

## ***K-Ar ages of igneous rocks from the western United States***

Fred W. McDowell

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K-AR AGES OF IGNEOUS ROCKS FROM THE WESTERN UNITED STATES

Fred W. McDowell  
Department of Geological Sciences  
The University of Texas at Austin

The following potassium-argon data were obtained as part of a Ph.D. research program during 1962-1966 at Lamont-Doherty Geological Observatory of Columbia University. The overall purpose of the dissertation was to provide a major addition to the body of age data from Cretaceous and Tertiary igneous rocks of the western U. S. and to summarize and discuss the general significance of all existing ages. For this reason sampling was widely distributed throughout the U. S. Cordilleran region, with particular emphasis on localities for which detailed information had been published or where local help with field relationships was available. Sampling was done during the summers of 1962 and 1964.

These widely scattered dates will not be published individually. They are given here in order to be available to interested workers. Although most of them are probably true intrusive ages, the reader is cautioned that any of them could be anomalous due to local complexities. Additional dates would be required to rigorously establish the time of crystallization for any of these localities. Ages regarded with suspicion are noted in the comments.

Portions of the dissertation involved more detailed study of larger intrusives, the Idaho and Boulder batholiths, and a close examination of the intrusive-ore relationship at Ely, Nevada. These results have been published or cited elsewhere, so additional discussion is not necessary here. The Santa Rita (Chino) New Mexico district has also received considerable attention, and the author is actively involved in further work there. A future publication combining the existing and additional data can be anticipated.

Isotope dilution techniques were employed in both potassium and argon analyses. For potassium the singly spiked samples were analyzed on a 6-inch, single filament, solid source mass spectrometer. R. F. induction heating and a 4½ inch Reynolds-type mass spectrometer operated statically were used in the argon technique. Replicate determinations during this period indicated a precision of 1% for potassium and 1.5% for argon (both one standard deviation). Constants used in age calculation were  $\lambda_{\beta} = 4.72 \times 10^{10} \text{ yr.}^{-1}$ ;  $\lambda_{\epsilon} = 0.585 \times 10^{10} \text{ yr.}^{-1}$ ; and  $K^{40}/K = 1.19 \times 10^{10} \text{ atoms/atom}$ .

Mineral separates, obtained by conventional means, were checked for purity by visual examination with a binocular microscope and, for the specific cases of chlorite in biotite and biotite in hornblende, by x-ray diffraction study. The petrographic descriptions list the minerals in approximate order of decreasing abundance, separating phenocrysts from groundmass.

SAMPLE DESCRIPTIONS

A. Intrusive Rocks—Arizona

1. L-843 K-Ar (biotite) 62.6±1.9 m.y. (a)  
63.6±1.9 m.y. (b)  
62.2±1.9 m.y. (c)

New Cornelia stock. Medium grained quartz monzonite (NW/4 NE/4 Sec. 27, T12S, R6W; NW corner of Ajo open-pit copper mine; Ajo 15' quadrangle; Pima Co., AZ) slightly porphyritic; composed of plagioclase (larger grains commonly zoned), orthoclase (partially sericitized), quartz, biotite (well formed, partially chloritized), hornblende? (completely altered to chlorite and magnetite). Analytical data: K = 3.53, 3.49%; (a)  $\bar{A}r^{40} = 3.96 \times 10^{10} \text{ mole/gm}$ ;  $\bar{A}r^{40}/\Sigma Ar^{40} = 82\%$ ; (b)  $\bar{A}r^{40} = 4.04 \times 10^{10} \text{ mole/gm}$ ;  $\bar{A}r^{40}/\Sigma Ar^{40} = 78\%$ ; (c)  $\bar{A}r^{40} = 3.94 \times 10^{10} \text{ mole/gm}$ ;  $\bar{A}r^{40}/\Sigma Ar^{40} = 78\%$ ; analyzed separate was 95% biotite, 5% chlorite, quartz, and feldspar. Collected by: D. Dixon, Phelps Dodge Corp., and F. W. McDowell, Columbia Univ.

2. L-844 K-Ar (biotite) 19.1±1.3 m.y.  
(hornblende) 19.6±3.5 m.y.

New Cornelia stock. Medium-grained, equigranular quartz monzonite (NE/4 SE/4 Sec. 21, T12S, R6W; W of Ajo; Ajo 15' quadrangle; Pima Co., AZ), composed of altered-plagioclase (badly sericitized), orthoclase (badly sericitized), quartz, biotite (scarce and somewhat chloritic), hornblende (partially altered to chlorite, epidote, magnetite). Analytical data: (Biotite, 12% chlorite, 5% hornblende)  $K = 4.74\%$ ;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 1.62 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 21\%$ . (Hornblende, 4% chlorite, biotite, and epidote)  $K = 0.394\%$ ;  $^{40}\text{Ar}^* = 0.138 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 9\%$ . Collected by: D. Dixon, Phelps Dodge Corp., and F. W. McDowell, Columbia Univ. Comment: Agreement of biotite and hornblende ages from an altered rock probably reflects time of alteration; compare with L-843 (above).

3. L-846 K-Ar (biotite) 57.6±1.7 m.y.

Schultz granite, porphyritic phase (110°55'00"W, 33°23'19"N; 1¼ mi N of Schultz Ranch, near Miami; Globe 15' quadrangle; Gila Co., AZ), composed of coarse-grained orthoclase (phenocrystic, incipient sericitization), quartz, plagioclase, biotite (unaltered). Analytical data:  $K = 6.98\%$ ;  $^{40}\text{Ar}^* = 7.24 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 90\%$ ; analyzed separate contained 2% impurities. Collected by: D. Johnson, Inspiration Consolidated Copper Co., and F. W. McDowell, Columbia Univ.

- 3A. L-850 K-Ar (biotite) 59.5±1.8 m.y.

Granite Mountain porphyry. Coarse grained porphyritic quartz monzonite (along Arizona Route 177, 4 mi W of Ray; Pinal Co., AZ). composed of plagioclase (patchy sericitization) phenocrysts in a groundmass of orthoclase (some microcline), quartz and biotite (slight chloritization). Analytical data:  $K = 7.05\%$ ;  $^{40}\text{Ar}^* = 7.56 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 94\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ.

4. L-847 K-Ar (hornblende) 61.7±2.3 m.y. (a)  
63.2±6.3 m.y. (b)

Morenci diorite porphyry. (109°24'13"W, 33°02'48"N; 3 mi SW of Morenci; Clifton 15' quadrangle; Greenlee Co., AZ). Fine grained, porphyritic, composed of plagioclase (large phenocrysts), hornblende (badly resorbed with magnetite and chlorite reaction rims), groundmass of quartz, orthoclase, and plagioclase. Analytical data:  $K = 0.392\%$ ,  $0.396\%$ . (a)  $^{40}\text{Ar}^* = 0.438 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 33\%$ ; (b)  $^{40}\text{Ar}^* = 0.450 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 15\%$ ; analyzed separate contained 10% chlorite and other impurities. Collected by: J. Durek, Phelps Dodge Corp., and F. W. McDowell, Columbia Univ.

5. L-976 K-Ar (biotite) 55.2±1.7 m.y.

Coarse, equigranular monzonite (W of Morenci open-pit copper mine; Greenlee Co., AZ), composed of plagioclase (partial sericitization), orthoclase, quartz, biotite (some chlorite and magnetite). Analytical data:  $K = 6.26\%$ ;  $^{40}\text{Ar}^* = 6.23 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 86\%$ ; analyzed separate contained 5% chlorite. Collected by: J. Durek, Phelps Dodge Corp.

#### B. Intrusive Rocks—Colorado

6. L-942 K-Ar (hornblende) 24.1±0.8 m.y.

Silverton stock. Medium-grained quartz monzonite (107°40'29"W, 37°47'57"N; along US Route 550 about 1 mi S of Silverton; Silverton 15' quadrangle; San Juan Co., CO), composed of orthoclase (badly sericitized), plagioclase, quartz, hornblende? (complete conversion to chlorite and magnetite), biotite (rare, slightly chloritic). Analytical data:  $K = 0.891\%$ ;  $^{40}\text{Ar}^* = 0.384 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^* = 40\%$ ; analyzed separate contained 12% chlorite, 5% biotite and other impurities. Collected by: F. W. McDowell, Columbia Univ.

