# *Radiometric ages of volcanic and plutonic rocks and hydrothermal mineralization in Nevada—determinations run under the USGS—NBMG Cooperative Progra*

L.J. Garside, H.F. Bonham, R.P. Ashley, M.L. Silberman, and E.H. McKee

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# RADIOMETRIC AGES OF VOLCANIC AND PLUTONIC ROCKS AND HYDROTHERMAL MINERALIZATION IN NEVADA—DETERMINATIONS RUN UNDER THE USGS–NBMG COOPERATIVE PROGRAM

LARRY J. GARSIDE
HAROLD F. BONHAM, JR. } *Nevada Bureau of Mines and Geology, Reno, NV 89557*
ROGER P. ASHLEY
MILES L. SILBERMAN
EDWIN H. McKEE } *U.S. Geological Survey, Menlo Park, CA 94025*

The following radiometric ages were done as part of a continuing cooperative study of the ages of volcanic and plutonic activity and hydrothermal mineralization in Nevada done by members of the Nevada Bureau of Mines and Geology and the U.S. Geological Survey. People who cooperated in this study include E. J. Collord, P. E. Dircksen, John Livermore, and A. B. Wallace.

This compilation of radiometric determinations includes some which because of geologic relations are believed not to reflect accurately the age of formation of the rocks. These questionable ages, indicated in the comments, are included to alert persons to potential dating problems in the particular areas or rock units involved. Most of the age dates from the Tonopah area have been reported previously (Silberman and others, 1978, 1979; Bonham and Garside, 1979). They are included in the compilation so that all the analytical data are available in a single publication. The data presented here supercedes that in previous publications which reported small differences, generally insignificant and less than 2 percent, in the K-Ar ages or error estimates for the same sample. The minor differences generally resulted from re-calculations using additional or refined potassium or argon analyses.

Mineral separates and whole rock samples were prepared at the Nevada Bureau of Mines and Geology or the U.S. Geological Survey from samples collected by the authors or other geologists listed in the sample descriptions. Mineral separation was by procedures described in Silberman and McKee (1971). Whole-rock samples were prepared by grinding to approximately 60–100 mesh and leaching in $HNO_3$ and HF solutions before Ar extraction. This procedure reduces atmospheric argon content (Keeling and Naughton, 1974).

Potassium was analyzed by flame photometry, using a lithium metaborate fusion technique, the lithium serving as an internal standard (Ingamells, 1970). Some samples also were analyzed by X-ray fluorescence using techniques described in Dodge and others (1971).

Argon analysis was done by standard isotope dilution mass spectrometry techniques using procedures described in Dalrymple and Lanphere (1969).

The constants used in K-Ar age calculation for some of the samples were:

$\lambda_e = 0.585 \times 10^{-10}$ yr$^{-1}$
$\lambda_\beta = 4.72 \times 10^{-10}$ yr$^{-1}$
$^{40}K/K(total) = 1.22 \times 10^{-4}$ g/g

New constants (Steiger and Jager, 1977) presently in use are:

$\lambda_\epsilon + \lambda_\epsilon' = 0.581 \times 10^{-10}$ yr$^{-1}$
$\lambda_\beta = 4.962 \times 10^{-10}$ yr$^{-1}$
$^{40}K/K$ total $= 1.167 \times 10^{-4}$

The difference in calculated age using the different constants is on the order of 2 percent. We report the ages using both the old and new constants in order to facilitate comparison with ages published in old reports (Silberman and others, 1978, 1979; Bonham and Garside, 1979). An asterisk (*) indicates K-Ar dates calculated on the basis of the old constants.

Fission track ages were determined at the U.S. Geological Survey, Menlo Park, by R. P. Ashley and R. C. Evarts using techniques described in Ashley (1973), and Ashley and Silberman (1976). The fission track decay constant for $U^{238}$ is $(\lambda_F) = 6.85 \times 10^{-17}$ yr$^{-1}$ (Fleischer and Price, 1964). Error estimates are made at two standard deviations by methods described in Naeser (1976).

