic framework. *Analytical data:* K_2O = 0.989%; $^{40}Ar^*$ = 5.13 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 93.8%.
(whole rock) 35.7 ± 1.6 m.y.

31. *BP0516851* K-Ar
Basaltic andesite lava flow, Mv (46°29'07"N, 122°10'52"W; E end of Riffe Lake, Lewis Co., WA). Porphyritic with coarse-grained plagioclase phenocrysts; hypocrystalline, trachytic groundmass of opaque minerals, plagioclase and altered or devitrified brown glass. *Analytical data:* K_2O = 0.518%, K_2O = 0.530%; $^{40}Ar^*$ = 1.874 × 10^{-11} moles/gm, $^{40}Ar^*$ = 1.829 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 53.0%, $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 62.3%.
(whole rock) 24.4 ± 1.2 m.y.

32. *MM0904851* K-Ar
Basaltic andesite lava flow, Mv (45°47'39"N, 121°59'53"W; Sedum Point, Skamania Co., WA). Aphyric to microphyric; rare phenocrysts of plagioclase and clinopyroxene; hypocrystalline groundmass of plagioclase, opaque minerals, and brown, weakly birefringent material (altered glass?). *Analytical data:* K_2O = 0.952%, K_2O = 0.952%; $^{40}Ar^*$ = 3.258 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.258 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 79.0%, $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 73.3%.
(whole rock) 23.6 ± 1.2 m.y.

33. *HS0116853* K-Ar
Pyroxene basaltic andesite flow or sill, Ev (46°37'33"N,122°37'50"W; South Fork of Newaukum River, Lewis Co., WA). Porphyritic with sparse, fine-grained phenocrysts of plagioclase, clinopyroxene, and altered olivine(?); holocrystalline groundmass of plagioclase, clinopyroxene, opaque minerals, and zeolites(?). *Analytical data:* K_2O = 0.603%, K_2O = 0.590%; $^{40}Ar^*$ = 3.436 × 10^{-11} moles/gm, $^{40}Ar^*$ = 3.302 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 51.6%; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 55.3%.
(whole rock) 38.8 ± 1.9 m.y.

34. *HS0117851A* K-Ar
Pyroxene andesite flow or sill, Ev (46°34'15"N, 122°18'50"W; Tilton River, Lewis Co., WA). Porphyritic with abundant, coarse- to medium-grained phenocrysts of plagioclase, clinopyroxene, and highly altered olivine(?); hypocrystalline groundmass with intersertal brown glass, plagioclase, opaque minerals, and clinopyroxene. *Analytical data:* K_2O = 1.205%, K_2O = 1.205%; $^{40}Ar^*$ = 6.600 × 10^{-11} moles/gm, $^{40}Ar^*$ = 6.828 × 10^{-11} moles/gm; $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 80.9%, $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 72.8%.
(whole rock) 38.3 ± 1.9 m.y.

35. *JA85001* K-Ar
Olivine basalt lava flow, QPv (45°57'21"N, 120°42'57"W; SW of Butler Creek, Klickitat Co., WA). Porphyritic olivine basalt with distinctive K_2O and TiO_2 contents. *Analytical data:* K_2O = 1.012%, K_2O = 1.040%; $^{40}Ar^*$ = 0.670 × 10^{-11} moles/gm, $^{40}Ar^*$ = 0.508 × 10^{-11} moles/gm; moles/gm, $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 19.6%, $^{40}Ar^*/\Sigma^{40}Ar \times 100$ = 14.0%.
(whole rock) 4.0 ± 0.4 m.y.

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