7. L-1126 K-Ar (biotite) 26.9±0.8 m.y.  
 Silverton stock. Medium-grained quartz monzonite (107°40'26"W, 37°47'43"N; along US Route 550, 1.6 mi S of Silverton; Silverton 15' quadrangle; San Juan Co., CO), composed of plagioclase, orthoclase (badly sericitized), quartz, biotite, altered hornblende(?). Analytical data: K = 6.80%, 6.77%;  $\text{Ar}^{40} = 3.21 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 69\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ.
8. L-1036 K-Ar (biotite) 25.4±0.8 m.y.  
 Ophir pluton. Medium-grained, porphyritic monzonite (107°52'05"W, 37°51'32"N; from large talus slope along Ophir Pass road about ½ mi E of Colorado Route 145; Ophir 7½' quadrangle; San Miguel Co., CO), composed of plagioclase (occasional large crystals) phenocrysts in a groundmass of plagioclase, orthoclase, biotite (partially chloritized and abundant magnetite inclusions), and augite. Analytical data: K = 4.75%;  $\text{Ar}^{40} = 2.15 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 55\%$ ; analyzed separate (80-100 mesh) contained 40% chlorite. Collected by: F. W. McDowell, Columbia Univ.
9. L-1037 K-Ar (hornblende) 120±4 m.y.  
 La Plata sill. Porphyritic diorite-monzonite (108°04'17"W, 37°23'07"N; just S of La Plata; La Plata 15' quadrangle; La Plata Co., CO), composed of plagioclase (very sericitic toward edges), hornblende (fractured, with chlorite development) phenocrysts in a very sericitic groundmass containing orthoclase(?) and quartz. Analytical data: K = 0.862%;  $\text{Ar}^{40} = 1.89 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 88\%$ ; analyzed separate contains about 40% chlorite. Collected by: F. W. McDowell, Columbia Univ. Comment: Age is unreasonably high for the San Juan Mts. volcanics and should not be accepted without confirmation.
10. L-945 K-Ar (aegirine-augite) 33.4±1.0 m.y. (a)  
 33.8±1.3 m.y. (b)  
 Cripple Creek syenite. Medium-grained syenite (from dump of Vindicator Mine NE of Victor; Teller Co., CO), composed of orthoclase (badly sericitized), plagioclase, aegirine-augite (partial alteration to biotite and magnetite), biotite (rare, primary), hornblende? (very rare). Analytical data: K = 0.551%; (a)  $\text{Ar}^{40} = 0.33 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 56\%$ ; (b)  $\text{Ar}^{40} = 0.333 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 44\%$ ; analyzed separate contained 2% biotite and other impurities. Collected by: F. W. McDowell, Columbia Univ.
11. L-1030 K-Ar (biotite) 9.5±0.3 m.y.  
 Hahns Peak stock. Porphyritic quartz monzonite (NE/4 SE/4 Sec. 12(?), T10N, R86W; 1 mi S of Columbine; Hahns Peak 30' quadrangle; Routt Co., CO), composed of orthoclase (sericitic around edges) and biotite (chloritic around edges) phenocrysts in a groundmass of plagioclase, quartz, orthoclase, biotite, and sericite. Analytical data: K = 6.12%;  $\text{Ar}^{40} = 1.04 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 43\%$ ; analyzed separate contained 10% impurities. Collected by: F. W. McDowell, Columbia Univ.
12. L-1031 K-Ar (hornblende) 77.6±2.3 m.y. (a)  
 71.8±2.2 m.y. (b)  
 Jamestown stock. Medium-grained granodiorite (SE/4 SE/4 Sec. 24, T2N, R71W; just west of Jamestown; Boulder 15' quadrangle; Boulder Co., CO), composed of plagioclase (some sericite), orthoclase, hornblende, and quartz. Analytical data: K = 0.551, 0.531, 0.552%; (a)  $\text{Ar}^{40} = 0.760 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 71\%$ ; (b)  $\text{Ar}^{40} = 0.707 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 56\%$ ; analyzed separate contained 2% epidote and feldspar. Collected by: F. W. McDowell, Columbia Univ. Comment: 71.8 m.y. is more in line with other intrusives from the region; disagreement between argon values is unexplained.
13. L-1032 K-Ar (biotite) 38.6±1.2 m.y.  
 Montezuma stock. Coarse, equigranular quartz monzonite (SE/4 NW/4 Sec. 21, T5S, R76W; along Montezuma



road about 2 mi W of US Route 40; Montezuma 15' quadrangle; Summit Co., CO), composed of orthoclase (tends toward larger crystals), plagioclase, quartz, and biotite (with abundant quartz inclusions). Analytical data:  $K = 5.44\%$ ;  $\bar{A}r^{40} = 3.76 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 77\%$ ; analyzed separate (80-100 mesh) contained 2% impurities. Collected by: F. W. McDowell, Columbia Univ.

14. L-1035 K-Ar (biotite)  $70.4 \pm 2.1$  m.y.  
(hornblende)  $69.4 \pm 2.1$  m.y.

Salida stock. Medium-grained, equigranular granodiorite (NW/4 SW/4 Sec. 35, T51N, R77W; old quarry about 6½ mi NNE of Salida; Cameron Mtn. 15' quadrangle; Chaffee Co., CO), composed of plagioclase, orthoclase, quartz, biotite, hornblende (common inclusions of plagioclase). Analytical data: (Biotite, pure, 80-100 mesh)  $K = 6.85\%$ ;  $\bar{A}r^{40} = 8.72 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 96\%$ . (Hornblende, 2% impurities, including biotite, 80-100 mesh)  $K = 0.834\%$ ;  $\bar{A}r^{40} = 1.05 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 86\%$ . Collected by: F. W. McDowell, Columbia Univ.

15. L-1124 K-Ar (biotite)  $59.1 \pm 1.8$  m.y.

Eldora stock. Medium-grained quartz monzonite (NW/4 NW/4 Sec. 20, T1S, R73W; ½ mi E of Hessie; Central City 15' quadrangle; Boulder Co., CO), composed of plagioclase, orthoclase, quartz, biotite (occasional chlorite grains), augite(?). Analytical data:  $K = 6.84\%$ ;  $\bar{A}r^{40} = 7.28 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 94\%$ ; analyzed separate (60-100 mesh) contained 5% impurities. Collected by: F. W. McDowell, Columbia Univ.

16. L-1125 K-Ar (biotite)  $64.7 \pm 1.9$  m.y.

Lincoln porphyry. Porphyritic granodiorite ( $106^{\circ}13'35''W$ ,  $39^{\circ}18'51''N$ ; along Colorado Route 91 about 7 mi N of Leadville; Mt. Lincoln 15' quadrangle; Lake Co., CO), composed of quartz, orthoclase (sericitic), plagioclase (sericitic, inclusions), biotite (partially chloritic) phenocrysts in a groundmass of quartz, plagioclase. Analytical data:  $K = 5.76\%$ ;  $\bar{A}r^{40} = 6.72 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 92\%$ ; analyzed separate contains 25% chlorite. Collected by: F. W. McDowell, Columbia Univ.

#### C. Intrusive Rocks—Idaho

17. L-1039 K-Ar (biotite)  $23.1 \pm 0.7$  m.y.  
(muscovite)  $24.5 \pm 0.7$  m.y.

Cassia batholith. Medium-grained granodiorite (near "City of Rocks" about 5 mi W of Almo; Cassia Co., ID), composed of plagioclase (some sericite), quartz, microcline, biotite (some chloritic grains), muscovite (well formed but associated with feldspar). Analytical data: (Biotite, pure, 80-100 mesh)  $K = 7.04\%$ ;  $\bar{A}r^{40} = 2.86 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 79\%$ . (Muscovite, 2% impurities, 80-100 mesh)  $K = 8.25\%$ ;  $\bar{A}r^{40} = 3.61 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 81\%$ . Collected by: F. W. McDowell, Columbia Univ.