1. *SAgd-1* Fission-track
*Silberman and others, 1978*
Granodiorite, Frazier's Well Pluton. (C SW¼ SW¼ S36, unsurveyed, T4N,R42E; 38°09'13"(09.22')N, 117°13'09"(13.15')W; Nye Co., NV). *Analytical data:* (sphene) Ps = $4.565 \times 10^6$ tracks/cm$^2$, ½Pi = $2.795 \times 10^6$ tracks/cm$^2$, $\phi = 1.19 \times 10^{15}$ N/cm$^2$, no. of grains counted = 8; (zircon) Ps = $1.786 \times 10^7$ tracks/cm$^2$, ½Pi = $9.548 \times 10^6$ tracks/cm$^2$, $\phi = 1.19 \times 10^{15}$ N/cm$^2$, no. of grains counted = 6. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* R. P. Ashley, U.S. Geological Survey. *Comment:* Epidote present as a deuteric (?) alteration mineral. The ages should be considered as minimum.
**(sphene) 59.3 ± 7.4 m.y.**
**(zircon) 67.9 ± 8.4 m.y.**

2. *Mzwt-1* K-Ar
*Silberman and others, 1978*
Mesozoic(?) welded tuff. (NW¼ NE¼ S12,T4N,R43E; 38°13'18" (13.30')N, 117°06'00"(06.00")W; Nye Co., NV). *Analytical data:* $K_2O$ = 1.57%, $^{40}Ar^*$ = $4.031 \times 10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.32. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Chlorite, actinolite, calcite and epidote are present in sample as alteration minerals. Thus, the age should only be considered a minimum.
***(plagioclase) 17.3 ± 0.8 m.y.**
**17.8 ± 0.8 m.y.**

