U.S. Geological Survey radiometric ages—compilation "C" Part five: Colorado, Montana, Utah, and Wyoming

R.H. Marvin, H.H. Mehnert, C.W. Naeser, and R.E. Zartman

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U.S. GEOLOGICAL SURVEY RADIOMETRIC AGES—COMPILATION "C"
Part five: Colorado, Montana, Utah, and Wyoming

RICHARD F. MARVIN
HARALD H. MEHNERT
CHARLES W. NAESER
ROBERT E. ZARTMAN

U.S. Geological Survey, Federal Center, Denver, CO 80225

This is part five of the third compilation of a planned series of age determinations by the U.S. Geological Survey appearing in Isochron/West. It contains both unpublished and published dates. However, the latter ages lacked either a specific sample location, petrologic information, or analytical data in their published form. Such specifics are often needed for evaluation and utilization of an isotopic age. That, we believe, is the value of this compilation—it supplies such information for most of the listed samples. Users are warned to use these ages with discretion as they constitute only a part of the total geologic picture in any particular area. For ease of reference, samples are grouped together by state.

Some of the listed ages are spurious due to the presence of xenocrystic material, excess radiogenic argon, mineral alteration, diffusion of radiogenic argon, etc. If the age is recognized as being spurious, this fact is mentioned. In a number of cases, we have insufficient information, geologic or otherwise, to accurately evaluate the listed age. The spurious mineral ages are of value in that they may indicate to future geochronologists and geologists that there are potential problems in dating certain rocks in that sampled locality.

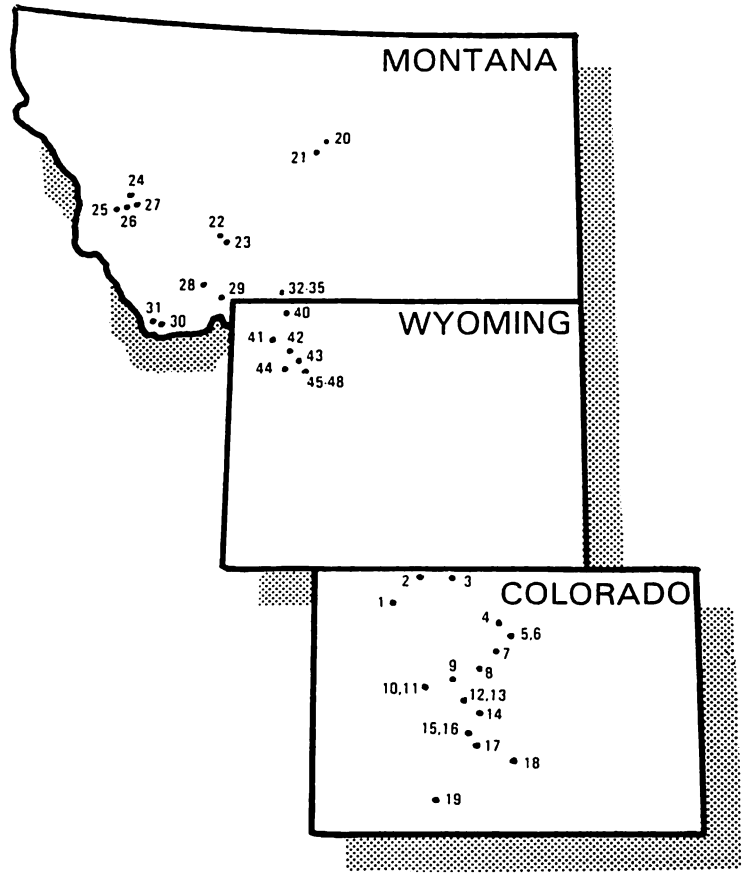
All the ages were determined by U.S. Geological Survey personnel in Denver, Colorado. Analysts are R. F. Marvin, H. H. Mehnert, and E. A. Brandt for K-Ar ages; C. E. Hedge and K. Futa or R. E. Zartman and W. T. Henderson for Rb-Sr ages; R. E. Zartman and M. D. Gallego or L. M. Kwak for U-Th-Pb ages; and C. W. Naeser for fission-track ages. Analytical techniques are not described as these dating methods are fairly common knowledge to most geologists.

The following decay constants, recommended by the IUGS Subcommission on Geochronology were used.

Potassium-40: $\lambda\epsilon = 0.581 \times 10^{-10}$/yr, $\lambda\beta = 4.962 \times 10^{-10}$/yr; atomic abundance is 0.01167 atomic percent

Rubidium-87: $\lambda\beta = 1.42 \times 10^{-11}$/yr

Fission-track: $\lambda = 7.03 \times 10^{-17}$/yr for U^{238}



Geologic index to sample localities in Montana, Wyoming, and Colorado.