18. L-955 K-Ar (hornblende)  $128 \pm 4$  m.y. (a)  
 $134 \pm 4$  m.y. (b)

Gem stock. Medium-grained monzonite (along Idaho Route 4 just S of Gem; Shoshone Co., ID), consisting of plagioclase (moderately sericitized), microcline, hornblende (many inclusions), quartz (minor). Analytical data:  $K = 1.08\%$ ; (a)  $\bar{A}r^{40} = 2.55 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 75\%$ ; (b)  $\bar{A}r^{40} = 2.67 \times 10^{10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 84\%$ ; analyzed separate contained 5% impurities. Collected by: F. W. McDowell, Columbia Univ.

19. L-1048 K-Ar (biotite) 50.7±1.5 m.y.  
(hornblende) 67.3±2.0 m.y. (a)  
59.5±1.8 m.y. (b)  
51.4±1.5 m.y. (c)  
49.7±1.5 m.y. (d)

Medium-grained lamprophyre dike (Star Mine, SW of Gem; Shoshone Co., ID), composed of hornblende (brown), plagioclase, biotite (subordinate and partly chloritic). Analytical data: (Biotite, 2% impurities)  $K = 5.68\%$ ;  $\text{Ar}^{40} = 5.19 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 82\%$ . (Hornblende, 2% biotite)  $K = 0.726\%$ ; (a)  $\text{Ar}^{40} = 0.883 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 78\%$ ; (b)  $\text{Ar}^{40} = 0.778 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 36\%$ ; (c)  $\text{Ar}^{40} = 0.671 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 60\%$ ; (d)  $\text{Ar}^{40} = 0.648 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 56\%$ . Collected by: A. H. Sorensen, Hecla Mining Co. Comment: Note poor reproducibility of argon values; the final two agree with the biotite result.

20. L-1049 K-Ar (hornblende) 1260±40 m.y.

Page Mine "diabase." Fine-grained, slightly porphyritic syenite (basic) (Page Mine about 4 mi SE of Enaville; Shoshone Co., ID), composed of hornblende (moderately chloritic), augite, orthoclase, quartz-calcite veining. Analytical data:  $K = 0.251\%$ ;  $\text{Ar}^{40} = 8.37 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 86\%$ ; analyzed separate (80-100 mesh) contained augite and chlorite. Collected by: A. H. Sorensen, Hecla Mining Co. Comment: A sill occurring within Beltian sediments.

21. L-956 K-Ar (biotite) 68.3±2.0 m.y.  
(muscovite) 66.2±2.0 m.y. (a)  
67.7±2.0 m.y. (b)

Idaho batholith outlier(?). Coarse-grained quartz monzonite (2 mi S of Viola, along US Route 95; Latah Co. ID), composed of microcline (commonly sericitized), quartz, plagioclase (resorbed and sericitized), biotite (some opaque interlayers), muscovite. Analytical data: (Biotite, pure, 60-100 mesh)  $K = 7.13\%$ ;  $\text{Ar}^{40} = 8.80 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 93\%$ . (Muscovite, pure, 60-100 mesh)  $K = 8.49\%$ , 8.52%; (a)  $\text{Ar}^{40} = 10.1 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 71\%$ ; (b)  $\text{Ar}^{40} = 10.4 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 89\%$ . Collected by: F. W. McDowell, Columbia Univ. Comment: Compare with the other Idaho batholith dates (below).

22. L-957 K-Ar (biotite) 73.1±2.2 m.y.

Idaho batholith. Coarse-grained granodiorite (116°04'05"W, 44°15'57"N; 2 mi S of Smiths Ferry, along Idaho Route 15; Squaw Creek 30' quadrangle; Valley Co., ID), composed of plagioclase (incipient sericitization), orthoclase, quartz, biotite, muscovite (minor amounts associated with biotite). Analytical data:  $K = 7.24\%$ ;  $\text{Ar}^{40} = 9.58 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 79\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell & Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

23. L-1027 K-Ar (biotite) 115±3 m.y.  
(hornblende) 126±4 m.y. (a)  
122±4 m.y. (b)

Idaho batholith. Medium-grained tonalite (along US Route 12 about 3.5 mi N of Kamiah; Lewis Co., ID), composed of quartz, plagioclase, orthoclase, biotite (largely primary), hornblende (poorly developed, partially altered to biotite). Analytical data: (Biotite, 80-100 mesh, 25% chlorite)  $K = 6.73\%$ ;  $\text{Ar}^{40} = 14.2 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 93\%$ . (Hornblende, 80-100 mesh, 5% biotite and 2% chlorite)  $K = 0.947\%$ ; (a)  $\text{Ar}^{40} = 2.19 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 81\%$ ; (b)  $\text{Ar}^{40} = 2.12 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 86\%$ . Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

24. L-1028 K-Ar (biotite) 77.0±2.3 m.y.

Idaho batholith. Coarse-grained tonalite (NW/4 SE/4 Sec. 1, T18N, R3E; Yellow Pine road about 4 mi NE

of McCall; Meadows 30' quadrangle; Valley Co., ID), composed of quartz, plagioclase (incipient sericitization), orthoclase, biotite. Analytical data: K = 7.11%;  $\text{Ar}^{40} = 9.91 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 89\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

25. L-1029 K-Ar (biotite) 43.1±1.3 m.y.

Idaho batholith. Medium-grained granodiorite (along Idaho Route 46 between Little Camas Reservoir and Hill City; Camas Co., ID), composed of quartz, orthoclase, plagioclase, biotite (minor development of chlorite). Analytical data: K = 6.68%;  $\text{Ar}^{40} = 5.17 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 85\%$ ; analyzed separate contained 3% chlorite. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

26. L-1121 K-Ar (biotite) 49.3±1.5 m.y.

Idaho batholith. Coarse-grained quartz monzonite (along Idaho Route 9, 43 mi W of Idaho state border; Idaho Co., ID), composed of orthoclase (minor sericitization), quartz, plagioclase, biotite (incipient chloritization of some grains). Analytical data: K = 6.90%;  $\text{Ar}^{40} = 6.11 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 87\%$ ; analyzed separate contained 10% chlorite. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

27. L-1122 K-Ar (hornblende) 160±5 m.y. (a)  
152±7 m.y. (b)

Idaho batholith. Medium-grained quartz gabbro (NE/4 SW/4 Sec. 28, T30N, R4E; along Idaho Route 13 N of Harpster; Buffalo Hump 30' quadrangle; Idaho Co., ID), composed of plagioclase, quartz, hornblende, hypersthene (corroded at edges), augite(?), orthoclase(?). Analytical data: K = 0.360%; (a)  $\text{Ar}^{40} = 1.07 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 78\%$ ; (b)  $\text{Ar}^{40} = 1.01 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 53\%$ ; analyzed separate contained 5% impurities. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

28. L-1123 K-Ar (biotite) 43.7±1.3 m.y.

Idaho batholith. Medium-grained, slightly porphyritic granodiorite (115°24'52"W, 43°47'26"N; along middle fork, Boise River 14 mi W of Atlanta; Rocky Bar 30' quadrangle; Elmore Co., ID), composed of plagioclase (some sericite), quartz, microcline, biotite (ragged around edges). Analytical data: K = 6.29%;  $\text{Ar}^{40} = 4.93 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 79\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

#### D. Intrusive Rocks—Montana

29. L-953 K-Ar (biotite) 38.3±1.1 m.y.

Idaho batholith. Medium-grained quartz monzonite (114°15'19"W, 46°06'11"N; Lost Horse Gulch, 4 mi W of canyon mouth; Hamilton 30' quadrangle; Ravalli Co., MT), showing slight banding; composed of orthoclase, plagioclase, quartz, biotite (some chloritization). Analytical data: K = 6.86%;  $\text{Ar}^{40} = 4.71 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 84\%$ ; analyzed separate (60-100 mesh) contained 15% chlorite. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

30. L-954 K-Ar (biotite) 42.0±1.3 m.y.

Idaho batholith. Medium-grained quartz monzonite (114°26'17"W, 46°8'14"N; Lost Horse Gulch, about 14



mi W of canyon mouth; Hamilton 30' quadrangle; Ravalli Co., MT), composed of orthoclase (some sericitization), plagioclase, quartz, biotite (moderate chloritization), muscovite (minor amount). Analytical data: K = 7.38%;  $Ar^{40} = 5.55 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 72\%$ ; analyzed separate (60-100 mesh) contained 7% chlorite. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

31. L-1026 K-Ar (biotite)  $62.1 \pm 1.9$  m.y. (a)  
 $59.1 \pm 1.8$  m.y. (b)

Idaho batholith. Medium-grained granite gneiss (Skalkaho Creek 4 3/4 mi WSW of Grantsdale; Ravalli Co., MT), light bands composed primarily of quartz, dark bands primarily oriented biotite; plagioclase and orthoclase subordinate in both bands. Analytical data: K = 7.92%; (a)  $Ar^{40} = 8.87 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 88\%$ ; (b)  $Ar^{40} = 8.43 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 86\%$ ; analyzed separate (80-100 mesh) contained 5% quartz and feldspar. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above and below).

