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K-AR DATES AND SR ISOTOPE INITIAL RATIOS FOR VOLCANIC ROCKS IN THE HARNEY BASIN, OREGON

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We report K-Ar dates done by Parker while a visitor at Yale as a part of his Ph. D. thesis research for Oregon State University, and some Sr isotope measurements made subsequently by Armstrong.

The K-Ar data were obtained using standard analytical techniques as described by Armstrong (1970). Argon was determined by isotope dilution, potassium by atomic absorption spectrophotometry. The dates are computed using the following constants: $K^{40} = 0.0119$ atom percent; $K\lambda_\beta = 4.72 \times 10^{-10} yr^{-1}$, $K\lambda_\epsilon = 0.584 \times 10^{-10} yr^{-1}$. Analyses of standards indicate that calibrations are accurate within 2%. Uncertainties reported are for analytical error only and represent one standard deviation, or the standard error for averaged dates.

Sr isotope analyses were done on a twelve inch radius, 60 degree sector, mass spectrometer equipped with expanded scale recorder. The standard deviation for individual measurements is .0002. On this instrument the E & A Sr standard gives $Sr^{87}/Sr^{86} = .7080$.

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GEOLOGIC DISCUSSION

The Harney Basin is the farthest northwest extension of the Basin and Range structural province. It is bounded on the north by the Blue Mountains uplift, on the west by the Deschutes Plateau, and on the east by the Owyhee upland. All rocks dated are of Pliocene age and belong to the Danforth or Harney formations.

The dates obtained in this study demonstrate that there have been at least three episodes of bimodal volcanism during the last 9 m.y. in the Harney Basin

The oldest lava flows dated in the Harney Basin are basalts 8.8 m.y. in age (sample no. 10). These flows are overlain by a rhyolite welded tuff (no. 11) which is the Prater Creek member of the Danforth Formation, 8.6 m.y. old. Overlying these flows are rhyolite flows (nos. 3 & 4) 8.2 and 8.4 m.y. in age.

The next eruption of basalt (no. 9) was 7.9 m.y. ago and is overlain by a welded tuff (no. 8) which is 7.1 m.y. old. A rhyolite dome (no. 13) 7.8 m.y. old was also extruded during this period of volcanism.

The next major eruption of basalt was not dated by the K-Ar method because of poor sample material. This basalt lies directly below the Double O member of the Danforth Formation also known as the Rattlesnake Ignimbrite member of the Rattlesnake Formation which is found farther north in the John Day Valley. The Double O member was found to be 6.5 m.y. old (nos. 12, 14, 15, 16, 17). A rhyolite dome (no. 7) was intruded about this time or somewhat later and a biotite separate gave an age of 6.4 m.y. An andesite flow (no. 6) overlying the Double O member was found to be 5.8 m.y. old.

The last episode of volcanism occurred 2.7 m.y. ago with mesa-forming basalts being erupted from low shield volcanoes (nó. 1), and phreatic eruptions of basalt (no. 2). A prominent dome of rhyolite (no. 5) 2.7 m.y. old also belongs in this episode of volcanism. The volcanics of this last episode belong to the Harney Formation.

