K-Ar ages of late Cenozoic basalts from southeastern Oregon, southwestern Idaho, and northern Nevada

W.K. Hart and R.W. Carlson

Isochron/West, Bulletin of Isotopic Geochronology, v. 38, pp. 23-26

This page is intentionally left blank to maintain order of facing pages.

K-Ar AGES OF LATE CENOZOIC BASALTS FROM SOUTHEASTERN OREGON, SOUTHWESTERN IDAHO, AND NORTHERN NEVADA

WILLIAM K. HART
RICHARD W. CARLSON } *Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road N.W., Washington, D.C. 20015*

The middle to late Cenozoic geology of the southeastern Oregon, southwestern Idaho, and northern Nevada portion of the Great Basin (fig. 1) is characterized by voluminous tholeiitic basalts, silicic ash-flow tuffs, and subordinate alkaline olivine basalts. High angle, north-south-trending normal faults dominate the topography, and along with river valleys, often expose thick sequences of tholeiitic and (or) ash-flow material. From ~16 Ma to 14 Ma bp large volumes of tholeiite were extruded throughout southeastern Oregon and northernmost central Nevada. These lavas are well exposed at Steens Mountain, Owyhee Reservoir, and Abert and Polker Jim Rims (Baksi and others, 1967; Bottomley and York, 1976; Hart and Mertzman, 1982). Although episodic, basaltic volcanism has continued to the present throughout much of the northwestern Great Basin. Beginning at ~10.5 Ma bp Snake River olivine tholeiite (SROT); low K, high-alumina olivine theoleiite (HAOT); and tholeiites chemically transitional (TB) to SROT and HAOT began erupting near the southern Oregon-Idaho border (Armstrong and others, 1975; Hart and others, 1983). Snake River volcanism migrated eastward with time, whereas HAOT and TB magmatism continued to dominate the late Tertiary and Quaternary record throughout the Oregon-Idaho-Nevada border region. During this 10.5–0 Ma time period HAOT was also extruded throughout northeastern California and south-central Oregon (McKee and others, 1983; Hart and others, 1983).

RESULTS

We report ten new K-Ar ages for basalts from the northwestern Great Basin. The K-Ar data are given below and correspond to the sample locations shown in figure 1. Major-element chemical analyses for the dated samples are listed in table 1. Olivine tholeiite lavas from map locations 2–8 and 10 range from 0.36 to 9.4 Ma in age. These basalts exhibit chemical and chronologic characteristics identical to those of previously analyzed transitional tholeiites from the Owyhee River–Western Snake River Plain region (Hart and others, 1983). Sample CH82-3, from location number 1 (4.4 Ma), exhibits similar TB chemistry except for higher SiO_2(50%), lower TiO_2(~1%), and lower total iron (as Fe_2O_3; 9.53%). The Robinette Mountain basalt of the Columbia River Group; some alkaline olivine basalt flows from southern Oregon–northern Nevada; and the top flow at Egli Rim, east of Silver Lake in central Oregon, have similar chemical signatures but are not time correlative (Swanson and others, 1979; Hart and others, 1983). The basalt sampled at location number 9 (H-9-52) is also somewhat enigmatic. This material is compositionally similar to the basalts exposed at Owyhee Reservoir (Owyhee Basalt) but is significantly younger (8.7 Ma) than the type section of Owyhee Basalt (14.3 Ma; Bottomley and York, 1976). Additional samples from the Owyhee Reservoir area are under investigation in order to further evaluate this age difference.

The ten samples analyzed in this study were combined with fifty-seven basalts from the same region (Hart and others, 1983) to produce the histogram in figure 2. This summary includes only basalts between 12 Ma and 0 Ma. Further work on material older than 12 Ma is in progress (Carlson and Hart, 1983). Figure 2 illustrates the episodic nature of northwestern Great Basin basaltic volcanism. Two major pulses are evident: 0–2 Ma and 4–10 Ma. The data may allow further subdivision of the 4–10 Ma episode into 4-5 Ma and 7–10 Ma pulses. These episodes are similar to those delineated from ash abundances in circum-Pacific Deep-Sea Drilling Program cores (Kennett and others, 1977). Episodic volcanism, such as that documented in the northwestern Great Basin, records fundamental changes in regional tectonic activity. For example, large volumes of volcanic material mark the initiation of extension in the Basin and Range at ~17 Ma. (McKee and others, 1970). The younger 0–12 Ma volcanism in the northwestern Great Basin probably reflects pulses of extensional tectonism related to mantle upwelling and possibly back-arc spreading behind the Cascade arc.