32. L-1120 K-Ar (muscovite)  $54.8 \pm 1.6$  m.y.

Idaho batholith. Medium-grained quartz monzonite (along US Route 93 1/2 mi N of Sula; Ravalli Co., MT), composed of orthoclase (partly sericitic) phenocrysts in a groundmass of quartz, plagioclase, muscovite, chlorite (from biotite). Analytical data: K = 8.61%;  $Ar^{40} = 8.50 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 88\%$ ; analyzed separate contained 2% feldspar. Collected by: F. W. McDowell, Columbia Univ. Cited: McDowell and Kulp, 1969. Comment: Compare with other Idaho batholith dates (above).

33. L-951 K-Ar (biotite)  $76.9 \pm 2.3$  m.y.  
(hornblende)  $76.9 \pm 2.3$  m.y.

Boulder batholith. Coarse-grained quartz monzonite (along US Route 10 2.7 mi W of intersection with Montana Route 41; Jefferson Co., MT), composed of plagioclase, orthoclase (partially altered), quartz, biotite, hornblende (abundant feldspar and opaque inclusions). Analytical data: (Biotite, 5% impurities) K = 5.72%;  $Ar^{40} = 7.96 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 79\%$ . (Hornblende, 2% impurities including biotite) K = 0.694%;  $Ar^{40} = 0.966 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 46\%$ . Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling, et al., 1968. Comment: Compare with other Boulder batholith ages (below).

34. L-952 K-Ar (coarse biotite)  $70.6 \pm 2.1$  m.y.  
(fine biotite)  $70.4 \pm 2.1$  m.y.  
(hornblende)  $80.6 \pm 2.4$  m.y. (a)  
 $78.4 \pm 9.2$  m.y. (b)

Boulder batholith. Coarse-grained quartz monzonite (N of US Route 10 2 mi SE of Butte; Silver Bow Co., MT), composed of plagioclase (altered), orthoclase (partial alteration), quartz, biotite (chlorite along cleavage), hornblende (plagioclase and quartz inclusions). Analytical data: (Biotite, +20 mesh, 15% chlorite) K = 6.34%;  $Ar^{40} = 8.09 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 87\%$ . (Biotite, 80-100 mesh, 5% hornblende) K = 4.97%;  $Ar^{40} = 6.33 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 57\%$ . (Hornblende, 80-100 mesh, 2% biotite) K = 0.477%; (a)  $Ar^{40} = 0.697 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 78\%$ ; (b)  $Ar^{40} = 0.678 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 13\%$ . Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling, et al., 1968. Comment: Compare with other Boulder batholith ages (above and below).

35. L-1023 K-Ar (biotite)  $77.3 \pm 2.3$  m.y.  
(hornblende)  $77.4 \pm 2.3$  m.y.

Boulder batholith. Medium-grained, slightly porphyritic diorite (along Montana Route 43 just W of Divide; Silver Bow Co., MT), composed of hornblende (severely resorbed, loaded with inclusions and poikiliths of feldspar and biotite), biotite (less common but with same characteristics, some chlorite development) phenocrysts, in a groundmass of plagioclase (abundant laths), orthoclase. Analytical data: (Biotite, 12%

chlorite, 60-100 mesh)  $K = 5.83\%$ ,  $^{40}\text{Ar}^* = 8.16 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 57\%$ . (Hornblende, 2% biotite and chlorite, 60-100 mesh)  $K = 0.450\%$ ,  $0.459\%$ ;  $^{40}\text{Ar}^* = 0.637 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 56\%$ .  
Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling, et al. 1968. Comment: Compare with other Boulder batholith ages (above and below).

36. L-1024 K-Ar (biotite) 68.1±2.0 m.y.  
 (hornblende) 69.2±2.1 m.y.

Boulder batholith. Porphyritic quartz monzonite (along forest service road 3.2 mi E of US Route 91 and 11 mi S of US Route 10, MT), composed of quartz, microcline (inclusions of plagioclase and biotite), and biotite phenocrysts in a groundmass of plagioclase, quartz, orthoclase, biotite (some chloritization), hornblende (uncommon in section). Analytical data: (Biotite, 3% chlorite)  $K = 6.91\%$ ;  $^{40}\text{Ar}^* = 8.50 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 82\%$ . (Hornblende, 2% biotite)  $K = 1.07\%$ ;  $^{40}\text{Ar}^* = 1.34 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 69\%$ .  
Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling, et al, 1968. Comment: Compare with other Boulder batholith ages (above and below).

- 36A. L-1025 K-Ar (biotite) 72.7±2.2 m.y. (a)  
71.8±2.2 m.y. (b)

Boulder batholith. Porphyritic quartz monzonite(?) (NE/4 SW/4 Sec. 33, T10N, R5W; along US Route 12, 5 mi E of McDonald Pass; Helena 15' quadrangle; Lewis and Clark Co., MT), composed of plagioclase, orthoclase, hornblende (rare, severely altered to biotite), biotite (primary) phenocrysts in a groundmass of quartz, orthoclase, biotite. Analytical data:  $K = 7.10\%$ ; (a)  $^{40}\text{Ar}^* = 9.39 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 78\%$ ; (b)  $^{40}\text{Ar}^* = 9.26 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 83\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling et al, 1968. Comment: Compare with other Boulder batholith ages (above and below).

37. L-1116 K-Ar (biotite) 75.2±2.3 m.y.  
 (hornblende) 75.1±2.3 m.y.

Boulder batholith. Coarse-grained quartz monzonite (SW/4 SW/4 Sec. 3, T3N, R7W; along US Route 91, 3 mi NE of Butte; Elk Park 15' quadrangle; Silver Bow Co., MT), composed of plagioclase, quartz, orthoclase (somewhat sericitic), biotite (some grains partially chloritic), hornblende (magnetite inclusions). Analytical data: (Biotite, 18% chlorite, <5% hornblende)  $K = 6.89\%$ ;  $^{40}\text{Ar}^* = 9.38 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 79\%$ . (Hornblende, pure, 60-100 mesh)  $K = 0.432\%$ ;  $^{40}\text{Ar}^* = 0.587 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 53\%$ . Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling, et al. 1968. Comment: Compare with other Boulder batholith ages (above and below).

38. L-1117 K-Ar (biotite) 76.0±2.3 m.y. (a)  
73.2±2.2 m.y. (b)  
 (hornblende) 81.7±2.7 m.y.

Boulder batholith. Coarse-grained quartz monzonite (SW/4 SW/4 Sec. 21, T5N, R6W; along US Route 91, 13.2 mi NE of Butte; Elk Park 15' quadrangle; Jefferson Co., MT), composed of plagioclase, orthoclase (minor sericite), biotite (occasional chlorite grains), hornblende. Analytical data: (Biotite, pure)  $K = 7.43\%$ ; (a)  $^{40}\text{Ar}^* = 10.2 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 89\%$ ; (b)  $^{40}\text{Ar}^* = 9.84 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 93\%$ . (Hornblende, pure)  $K = 0.519\%$ ;  $^{40}\text{Ar}^* = 0.769 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 39\%$ . Collected by: F. W. McDowell, Columbia Univ. Cited: Tilling, et al, 1968. Comment: Compare with other Boulder batholith ages (above).