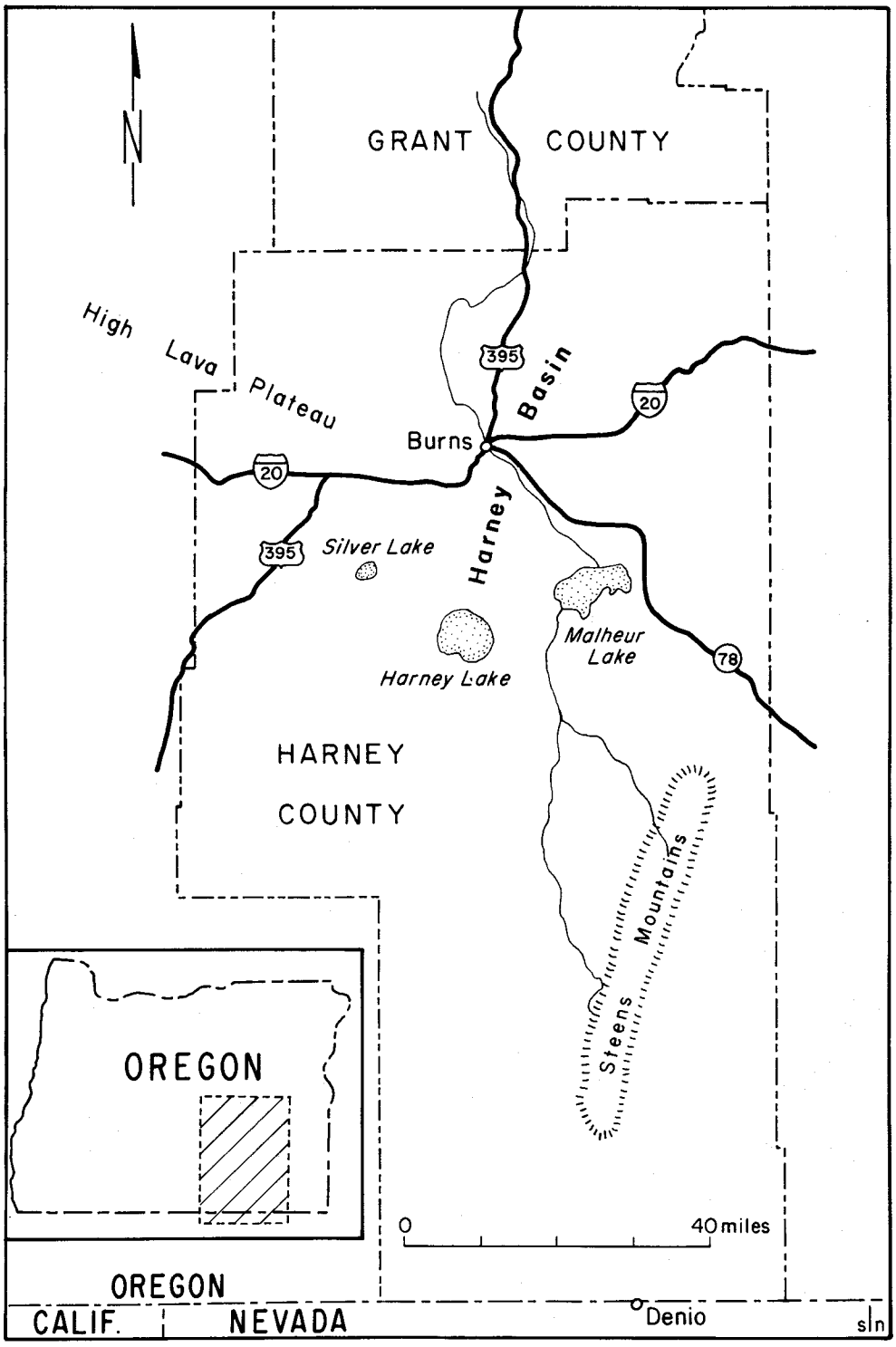

Figure 1. Index map showing the location of the Harney Basin, Oregon.

The sequence of K-Ar dates given above agrees with the stratigraphic sequence observed in the field. It is proposed that the above episodes represent distinct times of increased volcanic activity and not isolated dates from a continuous sequence of volcanic events.

The Sr isotope ratios for basalts, .7033 (no. 1) and .7036 (no. 9), are as low as are ever observed in volcanic arc regions and similar to the results for Cascade, Columbia River, and Clarno basalts reported by Hedge and others (1970). A single young rhyolite (no. 5) gave .7038, slightly higher than the basalt ratios. The Rattlesnake tuff was separated into feldspar (no. 17), .7035, and two glass fractions: light-colored (no. 19) .7042 and dark colored (no. 18) .7041. The two glasses are indistinguishable isotopically; the feldspar is distinctly less radiogenic as was observed in the case of many ash flows in east-central Nevada by Scott and others (1971).