SAMPLE DESCRIPTIONS

COLORADO

1. *USGS(D)SS1* K-Ar
Tonstein (40°25'N, 107°39'W; S6,T5N,R91W; near abandoned coal mine, Round Bottom 7.5' quad., Moffat Co., CO). *Analytical data:* K_2O = 0.45, 0.45%; $*Ar^{40}$ = 0.4770 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 69%. *Submitted by:* E. Johnson. *Comment:* Tonstein is in the Williams Fork Formation, Mesaverde Group (Late Cretaceous).
plagioclase 72.2 ± 5.1 Ma

2. *USGS(D)1781-75* U-Th-Pb
Andesine-clinopyroxene-biotite-magnetite-orthoclase diabasic diorite (40°59'25"N, 107°02'35"W; roadcut ¾ miles SE of Three Forks Ranch, just E of Middle Fork of the Little Snake River, Shield Mountain 7.5' quad., Routt Co., CO). *Analytical data:* Zircon (−60+100 mesh): U = 307.0 ppm, Th = 166.9 ppm, Pb = 105.4 ppm; isotopic composition of lead (atomic percent): ^{204}Pb = 0.0035, ^{206}Pb = 78.47, ^{207}Pb = 8.599, ^{208}Pb = 12.92. Isotopic composition of common lead assumed to be ^{204}Pb:^{206}Pb:^{207}Pb:^{208}Pb = 1:15.80:15.35:35.40. *Collected by:* G. L. Snyder. *Comments:* Northwesternmost phase of the gabbro of Elkhorn Mountain shown as Precambrian X (now called Early Proterozoic) gabbro (unit Xe) by Snyder (1980). The zircon from this dark, diabasic diorite phase of the gabbro yields almost concordant

U-Th-Pb ages, of which the $^{207}Pb/^{206}Pb$ age is interpreted to closely approximate the time of emplacement of the pluton.

zircon (−60 +100 mesh) $^{206}Pb/^{238}U$ = 1755 ± 10 Ma
$^{207}Pb/^{235}U$ = 1767 ± 12 Ma
$^{207}Pb/^{206}Pb$ = 1781 ± 20 Ma
$^{208}Pb/^{232}Th$ = 1760 ± 10 Ma

3. *USGS(D)1028* U-Th-Pb
Faintly-layered quartz-microcline-albite-biotite-fluorite granitic gneiss (40°59'14"N, 106°37'58"W; roadcut at crest of Pearl-Hog Park road above incised hairpin curve at 9,200' elevation, Davis Peak 7.5' quad., Jackson Co., CO). *Analytical data:* U = 2455.7 ppm, Th = 973.9 ppm, Pb = 687.0 ppm; isotopic composition of lead (atomic percent): ^{204}Pb = 0.1314, ^{206}Pb = 73.82, ^{207}Pb = 9.014, ^{208}Pb = 17.04. Isotopic composition of common lead assumed to be $^{204}Pb:^{206}Pb:^{207}Pb:^{208}Pb$ = 1:16.10:15.40:35.80. *Collected by:* G. L. Snyder. *Comments:* This presumedly metavolcanic rock is shown as Precambrian X (now called Early Proterozoic) metavolcanics (unit Xgn) by Snyder (1980). Geological relationships require that these felsic volcanic rocks be at least 1,800 Ma; accordingly, the U-Th-Pb isotopic systems of the zircon must either be significantly disturbed, or record, instead, a metamorphic episode superimposed on the original rock. Whether or not the Th-Pb system correctly dates the time of volcanism at 1,887 Ma is unknown.

zircon (−200 +270 mesh) $^{206}Pb/^{238}U$ = 1350 ± 8 Ma
$^{207}Pb/^{235}U$ = 1439 ± 12 Ma
$^{207}Pb/^{206}Pb$ = 1576 ± 18 Ma
$^{208}Pb/^{232}Pb$ = 1887 ± 10 Ma

4. *USGS(D)RD01* (Pearson, 1980) Fission-track
Biotite-quartz-plagioclase porphyry dike (40°08'40"N, 105°36'45"W; NW end of Red Deer Lake, Allens Park 7.5' quad., Boulder Co., CO). *Analytical data:* (6 grains) Ps = 7.50 × 10^6 tracks/cm² (833), Pi = 10.96 × 10^6 tracks/cm² (609), 0 = 1.33 × 10^{15} n/cm², U = 260 ppm. *Collected by:* R. C. Pearson. *Comment:* Published age of 52.6 Ma has been recalculated with revised constants.

zircon 54.2 ± 6.3 Ma

5. *USGS(D)75CS69* K-Ar
Monzonite (39°58'58"N, 105°34'45"W; boundary line between S5 and 8,T1S,R73W; Nederland 7.5' quad., Boulder Co., CO). *Analytical data:* K_2O = 9.13, 9.20%; $*Ar^{40}$ = 8.781 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 86%. *Collected by:* C. Simmons. *Comment:* Calculated age is probable age of emplacement for Caribou stock.

biotite 65.5 ± 2.4 Ma

6. *USGS(D)75CS78* K-Ar
Quartz monzonite (39°57'14"N, 105°36'20"W; SW¼ S18,T1S,R73W; Nederland 7.5' quad., Boulder Co., CO). *Analytical data:* K_2O = 0.79, 0.79%; $*Ar^{40}$ = 0.7993 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 80%. *Collected by:* C. Simmons. *Comment:* The calculated age is the approximate age of emplacement of the Eldora stock.