TABLE 1. Major-element data.[1]

Map no.	1	2	3	4	5	6	7	8	9	10
Sample no.	CH82-3	H-9-29	CH82-38	CH82-48	CH82-49	CH82-50	CH82-52A	CH82-52B	H-9-52	H-9-56B
SiO_2	50.1	47.1	47.4	47.3	46.6	46.9	47.1	47.2	54.9	48.0
Al_2O_3	16.3	16.2	15.7	14.9	14.7	15.4	15.1	15.0	16.8	16.2
TiO_2	0.98	1.80	2.0	1.67	2.47	1.91	2.19	2.24	0.91	1.02
Fe_2O_3*	9.53	11.6	12.6	12.4	14.1	13.6	13.4	13.6	7.62	9.82
MnO	0.15	0.17	0.18	0.18	0.19	0.18	0.18	0.18	0.13	0.15
MgO	7.83	9.08	6.27	9.15	7.21	8.25	7.08	6.56	5.13	8.32
CaO	10.7	11.0	10.4	10.6	9.64	10.0	10.6	10.7	7.84	11.9
Na_2O	2.39	2.54	2.76	2.05	2.22	2.32	2.31	2.29	3.31	2.49
K_2O	0.66	0.55	0.98	0.35	0.56	0.39	0.40	0.40	1.23	0.71
P_2O_5	0.14	0.23	0.36	0.35	0.53	0.29	0.34	0.35	0.23	0.32
L.O.I.	−0.38	−0.22	−0.23	0.08	0.08	−0.30	0.08	0.39	0.84	0.07
TOTAL	98.4	100.1	98.4	99.0	98.5	99.1	98.9	99.1	98.6	99.0

[1]All values in weight %; Fe_2O_3* = total Fe as Fe_2O_3; L.O.I. = % loss on ignition.