SAMPLE DESCRIPTIONS

1. YU-DP-14 — K-Ar — (whole rock) 2.6±.3 m.y.
   Sr^{87}/Sr^{86} initial ratio: .7033

   High alumina basalt (119°00′23″W, 43°26′24″N; Harney Co., OR). Analysis: SiO_2 = 48.7, TiO_2 = 1.43, Al_2O_3 = 17.4, FeO = 10.2, MgO = 8.4, CaO = 11.2, Na_2O = 2.75, K_2O = .29%. Analytical data: K = 0.244, 0.239%; $\overset{*}{Ar}^{40}$ = 0.0280 x 10^{-6} cc/gm (7% Σ Ar^{40}), 0.0229 x 10^{-6} cc/gm (5% Σ Ar^{40}). 5.3 ppm Rb, 214 ppm Sr, Rb^{87}/Sr^{86} = .072. Collected by: Donald Parker, Oregon State Univ.

2. YU-DP-41 — K-Ar — (whole rock) 2.8±.2 m.y.

   Alkali basalt (119°06′34″W, 43°20′24″N; Harney Co., OR). Analysis: SiO_2 = 50.1, TiO_2 = 1.70, Al_2O_3 = 15.0, FeO = 11.0, MgO = 7.1, CaO = 10.55, Na_2O = 3.0, K_2O = .80%. Analytical data: K = 0.655, 0.669%; $\overset{*}{Ar}^{40}$ = 0.0709 x 10^{-6} cc/gm (9% Σ Ar^{40}), 0.0766 x 10^{-6} cc/gm (6% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

3. YU-DP-119 — K-Ar — (whole rock) 8.2±.12 m.y.

   Rhyolite (119°13′30″W, 43°14′19″N; Harney Co., OR). Analysis: SiO_2 = 74.0, TiO_2 = .13, Al_2O_3 = 11.7, FeO = 3.0, MgO = .15, CaO = 1.2, Na_2O = 4.45, K_2O = 4.5%. Analytical data: K = 3.78, 3.79%; $\overset{*}{Ar}^{40}$ = 1.26 x 10^{-6} cc/gm (59% Σ Ar^{40}), 1.23 x 10^{-6} cc/gm (47% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

4. YU-DP-146 — K-Ar — (whole rock) 8.4±1.3 m.y.

   Rhyolite (119°21′11″W, 43°13′30″N; Harney Co., OR). Analytical data: K = 4.26, 4.26%; $\overset{*}{Ar}^{40}$ = 1.41 x 10^{-6} cc/gm (4% Σ Ar^{40}), 1.45 x 10^{-6} cc/gm (5% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

5. YU-DP-158 — K-Ar — (whole rock) 2.1±.24 m.y.
   Sr^{87}/Sr^{86} today: .7039 — (biotite) 2.7±.4 m.y.
   Sr^{87}/Sr^{86} initial ratio: .7038

   Rhyolite (119°12′00″W, 43°13′48″N; Harney Co., OR). Whole rock analysis: SiO_2 = 72.7, Al_2O_3 = 14.5, TiO_2 = .13, FeO = 10.5, MgO = .5, CaO = 1.9, Na_2O = 3.05, K_2O = 4.5. Analytical data: (Whole rock–hydrated glass) K = 3.75, 3.66%; $\overset{*}{Ar}^{40}$ = 0.307 x 10^{-6} cc/gm (9% Σ Ar^{40}). 121 ppm Rb, 222 ppm Sr, Rb^{87}/Sr^{86} = 1.58. (Biotite) K = 5.35, 5.38%; $\overset{*}{Ar}^{40}$ = 0.569 x 10^{-6} cc/gm (7% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