39. L-1020 K-Ar (hornblende) 49.3±2.2 m.y.

Judith Mountains pluton. Porphyritic diorite (SW/4 NW/4 Sec. 6, T16N, R20 E; along Warm Spring Creek 3/4 mi W of Maiden; Judith Peak 15' quadrangle; Fergus Co., MT), composed of orthoclase (badly sericitized), hornblende (altered at edges) phenocrysts in a groundmass of orthoclase, hornblende, plagioclase, quartz(?),

much sericite. Analytical data: K = 0.490%;  $\text{Ar}^{40} = 0.434 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 28\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ.

40. L-1021 K-Ar (biotite) 41.2±1.2 m.y.  
(hornblende) 44.9±1.3 m.y.

Little Belt Mountains pluton. Porphyritic syenite(?) (111°38'11"W, 47°04'52"N; ½ mi NE of Barker; Fort Benton 60' quadrangle; Chouteau Co., MT), composed of orthoclase (moderately sericitized), plagioclase phenocrysts in a groundmass of biotite, hornblende (feldspar inclusions, some alteration to biotite), quartz. Analytical data: (Biotite, pure, 60-100 mesh) K = 6.93%;  $\text{Ar}^{40} = 5.12 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 74\%$ . (Hornblende, 5% impurities, 60-100 mesh) K = 0.617%;  $\text{Ar}^{40} = 0.480 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 45\%$ . Collected by: F. W. McDowell, Columbia Univ.

41. L-1118 K-Ar (biotite) 71.9±2.2 m.y. (a)  
73.4±2.2 m.y. (b)  
(hornblende) 118±4 m.y. (a)  
118±4 m.y. (b)

Tobacco Root batholith. Medium-grained quartz monzonite (SW/4 NW/4 Sec. 35, T3S, R1W; along Montana Route 287A, 2 mi S of Norris; Norris 15' quadrangle; Madison Co., MT), composed of plagioclase (largest grains), quartz, orthoclase, biotite, hornblende (abundant inclusions and voids, some biotite alteration). Analytical data: (Biotite, 20% chlorite) K = 6.34%, 6.31%; (a)  $\text{Ar}^{40} = 8.22 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 90\%$ ; (b)  $\text{Ar}^{40} = 8.40 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 74\%$ . (Hornblende, 2% impurities including biotite) K = 0.704%; (a)  $\text{Ar}^{40} = 1.53 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 72\%$ ; (b)  $\text{Ar}^{40} = 1.53 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 78\%$ . Collected by: F. W. McDowell, Columbia Univ. Comment: Discordance of biotite and hornblende ages allows several possible interpretations and demands additional data.

42. L-1119 K-Ar (augite) 242±7 m.y.

Libby stock. Porphyritic syenite (SW/4 SE/4 Sec. 32, T31N, R31W; about 6 mi N of Libby; Libby 30' quadrangle; Lincoln Co., MT), composed of orthoclase phenocrysts in a groundmass of plagioclase, augite (altered to hornblende around edges), primary hornblende(?), orthoclase. Analytical data: K = 0.108%, 0.106%;  $\text{Ar}^{40} = 0.490 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 63\%$ ; analyzed separate contained 2% impurities. Collected by: F. W. McDowell, Columbia Univ.

#### E. Intrusive Rocks—Nevada

43. L-969 K-Ar (biotite) 37.0±1.1 m.y.

Fine-grained, porphyritic rhyolite intrusive (SW/4 SE/4 Sec. 9, T16N, R62E: drill core from N side of Liberty Pit, near Ruth; Ruth 7½' quadrangle; White Pine Co., NV), composed of quartz, biotite, plagioclase (sericite along cracks) phenocrysts in a groundmass of quartz, orthoclase, biotite. Analytical data: K = 7.38%;  $\text{Ar}^{40} = 4.89 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 86\%$ ; analyzed separate (80-100 mesh) was pure. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967.

44. L-958 K-Ar (hornblende) 103±3 m.y.

Fine-grained porphyritic monzonite cutting Liberty Pit stock (SE/4 NE/4 Sec. 16, T16N, R62E; Liberty Pit, near Ruth; Riepetown 7½' quadrangle; White Pine Co., NV), composed of plagioclase, orthoclase (strong sericitization), hornblende (incipient sericite and chlorite) phenocrysts, in a groundmass of orthoclase, plagioclase, quartz(?), hornblende. Analytical data: K = 1.28%;  $\text{Ar}^{40} = 2.40 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 87\%$ ; analyzed separate contained 2% feldspar. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Compare with Liberty Pit stock ages (below).

45. L-959 K-Ar (hornblende) 109±3 m.y. (a)  
108±3 m.y. (b)

Lane Valley stock. Porphyritic monzonite (SW/4 SE/4 Sec. 7, T16N, R63E; along US Route 50, 2 mi W of Ely; Ruth 7½' quadrangle; White Pine Co., NV), composed of plagioclase (strongly zoned), orthoclase, hornblende (resorbed, many inclusions) phenocrysts in a groundmass of orthoclase, plagioclase, quartz. Analytical data: K = 1.11%; (a)  $\text{Ar}^{40} = 2.22 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 63\%$ ; (b)  $\text{Ar}^{40} = 2.19 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 61\%$ ; analyzed separate contained 5% impurities. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Compare with ages of other intrusives in area (above and below).

46. L-961 K-Ar (hornblende) 109±3 m.y.

Weary Flat stock. Medium-grained monzonite (SE/4 NE/4 Sec. 8, T16N, R62E; along Nevada Route 44, 1½ mi SW of Ruth; Riepetown 7½' quadrangle; White Pine Co., NV), composed of plagioclase (large crystals), orthoclase, hornblende (inclusions of plagioclase and sphene), quartz. Analytical data: K = 0.688%;  $\text{Ar}^{40} = 1.37 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 89\%$ ; analyzed separate contained 2% impurities. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Compare with ages of other intrusives in area (above and below).

47. L-960 K-Ar (hornblende) 107±4 m.y.

Liberty Pit stock. Porphyritic monzonite (SW/4 SE/4 Sec. 9, T16N, R62E; Liberty open-pit copper mine, near Ruth; Ruth 7½' quadrangle; White Pine Co., NV), composed of plagioclase, hornblende (plagioclase and sphene inclusions) phenocrysts in a groundmass of orthoclase, plagioclase, quartz. Analytical data: K = 1.01%;  $\text{Ar}^{40} = 1.98 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 38\%$ ; analyzed separate (60-100 mesh) contained 5% impurities. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Compare with other ages of Liberty Pit stock (below).

48. L-962 K-Ar (biotite) 115±3 m.y.  
(hornblende) 107±3 m.y.

Liberty Pit stock. Porphyritic monzonite (NW/4 NE/4 Sec. 16, T16N, R62E; drill core from Liberty open-pit copper mine, near Ruth; Riepetown 7½' quadrangle; White Pine Co., NV), composed of orthoclase, plagioclase, quartz, hornblende (many small inclusions) phenocrysts in a groundmass of orthoclase, quartz, biotite (subordinate to hornblende, occasionally chloritic). Analytical data: (Biotite, 5% hornblende) K = 5.35%;  $\text{Ar}^{40} = 11.2 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 91\%$ . (Hornblende, pure) K = 0.836%;  $\text{Ar}^{40} = 1.64 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 90\%$ . Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Compare with other ages of Liberty Pit stock (above and below).

49. L-1013 K-Ar (biotite) 111±3 m.y.

Liberty Pit stock. Highly-altered monzonite porphyry (SE/4 SE/4 Sec. 9, T16N, R62E; NE corner, Liberty open-pit copper mine, near Ruth; Ruth 7½' quadrangle; White Pine Co., NV), composed of orthoclase (only occasional fresh grains), quartz, biotite (light brown, clustered) phenocrysts in a groundmass of quartz, sericite. Analytical data: K = 7.39%;  $\text{Ar}^{40} = 15.0 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 90\%$ ; analyzed separate (80-100 mesh) contained 2% impurities. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Agrees with ages of unaltered Liberty Pit stock (above).