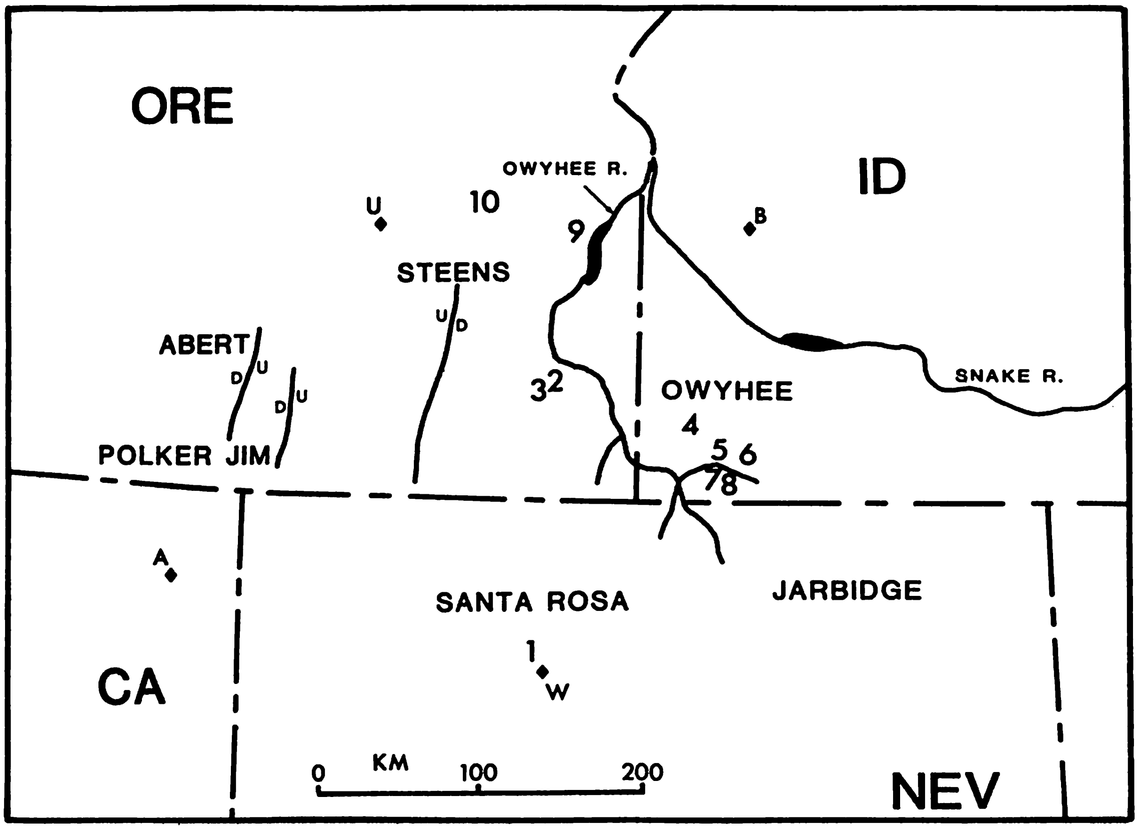

FIGURE 1. Location map of study area. Sample locations are numbered and correspond to the data given and table 1. Alturas, Boise, Burns, and Winnemucca are designated by A, B, U, and W, respectively.

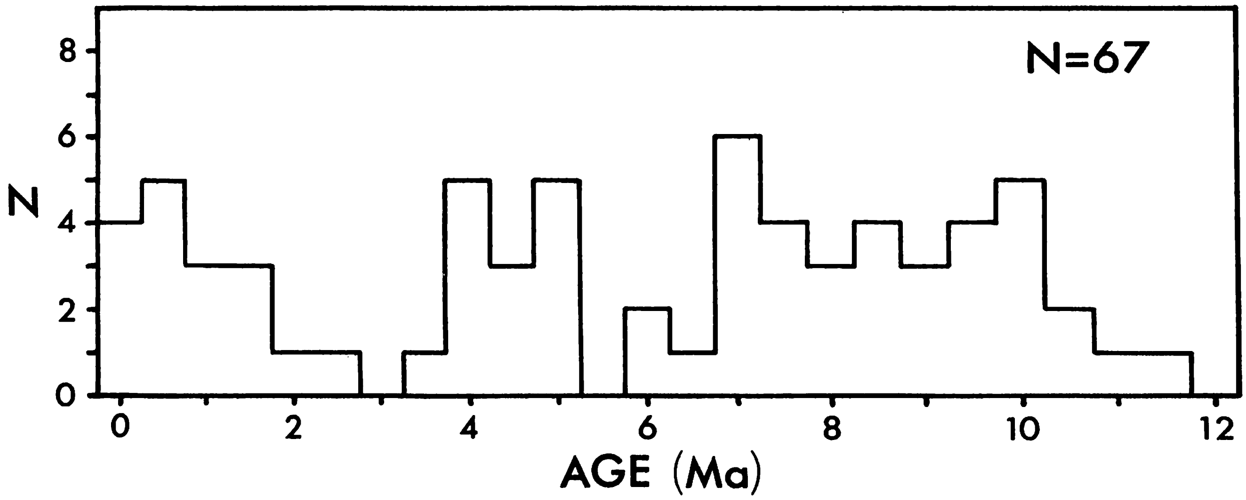

FIGURE 2. Histogram of K-Ar ages for late Miocene to Recent basalts from southeastern Oregon, southwestern Idaho, and northern Nevada. Data from this study and Hart and others, 1983.

Constants used in calculating the ages are: $\lambda_\epsilon = 0.581 \times 10^{-10}yr^{-1}$; $\lambda_\beta = 4.962 \times 10^{-10}yr^{-1}$; $^{40}K/K = 1.167 \times 10^{-4}$mol/mol.

ACKNOWLEDGMENT

We would like to thank Dr. J. L. Aronson for the use of his K-Ar laboratory at Case Western Reserve University.

SAMPLE DESCRIPTIONS

1. *CH82-3* K-Ar
Basalt (NE1/4, S6,T36N,R38E; flow front at base of Winnemucca Mtn., NV). Fine–medium grained, diktytaxitic, ophitic-subophitic augite and Ca-plagioclase; microphenocrysts of iddingsitized olivine; intergranular oxides. *Analytical data:* Sample weight = 5.9979 gm; K_2O = 0.661 (wt)%; $*Ar^{40} = 4.208 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 10.60%.
(whole rock) 4.42 ± 0.44 Ma