6. YU-DP-160 K-Ar (whole rock) 5.8±.8 m.y.

Andesite (119°28′00″W, 43°16′30″N; Harney Co., OR). Analysis: SiO_2 = 57.6, TiO_2 = 1.25, Al_2O_3 = 14.7, FeO = 8.6, MgO = 4.2, CaO = 7.0, Na_2O = 4.2, K_2O = 2.0%. Analytical data: K = 1.79, 1.74%; $^*Ar^{40}$ = 0.4652 x 10^{-6} cc/gm (8% Σ Ar^{40}), 0.3826 x 10^{-6} cc/gm (6% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

7. YU-DP-214 K-Ar (whole rock) 5.6±.4 m.y.
(biotite) 6.4±.2 m.y.

Rhyolite (119°18′00″W, 43°30′18″N; Harney Co., OR). Whole rock analysis: SiO_2 = 76.0, TiO_2 = .08, Al_2O_3 = 12.9, FeO = .75, MgO = .4, CaO = 1.60, Na_2O = 3.4, K_2O = 4.88%. Analytical data: (Whole rock–hydrated glass) K = 4.07, 4.06%; $^*Ar^{40}$ = 0.907 x 10^{-6} cc/gm (16% Σ Ar^{40}). (Biotite) K = 6.82, 6.97%; $^*Ar^{40}$ = 1.755 x 10^{-6} cc/gm (35% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

8. YU-DP-243 K-Ar (sanidine) 7.1±.10 m.y.

Welded tuff (119°03′45″W, 43°04′56″N; Harney Co., OR). Analytical data: K = 6.53, 6.51%; $^*Ar^{40}$ = 1.837 x 10^{-6} cc/gm (59% Σ Ar^{40}), 1.845 x 10^{-6} cc/gm (55% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

9. YU-DP-250 K-Ar (whole rock) 7.9±.9 m.y.
Sr^{87}/Sr^{86} initial ratio: .7036

High alumina basalt (119°03′45″W, 43°03′27″N; Harney Co., OR). Analysis: SiO_2 = 50.2, TiO_2 = 1.38, Al_2O_3 = 17.1, FeO = 10.4, MgO = 8.2, CaO = 11.2, Na_2O = 2.7, K_2O = .35%. Analytical data: K = 0.289, 0.293, 0.294%; $^*Ar^{40}$ = 0.0922 x 10^{-6} cc/gm (8% Σ Ar^{40}). 8.1 ppm Rb, 282 ppm Sr, Rb^{87}/Sr^{86} = .084. Collected by: Donald Parker, Oregon State Univ.

10. YU-DP-300 K-Ar (whole rock) 8.8±1.4 m.y.

Basalt (119°04′18″W, 43°03′06″N; Harney Co., OR). Analysis: SiO_2 = 49.5, TiO_2 = 1.72, Al_2O_3 = 15.4, FeO = 12.0, MgO = 8.2, CaO = 10.5, Na_2O = 3.0, K_2O = .42%. Analytical data: K = 0.341, 0.348%; $^*Ar^{40}$ = 0.124 x 10^{-6} cc/gm (4% Σ Ar^{40}), 0.119 x 10^{-6} cc/gm (5% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

11. YU-DP-311B K-Ar (whole rock) 8.6±.2 m.y.

Rhyolite welded tuff (119°22′23″W, 43°09′03″N; Harney Co., OR). Analysis: SiO_2 = 74.2, TiO_2 = .15, Al_2O_3 = 12.1, FeO = 3.0, MgO = .24, CaO = .43, Na_2O = 4.6, K_2O = 4.41%. Analytical data: K = 3.73, 3.76%; $^*Ar^{40}$ = 1.26 x 10^{-6} cc/gm (42% Σ Ar^{40}), 1.39 x 10^{-6} cc/gm (8% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