50. L-1014 K-Ar (biotite) 109±3 m.y.

Altered monzonite porphyry (SW/4 SW/4 Sec. 9, T16N, R62E; Emma open-pit copper mine, near Ruth;



Riepetown 7½' quadrangle; White Pine Co., NV), composed of orthoclase (well sericitized), quartz, biotite (very light brown, clustered) phenocrysts in a groundmass of quartz and sericite. Analytical data: K = 8.35%;  $\bar{A}r^{40} = 16.6 \times 10^{-10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 96\%$ ; analyzed separate (80-100 mesh) contained 5% impurities. Collected by: H. L. Bauer, Jr., Kennecott Copper Corp. Cited: McDowell and Kulp, 1967. Comment: Agrees with ages of altered Liberty Pit stock (above).

51. L-1040 K-Ar (biotite) 147±4 m.y.  
(hornblende) 140±5 m.y.

Contact stock. Porphyritic granodiorite (along US Route 93, 1 mi S of Contact; Elko Co., NV), composed of plagioclase (zoned, patchy sericitization) phenocrysts in a groundmass of orthoclase, plagioclase, quartz, biotite (some chloritic grains), hornblende (quartz and feldspar inclusions). Analytical data: (Biotite, 1% chlorite, 5-10% hornblende) K = 6.36%;  $\bar{A}r^{40} = 17.2 \times 10^{-10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 85\%$ . (Hornblende, 2% biotite) K = 0.492%;  $\bar{A}r^{40} = 1.27 \times 10^{-10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 42\%$ . Collected by: F. W. McDowell, Columbia Univ.

- 51A. L-1041 K-Ar (biotite) 21.8±0.7 m.y.

North Humboldt Mts. intrusive. Medium-grained granodiorite (8 mi SW of Wells; Elko Co., NV), composed of plagioclase, orthoclase, quartz, biotite (some grains partly chloritic), hornblende (minor). Analytical data: K = 6.50%;  $\bar{A}r^{40} = 2.53 \times 10^{-10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 66\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ.

52. L-1042 K-Ar (biotite) 124±5 m.y.

Silver Zone pluton. Medium-grained granite (along US Route 40, 1 mi E of summit, Silver Zone Pass; Elko Co., NV), composed of microcline, quartz, plagioclase (patchy sericite), biotite (somewhat chloritic), hornblende. Analytical data: K = 6.20%;  $\bar{A}r^{40} = 14.1 \times 10^{-10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 86\%$ ; analyzed separate contained 24% chlorite, 10% hornblende. Collected by: F. W. McDowell, Columbia Univ.

#### F. Intrusive Rocks—New Mexico

53. L-849 K-Ar (biotite) 58.9±1.8 m.y.  
(hornblende) 56.5±1.7 m.y.

Coarse-grained granodiorite dike in Santa Rita stock (NE/4 SE/4 Sec. 27, T17S, R12W; drill core from North Pit, Santa Rita Copper Mine; Santa Rita 7½' quadrangle; Grant Co., NM). Composed of plagioclase, microcline, quartz, biotite (some chloritization), hornblende (chlorite along cleavage planes, magnetite inclusions), hypersthene (minor amounts). Analytical data: (Biotite, 25% chlorite, minor hornblende) K = 4.59%;  $\bar{A}r^{40} = 4.87 \times 10^{-10}$  mole/gm;  $\bar{A}r/\Sigma Ar^{40} = 62\%$ . (Hornblende, 5% impurities) K = 0.754%, 0.761%;  $\bar{A}r^{40} = 0.771 \times 10^{-10}$  mole/gm;  $\bar{A}r^{40}/\Sigma Ar^{40} = 74\%$ . Collected by: B. Adams, Kennecott Copper Corp. Comment: Compare with ages of Santa Rita stock (below).

54. L-852 K-Ar (biotite) 55.9±1.7 m.y. (a)  
58.2±1.7 m.y. (b)

Santa Rita stock. Porphyritic granodiorite(?) (NE/4 SE/4 Sec. 27, T17S, R12W; North Pit, Santa Rita Copper Mine; Santa Rita 7½' quadrangle; Grant Co., NM), composed of plagioclase (zoned, clouded), microcline (commonly sericitized), biotite (slightly chloritic) phenocrysts in a groundmass of quartz, orthoclase,



biotite (very chloritic). Analytical data: K = 6.02%, 5.89%, 6.01%; (a)  $^{40}\text{Ar}^*$  =  $6.01 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 72\%$ ; (b)  $^{40}\text{Ar}^*$  =  $6.26 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 66\%$ ; analyzed separate (20-40 mesh), 15% chlorite. Collected by: B. Adams, Kennecott Copper Corp., and F. W. McDowell, Columbia Univ.

55. L-851A K-Ar (hornblende) 70.4±2.1 m.y.

Hanover-Fierro stock. Coarse, equigranular granodiorite (SW/4 SW/4 Sec. 10, T17S, R12W; along Hanover Creek ½ mi S of Fierro; Santa Rita 7½' quadrangle; Grant Co., NM), composed of plagioclase (partially altered), microcline, quartz, biotite (slight chlorite around edges and within grains), hornblende (mosaic of hornblende, chlorite, magnetite and sericite). Analytical data: K = 0.555%;  $^{40}\text{Ar}^*$  =  $0.707 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 60\%$ ; analyzed separate contained <1% biotite, 5% other impurities. Collected by: F. W. McDowell, Columbia Univ. Comment: Compare with other Hanover-Fierro stock dates (below).

56. L-851B K-Ar (biotite) 57.1±2.0 m.y.  
(hornblende) 67.2±2.9 m.y.

Hanover-Fierro stock. Coarse, equigranular granodiorite (SW/4 SW/4 Sec. 10, T17S, R12W; along Hanover Creek ½ mi S of Fierro; Santa Rita 7½' quadrangle; Grant Co., NM), composed of plagioclase (partially altered), microcline, quartz, biotite (slight chlorite around edges and within grains), hornblende (mosaic of hornblende, chlorite, magnetite and sericite). Analytical data: (Biotite, pure) K = 6.78%;  $^{40}\text{Ar}^*$  =  $6.28 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 69\%$ . (Hornblende, 2% quartz and biotite) K = 0.390%;  $^{40}\text{Ar}^*$  =  $0.473 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 29\%$ . Collected by: F. W. McDowell, Columbia Univ. Comment: Same outcrop as L-851A; compare with other Hanover-Fierro stock dates (above and below).

57. L-1017 K-Ar (biotite) 58.0±1.8 m.y.  
(hornblende) 58.4±1.8 m.y.

Hanover-Fierro stock. Porphyritic granodiorite (NE/4 SW/4 Sec. 15, T17S, R12W; gulch ¼ mi E of Hanover Creek; Santa Rita 7½' quadrangle; Grant Co., NM), composed of plagioclase, orthoclase, hornblende (many small quartz, feldspar, and magnetite inclusions), biotite phenocrysts in a groundmass of quartz, orthoclase, biotite (small amount). Analytical data: (Biotite, 10% impurities) K = 4.97%;  $^{40}\text{Ar}^*$  =  $5.19 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 65\%$ . (Hornblende, 5% impurities including biotite) K = 0.830%;  $^{40}\text{Ar}^*$  =  $8.73 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 63\%$ . Collected by: F. W. McDowell, Columbia Univ. Comment: Compare with other Hanover-Fierro stock dates (above).

58. L-1015 K-Ar (biotite) 56.2±1.7 m.y.

Tyrone stock. Coarse-grained quartz monzonite (NE/4 SE/4 Sec. 20, T19S, R15W; ¾ mi WSW of Tyrone; Wind Mountain 7½' quadrangle; Grant Co., NM), composed of orthoclase, quartz, plagioclase (sericitized along cracks), biotite. Analytical data: K = 6.33%;  $^{40}\text{Ar}^*$  =  $6.41 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 80\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ.