hornblende 68.2 ± 4.1 Ma

7. *USGS(D)75CS88* K-Ar
Granodiorite (39°45'37"N, 105°40'11"W; NE¼ S28,T3S,R74W; Empire 7.5' quad., Clear Creek Co., CO). *Analytical data:* K_2O = 8.57, 8.71%; $*Ar^{40}$ = 7.796 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 85%. *Collected by:* C. Simmons. *Comment:* Calculated age is approximate age of emplacement for a biotite granodiorite phase of the Empire stock.

biotite 61.6 ± 2.2 Ma

8. *USGS(D)75CS84a* K-Ar
Granodiorite (39°36'18"N, 105°54'55"W; Keystone 7.5' quad., Summit Co., CO). *Analytical data:* K_2O = 9.05, 9.08%; $*Ar^{40}$ = 4.999 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 70%. *Collected by:* C. Simmons. *Comment:* Calculated age is approximate age of emplacement for the Montezuma stock.

biotite 37.9 ± 1.4 Ma

9. *USGS(D)75CS86* K-Ar
Quartz monzonite sill (39°35'28"N, 106°02'20"W; Swan Mountain area, Frisco 7.5' quad., Summit Co., CO). *Analytical data:* K_2O = 7.42, 7.36%; $*Ar^{40}$ = 4.744 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 86%. *Collected by:* C. Simmons. *Comment:* Simmons and Hedge (1978) reported a Rb-Sr biotite-whole-rock isochron age of 45 Ma for this sill.

biotite 44.1 ± 1.6 Ma

10. *W3127* (Wallace and others, 1986) K-Ar
Quartz latite dike (39°27'28"N, 106°34'30"W; T7S,R82W; Holy Cross Wilderness area, Mount Jackson 7.5' quad., Eagle Co., CO). *Analytical data*: K_2O = 7.970% (isotope dilution, K. Futa, analyst, USGS), $*Ar^{40}$ = 7.261 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 87%. *Collected by:* A. R. Wallace. *Comment*: The age of the dike is listed as 61.7 Ma, but should be 62.2 Ma.

biotite 62.2 ± 1.7 Ma

11. *83P100* (Wallace and others, 1986) K-Ar
Monzogranite (39°24'33"N, 106°31'17"W; 850-ft N15°W of outlet of Treasure Vault Lake, Holy Cross Wilderness, Mount Jackson 7.5' quad., Eagle Co., CO). *Analytical data*: K_2O = 7.77, 7.66%; $*Ar^{40}$ = 7.236 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 89%. *Collected by:* R. E. Pearson. *Comment*: Leucocratic, fine- to medium-grained, equigranular to porphyritic monzogranite—part of the intrusive rocks of Treasure Vault Lake (Paleocene).

biotite 64.0 ± 2.3 Ma

12. *USGS(D)G-A-82* K-Ar
(Hedlund and others, 1983; Hedlund, 1985)
Rhyolite porphyry (39°03'50"N, 106°15'19"W; along road on N side of Low Pass Gulch, Granite 7.5' quad., Lake Co., CO). *Analytical data*: K_2O = 4.26, 4.23%; $*Ar^{40}$ = 4.061 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 94%. *Collected by:* D. C. Hedlund. *Comments*: Rhyolite porphyry dike consisting of high-temperature albite phenocrysts (fine-grained) in an aphanitic groundmass; no mafic minerals present.

whole-rock 65.3 ± 2.4 Ma

13. *USGS(D)JH-9-82* K-Ar
(Hedlund and others, 1983; Hedlund, 1985)
Rhyolite porphyry (39°02'10"N, 106°06'30"W; along the E side of Rough-and-Tumbling Creek, Jones Hill 7.5' quad., Park Co., CO). *Analytical data*: K_2O = 8.55, 8.50%; $*Ar^{40}$ = 7.672 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 90%. *Collected by:* D. C. Hedlund.

Comment: Rhyolite porphyry plug containing phenocrysts of albite, quartz, and biotite.

biotite 61.4 ± 2.2 Ma

14. *USGS(D)SBNM-1* K-Ar
Ash-flow tuff (38°49'20"N, 105°56'W; NE¼NE¼ S22,T14S,R77W; Antero Reservoir 15' quad., Chaffee Co., CO). *Analytical data*: (biotite) K_2O = 8.05, 8.05%; $*Ar^{40}$ = 4.358 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 80%; (hornblende) K_2O = 1.425, 1.395% (isotope dilution, K. Futa, analyst, USGS); $*Ar^{40}$ = 0.7861 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 73%. *Collected by:* G. Scott. *Comment*: An andesitic ash-flow tuff (Badger Creek Tuff) which is overlain by Buffalo Peaks andesite and underlain by Wall Mountain Tuff.

biotite 36.3 ± 0.9 Ma
hornblende 37.4 ± 0.7 Ma

15. *USGS(D)V-866* K-Ar
Rhyolite porphyry (38°29'35"N, 106°04'10"W; SW¼SE¼ S15,T49N,R8E; Bonanza 15' quad., Chaffee Co., CO). *Analytical data*: K_2O = 3.94, 3.96%; $*Ar^{40}$ = 4.039 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 93%. *Collected by:* R. E. Van Alstine. *Comments*: Rhyolite porphyry dike is cut by fluorite veins which induced some mineral alteration in the host rock. Calculated age has not been evaluated.