2. *H-9-29* K-Ar
Basalt (S31,T33S,R41E; flow front N of Bowden Hills, OR). Fine-grained, equigranular, diktytaxitic, intergranular-subophitic titanaugite and plagioclase (An_{64-68}); intergranular olivine and oxide; interstitial oxide-rich mesostasis and minor calcite; some glomeroporphyritic clumps of olivine + plagioclase. *Analytical data:* Sample weight = 7.1912 gm; K_2O = 0.545 (wt)%; $*Ar^{40} = 2.851 \times 10^{-13}$ moles/gm; $*Ar^{40}$ = 3.02%.
(whole rock) 0.36 ± 0.13 Ma

3. *CH82-38* K-Ar
Basalt (S36,T33S,R41E; eroded tumuli N of Bowden Hills, OR). Fine- to medium-grained, diktytaxitic, subophitic Ti-Rich augite and Ca-plagioclase; microphenocrysts of plagioclase (up to 2.5 mm) and fresh olivine (up to 0.6 mm); interstitial oxide and oxide-rich mesostasis; glomeroporphyritic clumps of olivine + plagioclase. *Analytical data:* Sample weight = 7.3596 gm; K_2O = 0.979 (wt)%; $*Ar^{40} = 1.072 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 1.44%.
(whole rock) 0.76 ± 0.38 Ma

4. *CH82-48* K-Ar
Basalt (SW1/4 SW1/4 S6,T10S,R3W; rim flow near intersection of Current and Hurry Back Creeks, SW Owyhee Mtns., ID). Fine-grained matrix with patches of ophitic augite and Ca-plagioclase and ophitic-intergranular augite, plagioclase, oxide and oxide-rich mesostasis; porphyritic, highly altered (iddingsite to clay) olivine up to 2.5 mm; glomeroporphyritic clumps of olivine. *Analytical data:* Sample weight = 7.0343 gm; K_2O = 0.348 (wt)%; $*Ar^{40} = 4.592 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 14.83%.
(whole rock) 9.16 ± 0.88 Ma

5. *CH82-49* K-Ar
Basalt (S1,T12S,R1E; rim flow of two flow sequences overlying tuffaceous sediments N of Squaw Meadows, ID). Medium-grained subophitic Ti-rich augite and Ca-plagioclase; intergranular iddingsitized olivine and oxide; scattered plagioclase laths and iddingsitized olivine microphenocrysts up to 1.5 mm; glomeroporphyritic clumps of olivine, plagioclase, olivine + plagioclase, interstitial oxide-rich mesostasis. *Analytical data:* Sample weight = 7.1040 gm; K_2O = 0.558 (wt)%; $*Ar^{40} = 7.552 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 17.66%.
(whole rock) 9.37 ± 0.74 Ma

6. *CH82-50* K-Ar
Basalt (SE1/4 S17,T12S,R1E; rim flow overlying tuffaceous material along E side of Battle Creek, ID). Fine-grained, diktytaxitic matrix of ophitic-subophitic augite and Ca-plagioclase plus intergranular-interstitial oxide and oxide-rich mesostasis; porphyritic, highly iddingsitized olivine (up to 4 mm) and plagioclase (up to 1.5 mm); abundant glomeroporphyritic clumps of olivine, plagioclase, and olivine + plagioclase. *Analytical data:* Sample weight = 7.0163 gm; K_2O = 0.394 (wt)%; $*Ar^{40} = 4.020 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 24.05%.
(whole rock) 7.08 ± 0.55 Ma

7. *CH82-52A* K-Ar
Basalt (S30,31,T14S,R1W; top flow along Owyhee River Canyon at Northwest Pipeline Corp. Compressor Station—Owyhee, ID). Fine-grained, equigranular, diktytaxitic, subophitic-ophitic Ti-rich augite and Ca-plagioclase; intergranular iddingsitized olivine (very abundant) and oxide; abundant interstitial oxide-rich mesostasis; scattered glomeroporphyritic clumps of 2–2.5 mm olivine and plagioclase. *Analytical data:* Sample weight = 7.0040 gm; K_2O = 0.399 (wt)%; $*Ar^{40} = 4.247 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 21.64%.
(whole rock) 7.38 ± 0.59 Ma

