

## ***Rb-Sr and K-Ar ages and Sr isotopic compositions of some granitic rocks of Oregon and Washington***

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RB-SR AND K-AR AGES AND SR ISOTOPIC COMPOSITIONS OF  
SOME GRANITIC ROCKS OF OREGON AND WASHINGTON

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This paper contains supplemental analytical and locality data for samples discussed in our Geological Society of America paper on the Mesozoic granitic rocks of Oregon, Washington, and Idaho (Armstrong, Taubeneck, and Hales, 1976). Supplemental data for the samples from Idaho were included in a recent review of the geochronometry of Idaho (Armstrong, 1975). Also included in this paper are data for one sample from southern Oregon which has been reported only in an abstract (Muntzert and Field, 1969).

The Ar data were determined by standard isotope dilution techniques at Yale University and Columbia University. K analyses at Yale were done by atomic absorption and at Columbia by flame photometer. The K-Ar dates are computed using the following constants:  $K^{40} = 0.0119$  atom percent;  $K\lambda_{\beta} = 4.72 \times 10^{-10} \text{ yr}^{-1}$ ,  $K\lambda_{\epsilon} = 0.584 \times 10^{-10} \text{ yr}^{-1}$ . Rb/Sr ratios were determined by x-ray fluorescence and Sr isotopic compositions measured on an automated 60-degree-sector 12-inch-radius solid source mass spectrometer at Yale University. Uncertainties reported are for one standard deviation.

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SAMPLE DESCRIPTIONS

1. Bald Mountain batholith Rb-Sr ( $\lambda = 1.42$ ) (whole rock) (except 2 aplites)  $147 \pm 17$  m.y.  
Initial  $\text{Sr}^{87}/\text{Sr}^{86} = 0.70391 \pm 0.00008$   
(whole rock – aplite) (252)  $158 \pm 8$  m.y.  
Initial  $\text{Sr}^{87}/\text{Sr}^{86} = 0.70388 \pm 0.00003$   
(whole rock – aplite) (821)  $140 \pm 7$  m.y.  
Initial  $\text{Sr}^{87}/\text{Sr}^{86} = 0.70393 \pm 0.00003$

Specimen	N Latitude	W Longitude	County	State
1 25 granodiorite	44°56'37"	118°9'14"	Baker	OR
2 32 quartz diorite	44°52'15"	118°11'40"	Baker	OR
3 35 quartz diorite	44°52'13"	118°9'53"	Baker	OR
4 140 granodiorite	44°56'24"	118°13'45"	Baker	OR
5 264 quartz diorite	44°51'48"	118°21'12"	Grant	OR
6 494 quartz diorite	44°54'51"	118°8'37"	Baker	OR
7 165 gabbro	44°51'54"	118°5'19"	Baker	OR
8 467 crosscutting felsic unit – leucogranodiorite	44°53'43"	118°8'48"	Baker	OR
9 468 crosscutting felsic unit – leucogranodiorite	44°53'40"	118°8'55"	Baker	OR
10 473 crosscutting felsic unit – quartz monzonite	44°54'44"	118°11'27"	Baker	OR
11 821 aplite	44°58'43"	118°10'39"	Baker	OR
12 252 aplite	44°51'24"	118°14'20"	Baker	OR

## 1. (continued)

<u>Analytical data:</u>	<u>ppm Rb</u>	<u>ppm Sr</u>	<u>Rb/Sr</u>	<u>Sr<sup>87</sup>/Sr<sup>86</sup></u>
1	40	569	0.070±.001	0.70454
2	28	642	0.043±.001	0.70426
3	29	686	0.042±.001	0.70434, 0.70419
4	44	543	0.081±.002	0.70447
5	26	656	0.040±.001	0.70442, 0.70416
6	35	652	0.053±.001	0.70409, 0.70388
7	8	1108	0.007±.0006	0.70375
8	55	412	0.134±.002	0.70460
9	73	388	0.187±.002	0.70496
10	67	245	0.272±.005	0.70563
11	87	87	1.01±.005	0.70975, 0.70973
12	104	48	2.16±.008	0.71787, 0.71820