12. YU-DP-311G K-Ar (whole rock) 6.6±.2 m.y.

Rhyolite welded tuff (119°22′23″W, 43°09′03″N; Harney Co., OR). Analytical data: K = 4.09, 4.09%; $^*Ar^{40}$ = 1.092 x 10^{-6} cc/gm (26% Σ Ar^{40}), 1.083 x 10^{-6} cc/gm (21% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

13. YU-DP-316D K-Ar (whole rock) 7.8±.5 m.y.

Rhyolite (119°18′45″W, 43°17′02″N; Harney Co., OR). Analysis: SiO_2 = 76.0, TiO_2 = .40, Al_2O_3 = 15.0, FeO = 2.4, MgO = .6, CaO = 1.45, Na_2O = 4.2, K_2O = 5.05%. Analytical data: K = 4.13, 4.03%; $\overset{*}{A}r^{40}$ = 1.28 x 10^{-6} cc/gm (16% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

14. YU-DP-330 K-Ar (whole rock) 6.7±.4 m.y.

Rhyolite welded tuff (119°22′23″W, 43°09′03″N; Harney Co., OR). A flow banded sample of no. 12 (above) that is oxidized and somewhat devitrified. Analytical data: K = 4.04, 4.03%; $\overset{*}{A}r^{40}$ = 1.044 x 10^{-6} cc/gm (10% Σ Ar^{40}), 1.106 x 10^{-6} cc/gm (11% Σ Ar^{40}). Collected by: Donald Parker, Oregon State Univ.

15. YU-E-84-67 K-Ar (anorthoclase) 6.6±.2 m.y.

Rhyolite welded tuff (119°30′00″W, 44°19′00″N; Grant Co., OR). Hand picked crystal separate. Analytical data: K = 4.41, 4.43%; $\overset{*}{A}r^{40}$ = 1.161 x 10^{-6} cc/gm (29% Σ Ar^{40}). Collected by: H. E. Enlows, Oregon State Univ.

16. YU-E-6-70 K-Ar (anorthoclase) 6.4±.2 m.y.

Rhyolite welded tuff (119°27′51″W, 44°46′54″N; Grant Co., OR). Hand picked crystal separate. Analytical data: K = 3.85, 3.83%; $\overset{*}{A}r^{40}$ = 0.985 x 10^{-6} cc/gm (28% Σ Ar^{40}). Collected by: H. E. Enlows, Oregon State Univ.

17. YU-Cottonwood K-Ar (anorthoclase) 6.4±.1 m.y.
Sr^{87}/Sr^{86} initial ratio of anorthoclase: .7035

Rhyolite welded tuff (119°38′42″W, 44°26′36″N; Grant Co., OR). Hand picked crystal separate. Analytical data: K = 3.76, 3.75%; $\overset{*}{A}r^{40}$ = 0.965 x 10^{-6} cc/gm (56% Σ Ar^{40}). 18.6 ppm Rb, 145 ppm Sr, Rb^{87}/Sr^{86} = .370. Collected by: H. E. Enlows, Oregon State Univ.

18. YU-DP-64-3-D
Sr^{87}/Sr^{86} today: .7063
initial ratio: .7042

Rhyolite welded tuff (119°30′0″W, 43°10′39″N; Harney Co., OR). Analytical data: (Hand picked glass shard separate) 112 ppm Rb, 14.3 ppm Sr, Rb^{87}/Sr^{86} = 22.7. Collected by: Donald Parker, Oregon State Univ.

19. YU-DP-64-3-L
Sr^{87}/Sr^{86} today: .7077
initial ratio: .7041

Rhyolite welded tuff (119°30′0″W, 43°10′39″N; Harney Co., OR). Analytical data: (Hand picked glass shard separate) 111 ppm Rb, 8.3 ppm Sr, Rb^{87}/Sr^{86} = 38.8. Collected by: Donald Parker, Oregon State Univ.

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