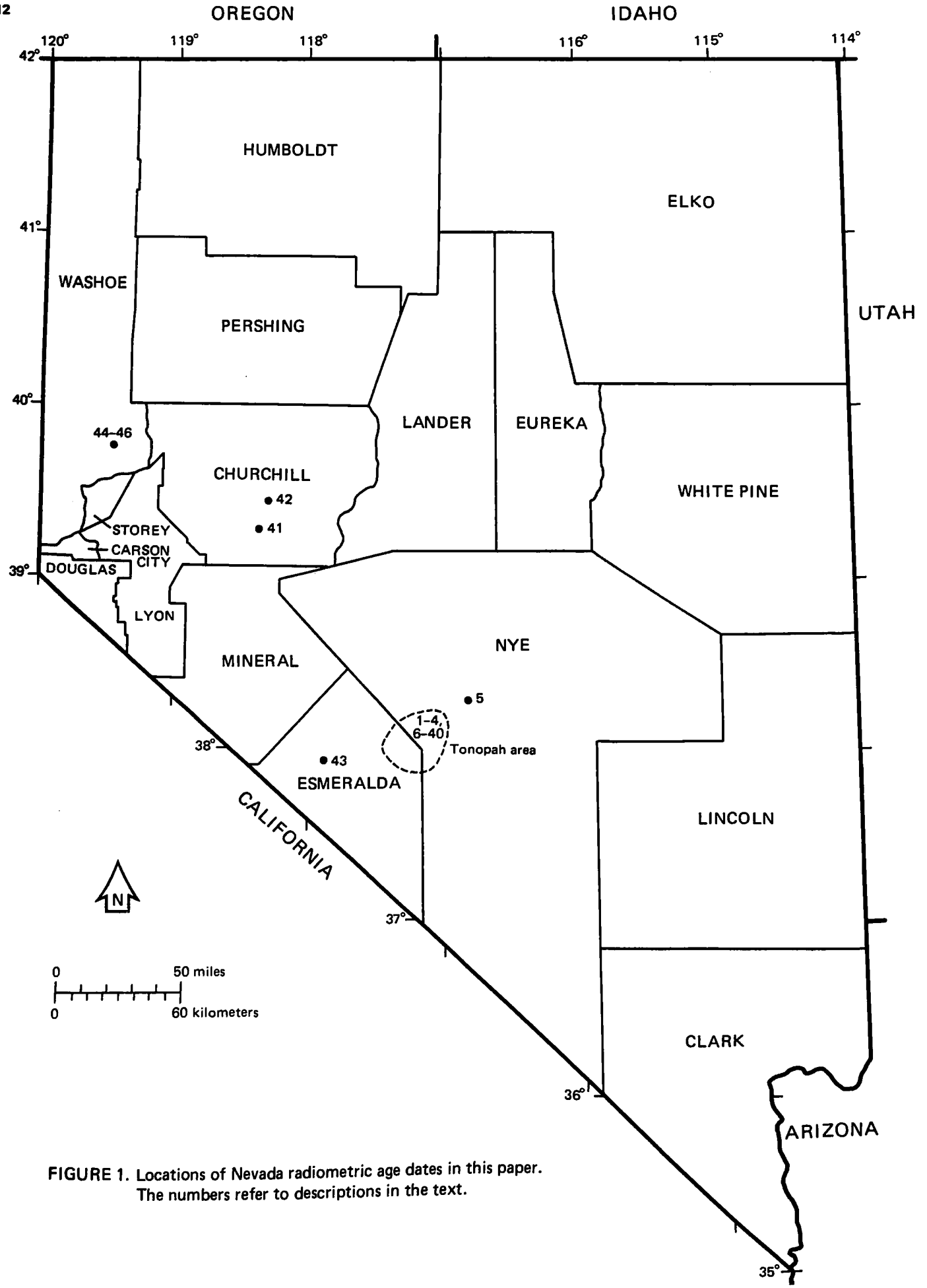


FIGURE 1. Locations of Nevada radiometric age dates in this paper. The numbers refer to descriptions in the text.

3. *TF-2* Fission-track
*Silberman and others, 1978*
Ash-flow tuff, Tonopah Formation. (NW¼ S31,T4N, R43E; 38°09'46"(09.77')N, 117°11'50"(11.83')W; Nye Co., NV). *Analytical data:* Ps = 2.420 x $10^6$ tracks/cm$^2$, ½Pi = 2.527 x $10^6$ tracks/cm$^2$, $\zeta$ = 1.19 x $10^{15}$ N/cm$^2$, no. of grains counted = 7. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* R. P. Ashley, U.S. Geological Survey. *Comment:* See sample TF-1 (no. 7).
**(zircon) 34.8 ± 4.2 m.y.**

4. *OWT-1* *K-Ar, Fission-track*
*Silberman and others, 1978*
Altered welded tuff, with phenocrysts of cloudy feldspar with many inclusions, large amounts of iron oxide and some epidote; tuff of Ralston Valley. (SE¼ NE¼ NE¼ S21,T4N,R44E; 38°11'27"(11.45')N, 117°02'27"(02.45')W; Nye Co., NV). *Analytical data:* (alkali feldspar) $K_2O$ = 6.63%, $^{40}Ar^*$ = 1.780 x $10^{-10}$ moles/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.82; (zircon) Ps = 1.342 x $10^7$ tracks/cm$^2$, ½Pi = 1.555 x $10^7$ tracks/cm$^2$, $\zeta$ = 1.19 x $10^{15}$ N/cm$^2$, no. of grains counted = 6. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology. *Dated by:* (alkali feldspar) M. L. Silberman, U.S. Geological Survey; (zircon) R. P. Ashley, U.S. Geological Survey. *Comment:* Feldspar phenocrysts are cloudy and inclusion-filled. The alkali-feldspar age is interpreted as an alteration age. The fission track zircon age is probably closer to the age of emplacement, as zircon appears to resist annealing during post-crystallization hydrothermal alteration (Ashley and Silberman, 1976).
***(alkali feldspar) 18.1 ± 0.5 m.y. (K-Ar)**
**18.6 ± 0.5 m.y.**
**(zircon) 31.4 ± 3.8 m.y. (FT)**

5. *Mc-1* K-Ar
*Silberman and others, 1978*
Tuff of Murphy's Camp. (SW¼ S3, unsurveyed T5N, R46E; 38°18'30"(18.5')N, 116°49'00"(49.0')W; Nye Co., NV). *Analytical data:* (biotite) $K_2O$ = 8.24%, $^{40}Ar^*$ = 3.084 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.66; (plagioclase) $K_2O$ = 2.51%, $^{40}Ar^*$ = 8.978 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.84. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Overlies the tuffs of Rye Patch in the Big Ten Peak caldera, and thus provides a minimum age limit for them.
***(biotite) 25.2 ± 0.8 m.y.**
**25.9 ± 0.8 m.y.**
***(plagioclase) 24.0 ± 0.7 m.y.**
**24.6 ± 0.7 m.y.**