59. L-1016 K-Ar (hornblende) 58.6±1.8 m.y.

Porphyritic diorite (NW/4 SW/4 Sec. 26, T17S, R13W; along US Route 180, 1 mi W of Central; Fort Bayard 7½' quadrangle; Grant Co., NM), composed of plagioclase (badly sericitized), hornblende (at least 50% altered to quartz and sericite), quartz phenocrysts in a groundmass of plagioclase, quartz. Analytical data: K = 0.770%;  $^{40}\text{Ar}^*$  =  $0.813 \times 10^{-10}$  mole/gm;  $^{40}\text{Ar}^*/\Sigma\text{Ar}^{40} = 50\%$ ; analyzed separate (60-100 mesh) contained abundant feldspar. Collected by: F. W. McDowell, Columbia Univ.

60. L-1052 K-Ar (hornblende)  $80.0 \pm 2.4$  m.y. (a)  
 $72.6 \pm 2.2$  m.y. (b)  
 $69.1 \pm 2.1$  m.y. (c)

Pinos Altos intrusive complex. Porphyritic granodiorite (NW/4 SE/4 Sec. 6, T17S, R13W; along New Mexico Route 25 just S of Pinos Altos; Fort Bayard  $7\frac{1}{2}'$  quadrangle; Grant Co., NM), composed of plagioclase, orthoclase phenocrysts in a groundmass of quartz, orthoclase, plagioclase, hornblende, (intergrowths of feldspar and quartz), biotite (almost entirely chlorite). Analytical data: K = 0.506%; (a)  $\overset{*}{\text{Ar}}^{40} = 0.733 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 44\%$ ; (b)  $\overset{*}{\text{Ar}}^{40} = 0.655 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 65\%$ ; (c)  $\overset{*}{\text{Ar}}^{40} = 0.632 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 57\%$ ; analyzed separate contained 2% impurities including biotite. Collected by: F. W. McDowell, Columbia Univ. Comment: First argon result is probably aberrant.

- 60A. L-1111 K-Ar (biotite)  $33.4 \pm 1.0$  m.y.

Kneeling Nun volcanics. Rhyolitic ignimbrite (NW/4 Sec. 9, T18S, R12W; Lucky Bill Canyon  $1\frac{1}{2}$  mi S of Santa Rita Copper Mine pit; Grant Co., NM), composed of quartz, plagioclase, sanidine, biotite phenocrysts in a fine-grained groundmass. Analytical data: K = 7.06%;  $\overset{*}{\text{Ar}}^{40} = 4.22 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 73\%$ ; analyzed separate was pure. Collected by: D. Giles, Univ. New Mexico.

61. L-1051 K-Ar (biotite)  $26.6 \pm 0.8$  m.y.

Bonita Lake stock. Medium-grained syenite (9 mi NNW of Ruidoso; Lincoln Co., NM), composed of orthoclase (very sericitic), plagioclase, biotite (quite fresh), quartz, hornblende(?) (severely altered). Analytical data: K = 7.44%;  $\overset{*}{\text{Ar}}^{40} = 3.54 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 75\%$ ; analyzed separate contained 2% impurities. Collected by: T. Thompson, Univ. New Mexico.

#### G. Intrusive Rocks—South Dakota and Wyoming

62. L-946 K-Ar (biotite)  $56.8 \pm 1.7$  m.y.  
(aegirine-augite)  $54.3 \pm 1.7$  m.y.

Homestake Mine phonolite. Porphyritic phonolite dike (SE/4 NW/4 Sec. 34, T5N, R3E; drill core from 5150-ft level in Homestake Mine, Lead; Deadwood South  $7\frac{1}{2}'$  quadrangle; Lawrence Co., SD), consisting of aegirine-augite, biotite (strongly resorbed), and orthoclase phenocrysts in a groundmass of plagioclase and aegirine-augite. Analytical data: (Biotite, 5% aegirine-augite) K = 7.20%;  $\overset{*}{\text{Ar}}^{40} = 7.36 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 81\%$ . (Aegirine-augite, 2% biotite) K = 0.354%, 0.344%;  $\overset{*}{\text{Ar}}^{40} = 0.349 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 39\%$ . Collected by: A. Slaughter, Homestake Mining Co.

63. L-948 K-Ar (biotite)  $49.4 \pm 1.5$  m.y.

Sheep Mountain stock. Porphyritic quartz monzonite ( $103^{\circ}45'10''\text{W}$ ,  $44^{\circ}23'37''\text{N}$ ; along road to Mount Roosevelt summit  $2\frac{3}{4}$  mi N of Lead; Spearfish  $15'$  quadrangle; Lawrence Co., SD), composed of orthoclase, quartz, plagioclase (slightly altered), biotite phenocrysts in a groundmass of quartz and orthoclase. Analytical data: K = 7.97%;  $\overset{*}{\text{Ar}}^{40} = 5.04 \times 10^{-10}$  mole/gm;  $\overset{*}{\text{Ar}}^{40}/\Sigma\text{Ar}^{40} = 80\%$ ; analyzed separate contained 2% impurities. Collected by: F. W. McDowell, Columbia Univ.

64. L-1053 K-Ar (biotite)  $58.9 \pm 1.8$  m.y.

Gilt Edge Mine pluton. Porphyritic monzonite (NE/4 SE/4 Sec. 12, T4N, R3E; 4 mi ESE of Lead; Deadwood

South 7½' quadrangle; Lawrence Co., SD), composed of plagioclase, orthoclase (incipient sericitization), biotite (primary), hornblende (entirely altered to chlorite, magnetite, biotite, sericite) phenocrysts in a groundmass of orthoclase, sericite. Analytical data: K = 6.68%;  $\text{Ar}^{40} = 7.10 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 66\%$ ; analyzed separate contained 2% impurities. Collected by: F. W. McDowell, Columbia Univ.

65. L-1112 K-Ar (biotite) 50.9±1.5 m.y.

Bear Butte laccolith. Porphyritic quartz monzonite (NW/4 NW/4 Sec. 20, T6N, R6E; Bear Butte, 6 mi NE of of Sturgis; Fort Meade 7½' quadrangle; Meade Co., SD), composed of orthoclase, biotite (slender, well formed grains), quartz phenocrysts in a well sericitized groundmass of quartz, plagioclase, orthoclase(?) biotite. Analytical data: K = 6.66%;  $\text{Ar}^{40} = 6.07 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 54\%$ ; analyzed separate contained 2% impurities. Collected by: F. W. McDowell, Columbia Univ.

66. L-1113 K-Ar (biotite) 55.9±1.7 m.y.

Vannocker laccolith. Porphyritic quartz monzonite (SE/4 NW/4 Sec. 8, T4N, R5E; along South Dakota Route 135 about 6 mi SSW of Sturgis; Deadman Mtn. 7½' quadrangle; Meade Co., SD), composed of plagioclase, biotite (corroded around edges), orthoclase phenocrysts in a groundmass of quartz, orthoclase (very sericitic), biotite. Analytical data: K = 6.17%;  $\text{Ar}^{40} = 6.21 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 62\%$ ; analyzed separate (60-100 mesh) contained 10% impurities. Collected by: F. W. McDowell, Columbia Univ.

67. L-1114 K-Ar (aegirine) 57.1±4.3 m.y.

Terry Peak pluton. Porphyritic grorudite (103°49'50"W, 44°19'42"N; from a large boulder along Route 194 just below Terry Peak lookout; Spearfish 15' quadrangle; Lawrence Co., SD), composed of orthoclase (badly sericitized), aegirine, hornblende(?) phenocrysts in a groundmass of orthoclase, plagioclase(?), sericite. Analytical data: K = 0.596%;  $\text{Ar}^{40} = 0.613 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 19\%$ ; analyzed separate (60-100 mesh) was pure. Collected by: F. W. McDowell, Columbia Univ.

68. L-949 K-Ar (hornblende and aegirine-augite) 38.8±2.1 m.y.

Bear Lodge pluton. Porphyritic syenite (NW/4 SE/4 Sec. 20, T52N, R63W; just S of observation tower near end of paved road, Bear Lodge Mts.; Sundance 15' quadrangle; Crook Co., WY), composed of orthoclase, hornblende (many inclusions), aegirine-augite, biotite (rare) phenocrysts in a groundmass of orthoclase and sericite. Analytical data: K = 0.497%;  $\text{Ar}^{40} = 0.346 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 25\%$ ; analyzed separate (60-100 mesh) contained 5% impurities. Collected by: F. W. McDowell, Columbia Univ. Comment: Compare with other Bear Lodge pluton date (below).