## 2. YU-WT 35

Rb-Sr

(whole rock – biotite) 133±6 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.70394±0.00004

<u>Specimen</u>	<u>ppm Rb</u>	<u>ppm Sr</u>	<u>Rb/Sr</u>	<u>Sr<sup>87</sup>/Sr<sup>86</sup></u>
35 whole rock YU-WT 35	29	686	0.042±.001	0.70434, 0.70419
35 plagioclase	5	590	0.009±.0003	0.70396, 0.70390
35 hornblende	5	36	0.135±.03	0.70468, 0.70462
35 biotite	183	84	2.19±.02	0.71590

Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U., and R. L. Armstrong, Yale U.

## 3. YU-WT 35

K-Ar

(biotite) 131±4 m.y.  
(hornblende) 140±4 m.y.Bald Mountain batholith, quartz diorite (44°52'13"N, 118°9'53"W; Baker Co., OR). Analytical data: K = 6.21, 6.31%; \*Ar<sup>40</sup> = 33.97 x 10<sup>-6</sup> cc/gm (83% Σ Ar<sup>40</sup>). K = 0.457, 0.458%; \*Ar<sup>40</sup> = 2.59, 2.73 x 10<sup>-6</sup> cc/gm (47, 39% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

## 4. YU-WT 165

K-Ar

(hornblende) 155±5 m.y.

Bald Mountain batholith, gabbro (44°51'54"N, 118°5'19"W; sec. 17, T8S, R38E; Baker Co., OR). Analytical data: K = 0.201, 0.209, 0.210%; \*Ar<sup>40</sup> = 1.354, 1.314 x 10<sup>-6</sup> cc/gm (35, 45% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

## 5. Wallowa batholith

Rb-Sr (λ = 1.42)

(whole rock) 130±2.4 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.70332±0.00003  
(whole rock – aplite) (1233) 134±7 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.7033Wallowa batholith – Pole Bride unit  
(Oldest major unit of zoned tonalite – granodiorite complex)

<u>Specimen</u>	<u>N Latitude</u>	<u>W Longitude</u>	<u>County</u>	<u>State</u>
9 tonalite-granodiorite	45°18'22"	117°24'41"	Wallowa	OR
216 tonalite-granodiorite	45°18'21"	117°25'03"	Wallowa	OR
1233 large aplite dike	45°17'54"	117°26'09"	Wallowa	OR

  

<u>Analytical data:</u>	<u>ppm Rb</u>	<u>ppm Sr</u>	<u>Rb/Sr</u>	<u>Sr<sup>87</sup>/Sr<sup>86</sup></u>
	69	449	0.154±.002	0.70420
	60	465	0.129±.001	0.70404
	123	86	1.44±.01	0.71129