6. *Taf$_2$-(1)* K-Ar
*Silberman and others, 1978*
Tuffs of Antelope Springs (?). (NW¼ SW¼ SE¼ S5, T1S,R43E; 37°52'36"(52.60')N, 117°10'33"(10.55')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 8.81%, $^{40}Ar^*$ = 3.381 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.69. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* E. H. McKee, U.S. Geological Survey. *Comment:* Minimum age; plagioclase in sample is altered to calcite and sericite and hornblende is altered to Fe-Ti oxides, sericite, quartz and chlorite. Ekren and others (1971) report ages of 25.4 ± 0.8 m.y., 27.7 ± 0.8 m.y., and 26.2 ± 0.8 m.y. on samples from the tuffs of Antelope Springs.
***(biotite) 25.8 ± 0.8 m.y.**
**26.5 ± 0.8 m.y.**

7. *TF-1* Fission-track
*Silberman and others, 1978*
Flow-banded rhyolite, Tonopah Formation. (SE¼ SE¼ SE¼ S1,T3N,R42E; 38°08'19"(08.32')N, 117°12'14"(12.23')W; Nye Co., NV). *Analytical data:* Ps = 1.002 x $10^7$ tracks/cm$^2$, ½Pi = 1.437 x $10^7$ tracks/cm$^2$, $\zeta$ = 1.14 x $10^{15}$ N/cm$^2$, no. of grains counted = 6. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and M. L. Silberman, U.S. Geological Survey. *Dated by:* R. P. Ashley, U.S. Geological Survey. *Comment:* This rhyolite intrudes pyroclastic rocks of the Tonopah Formation (sample TF-2, no. 3). The time span between the extrusive and intrusive phases seems long (11 m.y.); however, there is no geologic reason to doubt either age.
**(zircon) 24.3 ± 2.8 m.y.**

8. *GC-135* K-Ar
*Silberman and others, 1978*
Porphyritic biotite-hornblende dacite, Mizpah Formation. (NE¼ SW¼ SE¼ SE¼ S26,T3N,R42E; 38°04'49"(04.82'N, 117°13'28"(13.47')W; Nye Co., NV). *Analytical data:* $K_2O$ = 8.71%, $^{40}Ar^*$ = 2.656 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.66. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Main host rock for ore deposits of the Tonopah mining district.
***(biotite) 20.5 ± 0.8 m.y.**
**21.0 ± 0.8 m.y.**

9. *74 MLS-1* K-Ar, Fission-track
*Silberman and others, 1978*
*Bonham and Garside, 1979*
Tonopah Summit Member, Fraction Tuff. (NW¼ SW¼ S17,T2N,R43E; 38°01'37"(01.62')N, 117°10'57"(10.95')W; Nye Co., NV). *Analytical data:* (biotite): $K_2O$ = 8.25%, $^{40}Ar^*$ = 2.064 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.43; (zircon): fossil tracks counted = 664,

induced tracks counted = 1664, 6 grains counted, Ps = 1.67 x $10^6$ tracks/$cm^2$, Pi = 8.36 x $10^6$ tracks/$cm^2$, $\phi$ = 1.39 x $10^{15}$ N/$cm^2$; (apatite): fossil tracks counted = 241, induced tracks counted = 1,151, 100 grains counted, Ps = 6.37 x $10^4$ tracks/$cm^2$, Pi = 6.85 x $10^5$ tracks/$cm^2$, $\phi$ = 3.22 x $10^{15}$ N/$cm^2$. *Collected by:* M. L. Silberman, U.S. Geological Survey. *Dated by:* (biotite) M. L. Silberman, U.S. Geological Survey; (zircon, apatite) R. P. Ashley, U.S. Geological Survey. *Comment:* See comment on following sample ($TFR_2$-1, no. 10).

***(biotite) 16.9 ± 0.5 m.y. (K-Ar)**
**17.3 ± 0.5 m.y.**
**(zircon) 17.0 ± 1.3 m.y. (FT)**
**(apatite) 18.4 ± 3.1 m.y. (FT)**