whole-rock 69.7 ± 2.4 Ma

16. *USGS(D)VA-217* K-Ar
Rhyolite porphyry (38°29'30"N, 106°03'40"W; NE¼ S22,T49N,R8E; N side of Poncha Mountain, Bonanza 15' quad., Chaffee Co., CO). *Analytical data:* K_2O = 4.14, 4.14%; $*Ar^{40}$ = 5.501 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 96%. *Collected by:* R. E. Van Alstine. *Comments:* Light-colored rhyolite-porphyry dike has sparse phenocrysts in a cryptocrystalline groundmass of feldspar and quartz. Calculated age appears to be too old.

whole-rock 90.0 ± 3.1 Ma

17. *USGS(D)V-997* K-Ar
Quartz monzonite (38°27'10"N, 106°00'54"W; S31,T49N,R9E; outcrop on Methodist Mountain, Bonanza 15' quad., Chaffee Co., CO). *Analytical data:* K_2O = 8.17, 8.35%; $*Ar^{40}$ = 223.6 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 98%. *Collected by:* R. E. Van Alstine. *Comment:* Calculated biotite age is a minimum age.

biotite 1290 ± 50 Ma

18. *USGS(D)S69-404* (Sharp, 1978) K-Ar
Hornblende andesite (38°05'N, 105°22'30"W; Rosita Volcanic Center, Rosita or Aldrich Gulch 7.5' quad., W side of Wet Mountains, Custer Co., CO). *Analytical data:* K_2O = 4.330% (isotope dilution, W. T. Henderson, analyst, USGS), $*Ar^{40}$ = 1.720 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 86%. *Comments:* Published age is 26.7 Ma; this age has been recalculated with revised potassium-40 decay constants (Steiger and Jager, 1977). There is some doubt as to the reliability of this K-Ar age. The low potassium content indicates that the biotite was altered or that the biotite concentrate was impure.

biotite 27.4 ± 0.8 Ma

19. *USGS(D)BMG-1QC* Fission-track
(Brock and Gaskill, 1985)
Quartz diorite (37°24'05"N, 106°47'25"W; NW¼SE¼NE¼ S5,T36N,R2E; Benson-Montin-Greer No. 1 Quartz Creek well, Wolf Creek Pass 15' quad., Archuleta Co., CO). *Analytical data:* (6 grains) Ps = 2.88 × 10^6 tracks/cm² (614), Pi = 7.78 × 10^6 tracks/cm² (828), 0 = 1.1 × 10^{15} n/cm². *Submitted by:* M. R. Brock. *Comment:* Probable age of a concealed porphyritic, medium- to coarse-grained quartz diorite intrusive.

zircon 24.3 ± 2.8 Ma

MONTANA

20. *USGS(D)GK-JM-84* (Kirchner, 1982) K-Ar
Alkali syenite porphyry (47°15'N, 109°01'30"W; NE¼ S10,T17N,R21E; Linster Peak Dome, Judith Mountains, Judith Peak 15' quad., Fergus Co., MT). *Analytical data:* (sanidine) K_2O = 9.78, 9.76%; $*Ar^{40}$ = 8.479 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 84%; (hornblende) K_2O = 0.32, 0.32%; $*Ar^{40}$ = 0.2248 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 54%. *Collected by:* G. Kirchner. *Comments:* Kirchner (1982) stated that the alkali-syenite porphyry intruded the Linster Peak Dome about 66 Ma ago. Thus, these calculated ages are apparently reduced ages. However, more geochronological work needs to be done.

sanidine 59.3 ± 2.1 Ma
hornblende 46.7 ± 3.9 Ma

21. *USGS(D)GK-JM-89* (Kirchner, 1982) K-Ar
Monzonite porphyry (47°13'10"N, 109°04'55"W; SE¼NE¼ S19,T17N,R21E; Linster Peak Dome, Judith Mountains, Judith Peak 15' quad., Fergus Co., MT). *Analytical data:* (hornblende) K_2O = 1.65, 1.63%; $*Ar^{40}$ = 2.137 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 90%; (plagioclase) K_2O = 0.80, 0.78%; $*Ar^{40}$ = 1.063 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 76%. *Collected by:* G. Kirchner. *Comments:* These calculated ages for the monzonite porphyry are probably spurious. Kirchner (1982) stated that the monzonite porphyry was the oldest intrusive in the Linster Peak Dome area and that intrusion occurred 69–68 Ma ago.

hornblende 88.3 ± 3.2 Ma
plagioclase 91.1 ± 5.6 Ma

22. *USGS(D)201S-59* (Skipp and McGrew, 1977) K-Ar
Dacite (46°02'55"N, 111°10'50"W; NW¼NW¼ S1,T3N,R4E; E of the Horseshoe Hills, Maudlow 15' quad., Gallatin Co., MT). *Analytical data:* K_2O = 1.183%; $*Ar^{40}$ = 1.407 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 80%. *Collected by:* B. Skipp. *Comments:* A porphyritic hornblende dacite flow is present in the B member, Maudlow Formation. Dacite is stratigraphically correlated with the ammonite zone—*Scaphites hippocrepis II.* Published age of 78.9 Ma was recalculated with revised potassium-40 decay constants (Steiger and Jager, 1977).