69. L-950 K-Ar (augite and hornblende) 48.9±1.6 m.y.

Bear Lodge pluton. Porphyritic syenite (SW/4 SW/4 Sec. 28, T52N, R63W; 1.3 mi S of observation tower near end of paved road, Bear Lodge Mts.; Sundance 15' quadrangle; Crook Co., WY), composed of plagioclase (cloudy, partially resorbed), hornblende (corroded, partially converted to biotite and magnetite), augite phenocrysts in a groundmass of feldspar, sericite, biotite (secondary?), magnetite. Analytical data: K = 0.420%;  $\text{Ar}^{40} = 0.369 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 42\%$ ; analyzed separate (60-100 mesh) was pure. Collected by: F. W. McDowell, Columbia Univ. Comment: Compare with other Bear Lodge pluton date (above).

70. L-1018 K-Ar (augite) 54.3±2.2 m.y.

Black Buttes stock. Porphyritic monzonite (SE/4 SW/4 Sec. 23, T50N, R62W; head of Fish Canyon 9 mi SE of Sundance; Sundance 15' quadrangle; Crook Co., WY), composed of orthoclase (large grains), plagioclase, augite phenocrysts in a groundmass of orthoclase, augite. Analytical data: K = 0.173%, 0.170%;  $\text{Ar}^{40} =$

$0.168 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 30\%$ ; analyzed separate contained 5% impurities. Collected by: F. W. McDowell, Columbia Univ.

71. L-1115 K-Ar (aegirine)  $49.6 \pm 1.7$  m.y.  
 Missouri Buttes pluton. Porphyritic phonolite ( $104^{\circ}45'54''\text{W}$ ,  $44^{\circ}37'30''\text{N}$ ; NW side of Missouri Buttes; Devils Tower 30' quadrangle; Crook Co., WY), composed of orthoclase, nepheline, aegirine phenocrysts in a groundmass of sericite. Analytical data: K = 0.162%;  $\text{Ar}^{40} = 0.145 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 35\%$ ; analyzed separate (80-100 mesh) contained 2% impurities. Collected by: F. W. McDowell, Columbia Univ.
72. L-1019 K-Ar (phlogopite)  $1.1 \pm 0.4$  m.y.  
 Leucite Hills pluton. Porphyritic orendite(?) (NW/4 SE/4 Sec. 15, T21N, R102W; from Zirkel Mesa,  $6\frac{1}{2}$  mi NW of Superior; Superior 15' quadrangle; Sweetwater Co., WY), composed of phlogopite (fresh but strongly resorbed) phenocrysts in a groundmass of leucite, diopside, sanidine(?). Analytical data: K = 8.46%;  $\text{Ar}^{40} = 0.163 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 5\%$ ; analyzed separate was pure. Collected by: F. W. McDowell, Columbia Univ.

#### H. Intrusive Rocks—Utah

73. L-970 K-Ar (biotite)  $21.8 \pm 0.7$  m.y.  
 Marysvale stock. Medium-grained quartz monzonite (NE/4 NE/4 Sec. 4, T27S, R3W; dump of Prospector Mine, NE of Marysvale; Marysvale 15' quadrangle; Piute Co., UT), composed of plagioclase, orthoclase (cloudy), quartz, biotite (some grains completely altered to sericite, magnetite, chlorite), hornblende (badly altered to biotite, chlorite). Analytical data: K = 7.54%;  $\text{Ar}^{40} = 2.93 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 73\%$ ; analyzed separate contained 2% chlorite. Collected by: F. W. McDowell, Columbia Univ.
74. L-972 K-Ar (hornblende)  $30.0 \pm 3.0$  m.y.  
 Porphyritic monzonite dike (SW/4 NE/4 Sec. 29, T26S, R4W; along US Route 89 about 4 mi N of Marysvale; Sevier 15' quadrangle; Piute Co., UT), composed of plagioclase (local sericitization), hornblende (completely altered to biotite, chlorite, quartz, etc.—occasionally a well preserved grain) phenocrysts in a groundmass of very fine chlorite, sericite, magnetite. Analytical data: K = 0.606%;  $\text{Ar}^{40} = 0.325 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 15\%$ ; analyzed separate (60-100 mesh) contained 5% impurities. Collected by: F. W. McDowell, Columbia Univ.
75. L-973 K-Ar (biotite)  $36.9 \pm 1.1$  m.y.  
 Porphyritic quartz latite dike in Bingham stock (SW/4 SE/4 Sec. 26, T3S, R3W; Bingham open-pit copper mine; Bingham Canyon  $7\frac{1}{2}$ ' quadrangle; Salt Lake Co., UT), composed of quartz, biotite (well developed, rich brown) feldspar (completely sericitized) phenocrysts in a groundmass of quartz and sericite. Analytical data: K = 8.13%, 7.94%;  $\text{Ar}^{40} = 5.31 \times 10^{-10}$  mole/gm;  $\text{Ar}^{40}/\Sigma\text{Ar}^{40} = 64\%$ ; analyzed separate contained 2% impurities. Collected by: W. C. Peters, Kennecott Copper Corp. Comment: Compare with Bingham stock date (below). This and L-974 (below) are from dikes cutting the main intrusive phase at Bingham but pre-dating the mineralization. Although the main intrusive phases at Bingham contain both primary and secondary biotite, the biotite from these dikes is primary (W. C. Peters, written communication). However, the profound hydrothermal event may have lowered the biotite ages. See also comments for L-975.
76. L-974 K-Ar (biotite)  $36.9 \pm 1.1$  m.y.  
 Porphyritic biotite latite dike in Bingham stock (NW/4 NW/4 Sec. 35, T3S, R3W; Bingham open-pit copper



mine; Bingham 7½' quadrangle; Salt Lake Co., UT), composed of biotite (commonly green), plagioclase (rare, partially altered) phenocrysts in a groundmass of quartz, biotite (green), sericite. Analytical data: K = 7.78%;  $Ar^{40} = 5.14 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 73\%$ ; analyzed separate contained 2% impurities. Collected by: W. C. Peters, Kennecott Copper Corp. Comment: See L-973 (above).

77. L-975 K-Ar (biotite) 40.5±1.3 m.y.

Last Chance stock. Medium-grained quartz monzonite (SW/4 SE/4 Sec. 34, T3S, R3W; 2½ mi SSW of Bingham; Bingham Canyon 7½' quadrangle; Salt Lake Co., UT), composed of plagioclase, orthoclase, quartz, biotite (incipient chloritization), augite(?) (badly corroded with small grains of magnetite, biotite, and sericite along cracks). Analytical data: K = 7.26%;  $Ar^{40} = 5.27 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 37\%$ ; analyzed separate contained 2% impurities. Collected by: W. C. Peters, Kennecott Copper Corp. Comment: The Last Chance stock, adjacent to the Bingham intrusive, has not been hydrothermally altered to any great extent. Thus this age probably reflects the time of emplacement of this stock and (depending on field relationships) possibly the Bingham stock as well, which would leave a 4 m.y. gap between the stocks and the dike-ore formation. Other alternatives are: emplacement of Bingham stock-dike-ore system at 37±1 m.y. or lowering of 40.5 m.y. dike ages by the hydrothermal effects at 37 m.y. or later.

78. L-1038 K-Ar (biotite) 26.7±0.8 m.y.

Little Cottonwood stock. Porphyritic quartz monzonite (111°41'58"W, 40°34'24"N; along Utah Route 210, 5 mi E of canyon mouth, opposite Tanner Flat camp; Dromedary Peak 7½' quadrangle; Salt Lake Co., UT), composed of orthoclase (scattered) phenocrysts in a groundmass of plagioclase (patchy sericitization), quartz, orthoclase, biotite (moderate chloritization). Analytical data: K = 6.17%;  $Ar^{40} = 2.94 \times 10^{-10}$  mole/gm;  $Ar^{40}/\Sigma Ar^{40} = 62\%$ ; analyzed separate contained 37% chlorite. Collected by: F. W. McDowell, Columbia Univ.

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