8. *CH82-52B* K-Ar
Basalt (S30,31,T14S,R1W; two flows below CH82-52A; same location). Petrography identical to CH82-52A except that there is less oxide and oxide-rich mesostasis. *Analytical data:* Sample weight = 7.1723 gm; K_2O = 0.402 (wt)%; $*Ar^{40} = 4.263 \times 10^{-12}$ moles; $*Ar^{40}$ = 22.40%.
(whole rock) 7.36 ± 0.58 Ma

9. *H-9-52* K-Ar
Basalt (SW1/4 S23,T22S,R44E; rim flow along eastern boundary of Oxbow Basin, W of Owyhee Reservoir, OR). Fine-grained intergranular-intersertal matrix of plagioclase, mafic microlites, oxide, minor altered glass (clay), and oxide-rich mesostasis; porphyritic plagioclase (>3 mm; An_{69-62}), augite, and orthopyroxene (rimmed with cpx); some microphenocrysts of olivine completely replaced by clay. *Analytical data:* Sample weight = 4.1113 gm; K_2O = 1.230 (wt)%; $*Ar^{40} = 1.538 \times 10^{-11}$ moles/gm; $*Ar^{40}$ = 42.00%.
(whole rock) 8.67 ± 0.42 Ma

10. *H-9-56B* K-Ar
Basalt (S34,T20S,R36E; flow overlying ash/lacustrine sediment along U.S. 20, Drinkwater Pass, OR). Fine-grained, holocrystalline, diktytaxitic, subophitic-intergranular matrix of plagioclase, augite, olivine and oxide; porphyritic and glomeroporphyritic plagioclase (An_{68-72}) and iddingsitized olivine up to 2 mm; scattered highly resorbed plagioclase grains. *Analytical data:* Sample weight = 5.0255 gm; K_2O = 0.711 (wt)%; $*Ar^{40} = 7.599 \times 10^{-12}$ moles/gm; $*Ar^{40}$ = 54.35%.
(whole rock) 7.41 ± 0.39 Ma

REFERENCES

Armstrong, R. L., Leeman, W. P., and Malde, H. E. (1975) K-Ar dating, Quaternary and Neogene volcanic rocks of the Snake River Plain, Idaho: American Journal of Science, v. 275, p. 225–251.

Baksi, A. K., York, D., and Watkins, N. D. (1967) The age of the Steens Mountain geomagnetic polarity transition: Journal of Geophysical Research, v. 72, p. 6299–6308.

Bottomley, R. J., and York, D. (1967) ^{40}Ar-^{39}Ar determinations on the Owyhee Basalt of the Columbia Plateau: Earth and Planetary Science Letters, v. 31, p. 71–84.

Carlson, R. W., and Hart, W. K. (1983) Areal extent and isotope geochemistry of the Steens Mountain flood basalt, southeast Oregon: Transactions of the American Geophysical Union, v. 64, no. 18, p. 338.

Hart, W. K., and Mertzman, S. A. (1982) K-Ar ages of basalts from south-central and southeastern Oregon: Isochron/West, no. 33, p. 23–26.

Hart, W. K., Aronson, J. L., and Mertzman, S. A. (1983) Areal distribution and age of low K, high-alumina olivine tholeiite magmatism in the northwestern Great Basin, U.S.A.: Geological Society of American Bulletin (in press).

Kennett, J. P., McBirney, A. R., and Thunell, R. C. (1977) Episodes of Cenozoic volcanism in the circum-Pacific region: Journal of Volcanology and Geothermal Research, v. 2, p. 145–163.

McKee, E. H., Noble, D. C., and Silberman, M. L. (1970) Middle Miocene hiatus in volcanic activity in the Great Basin area of the western United States: Earth and Planetary Science Letters, v. 8, p. 93–96.

McKee, E. H., Duffield, W. A., and Stern, R. J. (1983) Late Miocene and early Pliocene basaltic rocks and their implications for crustal structure, northeastern California and south-central Oregon: Geological Society of America Bulletin, v. 94, p. 292–304.

Swanson, D. A., Wright, T. L., Hooper, P. R., and Bentley, R. D. (1979) Revisions in the stratigraphic nomenclature of the Columbia River Basalt group: United States Geological Survey Bulletin 1457G, p. G1–G59.

NEW MEXICO TECH PRINT PLANT
Camera-ready copy provided by the Nevada Bureau of Mines and Geology
Presswork: Text and cover printed on Davidson 600
Paper: Body on 60-lb white offset; cover on 65-lb Russett
Ink: Van Son rubber base plus all-purpose black