hornblende 80.8 ± 1.0 Ma

23. *USGS(D)60S-60* (Skipp and McGrew, 1977) K-Ar
Dacite (46°01'50"N, 111°09'50"W; NE¼ S12,T3N,R4E; E of the Horseshoe Hills, Maudlow 15' quad., Gallatin Co., MT). *Analytical data:* K_2O = 0.797%; $*Ar^{40}$ = 0.8985 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 76%. *Collected by:* B. Skipp. *Comments:* A porphyritic dacite breccia is present in the F member, Maudlow Formation, and is stratigraphically correlated with the ammonite zone—*Baculites perplexes.* Published age of 74.9 Ma was recalculated

with revised potassium-40 decay constants (Steiger and Jager, 1977).

hornblende 76.6 ± 1.0 Ma

24. *USGS(D)FC-263* K-Ar
Granite, Port Royal batholith (46°24'30"N, 113°05'40"W; Flint Creek Range, Pikes Peak 7.5' quad., Granite Co., MT). *Analytical data:* K_2O = 8.77, 8.81%; $*Ar^{40}$ = 8.334 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 87%. *Collected by:* G. E. Ericksen.
biotite 64.7 ± 1.6 Ma

25. *USGS(D)FC-271* K-Ar
Granite, Phillipsburg batholith (46°18'52"N, 113°15'00"W; near the Granite Mine in the Flint Creek Range, Fred Burr Lake 7.5' quad., Granite Co., MT). *Analytical data:* K_2O = 8.24, 8.24%; $*Ar^{40}$ = 9.353 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 71%. *Collected by:* G. E. Ericksen.
biotite 77.2 ± 1.9 Ma

26. *USGS(D)FC-272* K-Ar
Granite, Phillipsburg batholith (46°16'42"N, 113°11'17"W; near the Red Lion Mine in the Flint Creek Range, Fred Burr Lake 7.5' quad., Granite Co., MT). *Analytical data:* K_2O = 8.75, 8.72%; $*Ar^{40}$ = 9.406 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 85%. *Collected by:* G. E. Ericksen.
biotite 73.3 ± 1.8 Ma

27. *USGS(D)FC-273* K-Ar
Granite, Mount Powell batholith (46°18'23"N, 113°00'16"W; Race Track Creek drainage area in the Flint Creek Range, Pozega Lakes 7.5' quad., Powell Co., MT). *Analytical data:* (biotite) K_2O = 9.58, 9.57%; $*Ar^{40}$ = 0.370 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 79%; (muscovite) K_2O = 10.45, 10.37%; $*Ar^{40}$ = 9.375 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 81%. *Collected by:* G. E. Ericksen. *Comment:* Apparent age of the Mount Powell batholith is around 61 Ma.
biotite 59.7 ± 1.4 Ma
muscovite 61.5 ± 1.0 Ma

28. *USGS(D)8271* K-Ar
Dacite (45°14'23"N, 111°31'00"W; SE¼ S7,T7S,R2E; central Madison Range, Cameron 15' quad., Madison Co., MT). *Analytical data:* K_2O = 0.62, 0.61%; $*Ar^{40}$ = 0.8723 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 79%. *Collected by:* R. G. Tysdal. *Comments:* A hornblende dacite porphyry sill (part of the intrusive complex at Lone Mountain) was sampled at an exposure made by dynamite. A thin section of the rock showed no alteration of the hornblende; some epidote was present. The calculated hornblende age is spurious (too old). Sill intrudes Cretaceous strata that could not be as old as 96 Ma, based on megafaunal data. The spurious age is probably due to the presence of excess radiogenic argon.
hornblende 95.9 ± 6.0 Ma

29. *USGS(D)82MTz1935* K-Ar
Andesite (45°00'15"N, 111°06'42"W; S33,T9S,R5E; SE end of the Madison Range, Crown Butte 15' quad., Gallatin Co., MT). *Analytical data:* K_2O = 0.898% (isotope dilution, K. Futa, analyst, USGS); $*Ar^{40}$ = 1.396 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 84%. *Collected by:* R. G. Tysdal. *Comments:* A porphyritic hornblende andesite from the Gallatin laccolith; hornblende phenocrysts show some alteration. The calculated age is considered to be too old.
hornblende 105 ± 3 Ma

30. *53S82* (Skipp, 1984) K-Ar
Rhyodacite breccia flow (44°29"N, 112°53'30"W; SE¼SW¼ S36,T15S,R11W; Italian Peak Wilderness area, Beaverhead Mountains, Scott Peak 15' quad., Beaverhead Co., MT). *Analytical data:* K_2O = 0.940% (isotope dilution, K. Futa, analyst, USGS); $*Ar^{40}$ = 0.6543 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 73%. *Collected by:* B. Skipp. *Comments:* The porphyritic rhyodacite breccia—about 30% phenocrysts, dominantly plagioclase and hornblende—is one of the units of the Challis Volcanics of SE Idaho. Scholten and others (1955) had originally named these volcanics, the Medicine Lodge Volcanics.
hornblende 47.7 ± 1.3 Ma