6. YU-WT 216 Rb-Sr (whole rock – biotite) 135±7 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.70341±0.00006
- | Specimen                 | ppm Rb | ppm Sr | Rb/Sr      | Sr <sup>87</sup> /Sr <sup>86</sup> |
|--------------------------|--------|--------|------------|------------------------------------|
| 216 whole rock YU-WT 216 | 60     | 465    | 0.129±.001 | 0.70404                            |
| 216 plagioclase          | 35     | 537    | 0.065±.001 | 0.70381                            |
| 216 hornblende           | 11     | 28     | 0.39±.03   | 0.70565                            |
| 216 biotite              | 381    | 16.5   | 23.1±1.2   | 0.83195                            |
- Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.
7. WT-211 K-Ar (biotite) 144±5 m.y.  
Biotite-hornblende quartz diorite of Pole Bridge quartz diorite (45°19'13"N, 117°25'44"W; Wallowa Co., OR).  
Analytical data: K = 6.10%; Ar<sup>40</sup> = 36.4 x 10<sup>-6</sup> cc/gm. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
8. YU-WT 216 K-Ar (biotite) 126±4 m.y.  
(hornblende) 143±4 m.y.  
Wallowa batholith, tonalite-granodiorite (45°18'21"N, 117°25'03"W; sec. 15, T3S, R43E; Wallowa Co., OR).  
Nearby sample gave 144±5 m.y. biotite date. Analytical data: (biotite) K = 6.97, 6.90%; \*Ar<sup>40</sup> = 36.02 x 10<sup>-6</sup> cc/gm (76% Σ Ar<sup>40</sup>); (hornblende) K = 0.317, 0.337%; \*Ar<sup>40</sup> = 1.940, 1.947 x 10<sup>-6</sup> cc/gm (35, 24% Σ Ar<sup>40</sup>).  
Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.
9. Wallowa batholith – Hurricane Divide unit Rb-Sr (λ = 1.42) (whole rock – aplite (100)) 125±6 m.y.  
(Second major unit of zoned tonalite – granodiorite).  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.7033
- | Specimen                                    | N Latitude | W Longitude | County  | State |
|---|------------|-------------|---------|-------|
| 100 narrow aplite dike                      | 45°15'25"  | 117°25'08"  | Wallowa | OR    |
| 267 hornblende-biotite granodiorite         | 45°13'48"  | 117°24'43"  | Wallowa | OR    |
| 538 hornblende-biotite granodiorite         | 45°13'00"  | 117°27'09"  | Wallowa | OR    |
| 602 biotite-hornblende mafic quartz diorite | 45°16'54"  | 117°24'53"  | Wallowa | OR    |
| 734 hornblende-biotite quartz diorite       | 45°13'35"  | 117°19'27"  | Wallowa | OR    |
| 1350 biotite-hornblende quartz diorite      | 45°15'39"  | 117°21'36"  | Wallowa | OR    |
- | Analytical data: | ppm Rb | ppm Sr | Rb/Sr      | Sr <sup>87</sup> /Sr <sup>86</sup> |
|------------------|--------|--------|------------|------------------------------------|
|                  | 82     | 182    | 0.450±.002 | 0.70562                            |
|                  | 54     | 461    | 0.117±.004 | 0.70395                            |
|                  | 60     | 421    | 0.143±.004 | 0.70397                            |
|                  | 26     | 622    | 0.041±.002 | 0.70377                            |
|                  | 30     | 544    | 0.055±.002 | 0.70376                            |
|                  | 31     | 607    | 0.050±.002 | 0.70367                            |
- Collected by: W. H. Taubeneck; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.
10. Wallowa batholith – Early gabbro and late felsic units Rb-Sr (λ = 1.42) (whole rock – aplite) (169) 132±13 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.7033  
(whole rock – hornblende-biotite granodiorite) (180) 113±20 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.7033  
(whole rock – biotite granodiorite) (461) 124±15 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.7033  
(whole rock – hornblende-biotite granodiorite) (684) 111±17 m.y.  
Initial Sr<sup>87</sup>/Sr<sup>86</sup> = 0.7033

## 10. (continued)

<u>Specimen</u>	<u>N Latitude</u>	<u>W Longitude</u>	<u>County</u>	<u>State</u>
146 gabbro, pre-Hurricane Divide	45° 16' 02''	117° 25' 35''	Wallowa	OR
563 gabbro, pre-Hurricane Divide	45° 13' 31''	117° 24' 05''	Wallowa	OR
169 aplite	45° 11' 03''	117° 30' 59''	Union	OR
180 hornblende-biotite granodiorite	45° 11' 43''	117° 31' 28''	Union	OR
461 biotite granodiorite ("late" felsic unit)	45° 08' 25''	117° 21' 34''	Union	OR
684 hornblende-biotite granodiorite ("late" felsic unit)	45° 07' 17''	117° 26' 39''	Union	OR
<u>Analytical data:</u>	<u>ppm Rb</u>	<u>ppm Sr</u>	<u>Rb/Sr</u>	<u>Sr<sup>87</sup>/Sr<sup>86</sup></u>
	5	775	0.006±.001	0.70338, 0.70326
	2	746	0.002±.0004	0.70338
	86	144	0.601±.008	0.70653, 0.70662
	61	415	0.146±.002	0.70393, 0.70403
	78	251	0.309±.004	0.70488
	74	333	0.222±.001	0.70432

Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

11. YU-WT 146 K-Ar (hornblende) 160±5 m.y.  
 Wallowa batholith, early gabbro (Pre-Hurricane Divide) (45° 16' 02''N, 117° 25' 35''W; sec. 34, T3S, R43E; Wallowa Co., OR). Analytical data: K = 0.278, 0.272, 0.277%; \*Ar<sup>40</sup> = 1.84, 1.83 x 10<sup>-6</sup> cc/gm (32, 29% Σ Ar<sup>40</sup>).  
Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

12. YU-WT 180 K-Ar (biotite) 118±4 m.y.  
 Wallowa batholith, hornblende-biotite granodiorite (45° 11' 43''N, 117° 31' 28''W; sec. 23, T4S, R42E; Union Co., OR). Analytical data: K = 6.52, 6.47%; \*Ar<sup>40</sup> = 31.49 x 10<sup>-6</sup> cc/gm (78% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

<u>Specimen</u>	<u>N Latitude</u>	<u>W Longitude</u>	<u>County</u>	<u>State</u>
53 biotite-hornblende granodiorite	44° 50' 45''	119° 02' 20''	Grant	OR
76 hornblende-biotite quartz diorite	44° 58' 46''	118° 43' 19''	Grant	OR
77 biotite-hornblende quartz diorite	45° 16' 14''	118° 48' 15''	Umatilla	OR
901 biotite-hornblende quartz diorite	45° 12' 56''	119° 08' 16''	Umatilla	OR
906 epidote-bearing biotite trondhjemite	45° 11' 28''	119° 19' 15''	Morrow	OR
<u>Analytical data:</u>	<u>ppm Rb</u>	<u>ppm Sr</u>	<u>Rb/Sr</u>	<u>Sr<sup>87</sup>/Sr<sup>86</sup></u>
	47	679	0.069±.001	0.70429
	47	572	0.082±.001	0.70418
	43	519	0.082±.001	0.70413
	17	406	0.041±.001	0.70373
	33	638	0.052±.002	0.70333

Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

13. WT-1019 K-Ar (biotite) 95±3 m.y.  
Wallowa batholith, biotite – muscovite – trondhjemite of Blue Lake cordierite trondhjemite (45°10'11"N, 117°21'21"W; Wallowa Co., OR). Analytical data: K = 5.91%; \*Ar<sup>40</sup> = 23.0 x 10<sup>-6</sup> cc/gm (63% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
14. WT-487 K-Ar (biotite) 136±4 m.y.  
Wallowa batholith, hornblende – biotite granodiorite (45°7'14"N, 117°26'27"W; Union Co., OR). Cuts earlier units of batholith. Analytical data: K = 5.60%; \*Ar<sup>40</sup> = 31.4 x 10<sup>-6</sup> cc/gm. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
15. WT-751 K-Ar (biotite) 122±4 m.y.  
Wallowa batholith, biotite-hornblende quartz diorite of Needle Point quartz diorite (45°2'44"N, 117°25'22"W; Baker Co., OR). Analytical data: K = 6.87%; \*Ar<sup>40</sup> = 34.1 x 10<sup>-6</sup> cc/gm (74% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
16. WT-204 K-Ar (biotite) 149±5 m.y.  
Wallowa batholith, hornblende-biotite granodiorite of Craig Mountain granodiorite (45°11'30"N, 117°14'01"W; Wallowa Co., OR). Analytical data: K = 5.40%. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
17. WT-308 K-Ar (biotite) 119±4 m.y.  
Wallowa batholith, hornblende-biotite quartz diorite of Craig Mountain quartz diorite (45°13'51"N, 117°10'02"W; Wallowa Co., OR). Analytical data: K = 7.88%; \*Ar<sup>40</sup> = 38.5 x 10<sup>-6</sup> cc/gm. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
18. WT-582 K-Ar (biotite) 117±3 m.y.  
Wallowa batholith, hornblende-biotite quartz monzonite (45°16'22"N, 117°27'26"W; Wallowa Co., OR). Analytical data: K = 6.19, 6.11%. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
19. WT-811 K-Ar (biotite) 124±4 m.y.  
Wallowa batholith, hornblende-biotite quartz diorite (45°17'42"N, 117°28'32"W; Wallowa Co., OR). Analytical data: K = 7.51, 7.54%; \*Ar<sup>40</sup> = 38.2 x 10<sup>-6</sup> cc/gm. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
20. WT-818 K-Ar (biotite) 128±4 m.y.  
(hornblende) 125±4 m.y.  
Cornucopia stock, hornblende-biotite tonalite of Cornucopia tonalite (45°0'16"N, 117°19'02"W; Baker Co., OR). Analytical data: K = 6.89%; \*Ar<sup>40</sup> = 36.2 x 10<sup>-6</sup> cc/gm (93% Σ Ar<sup>40</sup>). K = 1.03%; \*Ar<sup>40</sup> = 3.76 x 10<sup>-6</sup> cc/gm (81% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
21. WT-745 K-Ar (biotite) 136±4 m.y.  
Cornucopia stock, biotite-muscovite trondhjemite of Crater Lake cordierite trondhjemite (45°3'25"N, 117°16'37"W; Baker Co., OR). A relatively late intrusive. Analytical data: K = 6.25%; \*Ar<sup>40</sup> = 35.4 x 10<sup>-6</sup> cc/gm. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
22. WT-988 K-Ar (book muscovite) 93±3 m.y.  
Cornucopia stock, pegmatite in Pine Lakes cordierite trondhjemite (45°2'14"N, 117°14'31"W; Baker Co., OR). Analytical data: K = 6.31%; \*Ar<sup>40</sup> = 23.9 x 10<sup>-6</sup> cc/gm (84% Σ Ar<sup>40</sup>). Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.
23. WR-987 K-Ar (biotite) 118±4 m.y.  
Cornucopia stock, biotite trondhjemite of Tramway trondhjemite (45°2'24"N, 117°14'06"W; Baker Co., OR). Analytical data: K = 6.76%; \*Ar<sup>40</sup> = 32.7 x 10<sup>-6</sup> cc/gm. Collected by: W. H. Taubeneck, Ore. State U.; dated by: J. L. Kulp, Columbia U.