31. *54-S81* (Skipp, 1984) K-Ar
Rhyodacite breccia flow (44°27'N, 112°59'W; SE¼SE¼ S7,T16S,R11W; Beaverhead Mountains, Scott Peak 15' quad., Beaverhead Co., MT). *Analytical data:* K_2O = 0.81, 0.80%; $*Ar^{40}$ = 0.6036 and 0.5758 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 63, 73%. *Collected by:* B. Skipp. *Comments:* The porphyritic rhyodacite breccia is one of the units of the Challis Volcanics of SE Idaho. Scholten and others (1955) had originally named these volcanics, the Medicine Lodge Volcanics. These ages indicate an age of around 50 Ma for this unit.
hornblende 51.4 ± 3.1 Ma
49.0 ± 3.0 Ma

32. *USGS(D)E-85g* (Elliot, 1974, 1979) Fission-track
Quartz "Eye" rhyodacite porphyry (45°03'19"N, 109°56'48"W; near Homestake Mine, Cooke City 15' quad., Park Co., MT). *Analytical data:* Ps = 5.62 × 10^6 tracks/cm² (1170), Pi = 9.64 × 10^6 tracks/cm² (1004), 0 = 1.19 × 10^{15} n/cm². *Collected by:* J. E. Elliott. *Comments:* This age is a reduced age according to intrusive relationships of igneous bodies in this area. Published age of 40.6 Ma has been revised with decay constants recommended by Steiger and Jager (1977).
zircon 41.3 ± 4.0 Ma

33. *USGS(D)E-516B* (Elliott, 1974, 1979) Fission-track
Rhyodacite porphyry of Henderson Mountain (45°02'33"N, 109°55'44"W; Henderson Mountain, Cooke City 15' quad., Park Co., MT). *Analytical data:* Ps = 5.64 × 10^6 tracks/cm² (1070), Pi = 8.84 × 10^6 tracks/cm² (839), 0 = 1.19 × 10^{15} n/cm². *Collected by:* J. E. Elliott. *Comments:* This is the apparent intrusive age for the rhyodacite porphyry of Henderson Mountain. Published age of 44.0 Ma has been revised with decay constants recommended by Steiger and Jager (1977).
zircon 45.2 ± 4.6 Ma

34. *USGS(D)E-468A* (Elliott, 1974, 1979) Fission-track
Syenite of Goose Lake (45°07'46"N, 109°54'39"W; near Goose Lake, Cooke City 15' quad., Rhyodacite porphyry of Henderson Mountain, Park Co., MT). *Analytical data:* Ps = 2.48 × 10^6 tracks/cm² (517), Pi = 3.84 × 10^6 tracks/cm² (401), 0 = 2.27 × 10^{15} n/cm². *Collected by:* J. E.

Elliott. *Comments:* Calculated age is apparent intrusive age of syenite stock. Published age of 84.6 Ma has been revised with decay constants recommended by Steiger and Jager (1977).

sphene 87.0 ± 12 Ma

35. *USGS(D)E-582A* K-Ar
Granitoid (~45°07'30"N, ~109°54'30"W; N of Cooke City, near Goose Lake; Cooke City 15' quad., Park Co., MT). *Analytical data:* K_2O = 1.028%; $*Ar^{40}$ = 0.9007 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 56%. *Collected by:* J. E. Elliott. *Comments:* This calculated age has not been evaluated. Other radiometric ages in the Cooke City area suggest intrusive activity occurred at various times from Late Cretaceous to Early Oligocene (Elliott, 1974, 1979).

hornblende 59.9 ± 1.1 Ma

UTAH

36. *USGS(D)293-DL-64* K-Ar
Granitoid (39°47'27"N, 113°52'20"W; S9, T12S,R18W; Deep Creek Range, Indian Farm Creek 7.5' quad., Juab Co., UT). *Analytical data:* (biotite) K_2O = 9.68%; $*Ar^{40}$ = 3.472 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 70%; (hornblende) K_2O = 0.63%; $*Ar^{40}$ = 0.3551 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 39%. *Collected by:* D. E. Lee. *Comments:* The discordant ages probably indicate that a thermal event, subsequent to the initial formation of the granitoid pluton, has affected the K-Ar isotopic systems of the biotite crystals, and possibly the hornblende, too.

biotite 24.8 ± 0.7 Ma
hornblende 38.7 ± 0.39 Ma

37. *USGS(D)298-DL-64* K-Ar
Granitoid (39°11'12"N, 113°26'30"W; Notch Peak 15' quad., House Range, Millard Co., UT). *Analytical data:* K_2O = 9.29%; $*Ar^{40}$ = 21.70 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 95%. *Collected by:* D. E. Lee. *Comments:* Potassium content data supplied by D. E. Lee. The biotite age may reflect the time of crystallization.

biotite 155 ± 6 Ma

38. *USGS(D)299-DL-64* K-Ar
Granitoid (39°11'12"N, 113°26'30"W; Notch Peak 15' quad., House Range, Millard Co., UT). *Analytical data:* (biotite) K_2O = 8.23%; $*Ar^{40}$ = 18.95 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 95%; (amphibole) K_2O = 0.61%; $*Ar^{40}$ = 1.238 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 75%. *Collected by:* D. E. Lee. *Comments:* Potassium values supplied by D. E. Lee. The age given by the amphibole concentrate appears to be too young; the cause of a reduced age is not known. The biotite age may reflect the time of crystallization.

biotite 153 ± 6 Ma
amphibole 136 ± 9 Ma

39. *USGS(D)78-1288* (Rowley and others, 1986) K-Ar
Basal vitrophyre of an ash-flow tuff, Mount Dutton Formation (38°20'45"N, 112°04'35"W; NE¼SW¼ S25,T28S,R2½W; Marysvale 15' quad., Piute Co., UT). *Analytical data:* K_2O = 8.47, 8.49%; $*Ar^{40}$ = 3.127 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 90%. *Collected by:* P. D. Rowley.

sanidine 25.4 ± 0.92 Ma

WYOMING

40. *USGS(D)A-13* (Kudo and Broxton, 1985) Fission-track
Quartz monzonite (44°50'20"N, 109°48'30"W; on Hurricane Mesa, Absaroka Mountains, Pilot Peak 15' quad., Park Co., WY). *Analytical data:* (5 grains) Ps = 5.81 × 10^6 tracks/cm² (242), Pi = 10.94 × 10^6 tracks/cm² (228), 0 = 1.27 × 10^{15} n/cm². *Submitted by:* A. M. Kudo. *Comment:* The quartz monzonite is from the core of the Crandall pluton and is part of the Crandall ring dike complex.

zircon 40.2 ± 7.6 Ma

41. *USGS(D)FN-81-2* K-Ar, Fission-track
Fine-grained granodiorite (44°23'00"N, 110°00'00"W; 60-m above Crock Mine in T51N,R109W; Eagle Creek 7.5' quad., Park Co., WY). *Analytical data:* (biotite) K_2O = 6.85, 7.01%; $*Ar^{40}$ = 5.037 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 74%; (zircon—10 grains) Ps = 2.98 × 10^6 tracks/cm² (781), Pi = 3.88 × 10^6 tracks/cm² (510), 0 = 0.93 × 10^{15} n/cm², U = 120 ppm; (apatite—50 grains) Ps = 0.176 × 10^6 tracks/cm² (276), Pi = 0.250 × 10^6 tracks/cm² (393), 0 = 0.93 × 10^{15} n/cm², U = 7.9 ppm. *Collected by:* F. Fisher. *Fission-track ages determined by:* P. A. M. Andriessen. *Comments:* Until additional information is available, the apparent age of the granodiorite is considered to be 50 Ma. The younger ages may reflect some annealing of fission-tracks.

K-Ar: biotite 49.8 ± 1.8 Ma
Fission-track: zircon 42.4 ± 5.2 Ma
apatite 38.9 ± 6.4 Ma

42. *USGS(D)FN-81-1* K-Ar, Fission-track
Porphyritic biotite-hornblende andesite (44°14'30"N, 109°42'37"W; near top of Clouds Home Peak in T49N,R107W; Clouds Home Peak 7.5' quad., Park Co., WY). *Analytical data:* (biotite) K_2O = 4.79, 4.79%; $*Ar^{40}$ = 3.312 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 88%; (zircon—6 grains) Ps = 4.27 × 10^6 tracks/cm² (1141), Pi = 5.74 × 10^6 tracks/cm² (767), 0 = 0.93 × 10^{15} n/cm², U = 180 ppm; (apatite—50 grains) Ps = 0.146 × 10^6 tracks/cm² (230), Pi = 0.208 × 10^6 tracks/cm² (328), 0 = 0.93 × 10^{15} n/cm², U = 6.6 ppm. *Collected by:* F. Fisher. *Fission-track ages determined by:* P. A. M. Andriessen. *Comments:* Until additional information is available, the apparent age of the andesite is considered to be 47 Ma. The younger ages may reflect minor annealing of fission-tracks.

K-Ar: biotite 47.4 ± 1.7 Ma
Fission-track: zircon 41.2 ± 4.3 Ma
apatite 38.9 ± 6.9 Ma

43. *USGS(D)FA-1350* K-Ar
Fine-grained granodiorite (44°02'35"N, 109°38'00"W; T47N,R107W; Fall Creek 7.5' quad., Park Co., WY). *Analytical data:* K_2O = 8.15, 8.06%; $*Ar^{40}$ = 5.289 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 87%. *Collected by:* F. Fisher.

biotite 44.8 ± 1.6 Ma

44. *USGS(D)FN-81-10* K-Ar, Fission-track
Porphyritic biotite-hornblende andesite (43°56'15"N, 109°47'00"W; T46N,R108W; Younts Peak 7.5' quad., Park Co., WY). *Analytical data:* (biotite) K_2O = 7.91, 7.96%; $*Ar^{40}$ = 5.136 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 84%; (zircon—6 grains) Ps = 4.16 × 10^6 tracks/cm² (1166), Pi = 4.94 × 10^6 tracks/cm² (694), 0 = 9.30 × 10^{15} n/cm², U = 155 ppm;

(apatite—50 grains) Ps = 0.135 × 10^6 tracks/cm² (212), Pi = 0.161 × 10^6 tracks/cm² (254), 0 = 9.30 × 10^{15} n/cm², U = 5.1 ppm. *Collected by:* F. Fisher. *Fission-track ages determined by:* P. A. M. Andriessen. *Comment:* Age of the andesite is around 45 Ma.