24. YU-JM-291 K-Ar (biotite)  $32.6 \pm 1.0$  m.y.  
(hornblende)  $33.6 \pm 1.0$  m.y.  
Hornblende-biotite adamellite ( $42^{\circ}37'40''$ N,  $120^{\circ}32'0''$ W; NE/4 sec. 13, T34S, R18E; Lake Co., OR). E flank of Paisley Mountains, 10 km S of Paisley. The hornblende separate contains about 5% biotite. Analytical data: (biotite) K = 5.54, 5.45%;  $*Ar^{40} = 7.23, 7.23 \times 10^{-6}$  cc/gm (50, 57%  $\Sigma Ar^{40}$ ); (hornblende) K = 1.27, 1.26%;  $*Ar^{40} = 1.71 \times 10^{-6}$  cc/gm (29%  $\Sigma Ar^{40}$ ). Collected by: J. K. Muntzert and C. W. Field, Ore. State U.; dated by: R. L. Armstrong and P. N. Taylor, Yale U.

25. Granitic step toes SE Washington		Rb-Sr		Age Indeterminant Initial $Sr^{87}/Sr^{86}$ variable	
<u>Specimen</u>	<u>N Latitude</u>	<u>W Longitude</u>	<u>County</u>	<u>State</u>	
1 16 hornblende-biotite quartz monzonite	$46^{\circ}36'18''$	$117^{\circ}21'31''$	Whitman	WA	
2 19 hornblende-biotite quartz diorite	$46^{\circ}37'37''$	$117^{\circ}06'27''$	Whitman	WA	
<u>Analytical data:</u>	<u>ppm Rb</u>	<u>ppm Sr</u>	<u>Rb/Sr</u>	<u><math>Sr^{87}/Sr^{86}</math></u>	
1	91	370	$0.245 \pm 0.004$	0.70922	
2	47	489	$0.096 \pm 0.001$	0.71405	

Collected by: W. H. Taubeneck, Ore. State U.; dated by: Peter Hales, Ore. State U. and R. L. Armstrong, Yale U.

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