K-Ar: biotite 44.4 ± 1.6 Ma
Fission-track: zircon 46.5 ± 4.4 Ma
apatite 46.2 ± 5.2 Ma

45. *USGS(D)FN-81-6* K-Ar, Fission-track
Porphyritic biotite andesite (43°54'30"N, 109°21'15"W; near top of Yellow Ridge, Francs Peak 7.5' quad., Park Co., WY). *Analytical data:* (biotite) K_2O = 8.02, 8.02%; $*Ar^{40}$ = 5.434 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 21%; (zircon—6 grains) Ps = 3.08 × 10^6 tracks/cm² (531), Pi = 5.74 × 10^6 tracks/cm² (495), 0 = 0.93 × 10^{15} n/cm², U = 180 ppm; (apatite—50 grains) Ps = 0.093 × 10^6 tracks/cm² (146), Pi = 0.191 × 10^6 tracks/cm² (301), 0 = 0.93 × 10^{15} n/cm², U = 6 ppm. *Collected by:* F. Fisher. *Fission-track ages determined by:* P. A. M. Andriessen. *Comments:* Until additional information is available, the apparent age of the andesite is considered to be 47 Ma. The fission-track ages strongly suggest a subsequent thermal event, possibly during the Oligocene.

K-Ar: biotite 46.5 ± 1.7 Ma
Fission-track: zircon 29.8 ± 4.0 Ma
apatite 26.9 ± 5.6 Ma

46. *USGS(D)FN-81-7* K-Ar, Fission-track
Porphyritic rhyodacite (43°54'30"N, 109°20'15"W; Francs Peak 7.5' quad., Park Co., WY). *Analytical data:* (biotite) K_2O = 7.15, 7.15%; $*Ar^{40}$ = 4.861 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 80%; (zircon—6 grains) Ps = 4.34 × 10^6 tracks/cm² (1063), Pi = 6.42 × 10^6 tracks/cm² (786), 0 = 0.93 × 10^{15} n/cm², U = 200 ppm; (apatite—50 grains) Ps = 0.193 × 10^6 tracks/cm² (303), Pi = 0.250 × 10^6 tracks/cm² (394), 0 = 0.93 × 10^{15} n/cm², U = 7.9 ppm. *Collected by:* F. Fisher. *Fission-track ages determined by:* P. A. M. Andriessen. *Comments:* Until additional information is available, the apparent age of the rhyodacite is considered to be 47 Ma. The fission-track ages are too young.

K-Ar: biotite 46.7 ± 1.7 Ma
Fission-track: zircon 37.5 ± 3.9 Ma
apatite 42.6 ± 6.8 Ma

47. *USGS(D)FN-81-9* K-Ar, Fission-track
Fine-grained granodiorite (43°56'00"N, 109°17'20"W; Francs Peak 7.5' quad., Park, Co., WY). *Analytical data:* (biotite) K_2O = 8.70, 8.72%; $*Ar^{40}$ = 5.324 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 80%; (zircon—6 grains) Ps = 4.96 × 10^6 tracks/cm² (1197), Pi = 7.88 × 10^6 tracks/cm² (951), 0 = 0.93 × 10^{15} n/cm², U = 250 ppm. *Collected by:* F. Fisher. *Fission-track age determined by:* P. A. M. Andriessen. *Comment:* The calculated ages are apparently cooling ages.

K-Ar: biotite 42.0 ± 1.5 Ma
Fission-track: zircon 34.9 ± 3.5 Ma

48. *USGS(D)FN-81-8* K-Ar, Fission-track
Vein gangue (43°56'15"N, 109°17'20"W; Francs Peak 7.5' quad., Park Co., WY). *Analytical data:* (actinolite) K_2O = 0.1860% (isotope dilution, K. Futa, analyst, USGS); $*Ar^{40}$ = 0.1283 × 10^{-10} mol/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 33%; (zircon—6 grains) Ps = 2.27 × 10^6 tracks/cm² (682), Pi = 3.24 × 10^6 tracks/cm² (486), 0 = 0.93 × 10^{15} n/cm², U = 100 ppm; (sphene—4 grains) Ps = 2.01 × 10^6 tracks/cm² (898), Pi = 3.12 × 10^6 tracks/cm² (696), 0 = 0.93 × 10^{15} n/cm², U = 100 ppm; (apatite—50 grains) Ps = 0.348 × 10^6 tracks/cm² (243), Pi = 0.606 × 10^6 tracks/cm² (431), 0 = 0.93 × 10^{15} n/cm², U = 19 ppm. *Collected by:* F. Fisher. *Fission-track ages determined by:* P. A. M. Andriessen. *Comments:* Quartz-feldspar-actinolite vein carrying copper minerals. The apatite age suggests that the latest hydrothermal activity occurred around 30 Ma although the vein may have formed without any copper minerals about 47 Ma.

K-Ar: actinolite 47.3 ± 1.4 Ma
Fission-track: zircon 38.9 ± 4.9 Ma
sphene 35.8 ± 4.0 Ma
apatite 31.3 ± 5.2 Ma

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