10. *$TFR_2$-(1)* K-Ar

*Silberman and others, 1978*

Tonopah Summit Member, Fraction Tuff. (SW¼ NW¼ NE¼ S10,T1N,R42E; 37°57'34"(57.57')N, 117°14'50"(14.83')W; Esmeralda Co., NV). *Analytical data:* (sanidine) $K_2O$ = 11.03%, $^{40}Ar^*$ = 2.636 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.77; (biotite) $K_2O$ = 8.38%, $^{40}Ar^*$ = 2.094 x $10^{-10}$ mole/g, $^{40}Ar^*/\ ^{40}Ar$ = 0.62. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman and E. H. McKee, U.S. Geological Survey. *Comment:* The Tonopah Summit Member of the Fraction Tuff is hydrothermally altered in virtually all exposures in the Tonopah area. The K-Ar ages on this unit may reflect heating by younger rhyolite intrusions. The Tonopah Summit Member is believed to be between 18 and 19 m.y. old, based on stratigraphic relations and radiometric dating of overlying and underlying units (Bonham and Garside, 1979, p. 55).

***(sanidine) 16.1 ± 0.5 m.y.**
**16.5 ± 0.5 m.y.**
***(biotite) 16.8 ± 0.7 m.y.**
**17.2 ± 0.7 m.y.**

11. *SS-25* K-Ar

*Silberman and others, 1978*

Hydrated glass from vitrophyre, lower unit, King Tonopah Member of Fraction Tuff. (C SE¼ SW¼ SW¼ S22,T3N,R42E; 38°05'39"(05.65')N, 117°15'17"(15.28')W; Nye Co., NV). *Analytical data:* $K_2O$ = 5.66%, $^{40}Ar^*$ = 1.647 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.55. *Collected by:* L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(glass) 19.6 ± 0.4 m.y.**
**20.1 ± 0.4 m.y.**

12. *TV-2* K-Ar

*Silberman and others, 1978*

Lower unit, King Tonopah Member of Fraction Tuff. (SW¼ SE¼ S15,T3N,R42E; 38°06'40"(06.67')N, 117°14'39"(14.65')W; Nye Co., NV). *Analytical data:* $K_2O$ = 6.26%, $^{40}Ar^*$ = 1.850 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.66. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(alkali feldspar) 19.9 ± 0.6. m.y.**
**20.4 ± 0.6 m.y.**

13. *TFR-1* K-Ar

*Silberman and others, 1978*

Lower unit, King Tonopah Member of Fraction Tuff. (NE¼ SW¼ SW¼ S24, T3N,R42E; 38°05'50"(05.83')N, 117°13'06"(13.10')W; Nye Co., NV). *Analytical data:* (alkali feldspar) $K_2O$ = 5.71%, $^{40}Ar^*$ = 1.668 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.49; (biotite) $K_2O$ = 8.58%, $^{40}Ar^*$ = 2.740 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.65. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman and E. H. McKee, U.S. Geological Survey. *Comment:* The biotite age from this sample is slightly older than the other mineral ages from this and other samples of the King Tonopah Member of the Fraction Tuff (no. 11 and 12); this older age may be due to crystal contamination during the eruption process.

***(alkali feldspar) 19.7 ± 0.6 m.y.**
**20.2 ± 0.6 m.y.**
***(biotite) 21.5 ± 0.6 m.y.**
**22.1 ± 0.6 m.y.**

14. *TV-1* K-Ar

*Silberman and others, 1978*

Upper unit, King Tonopah Member of Fraction Tuff. (SW¼ NW¼ S24,T3N,R42E; 38°06'04"(06.07')N, 117°13'06"(13.10')W; Nye Co., NV). *Analytical data:* $K_2O$ = 4.81%, $^{40}Ar^*$ = 1.299 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.65. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* The upper unit of the King Tonopah Member of the Fraction Tuff yields an age approximately 1.5 m.y. younger than that of the lower unit. The age of the upper unit appears to overlap in time hydrothermal mineralization and alteration in the Tonopah mining district.

***(alkali feldspar) 18.2 ± 0.6 m.y.**
**18.7 ± 0.6 m.y.**

15. *R-1* K-Ar

*Silberman and others, 1978*

Rhyolite dome, rhyolite of the Cleft. (NW¼ NW¼ S3, unsurveyed T4N,R42E; 38°14'22"(14.37')N, 117°15'16"(15.27')W; Nye Co., NV). *Analytical data:* $K_2O$ = 9.48%, $^{40}Ar^*$ = 2.697 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.81. *Collected by:* H. F. Bonham, Nevada

Bureau of Mines and Geology, and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(sanidine) 19.2 ± 0.6 m.y.**
**19.7 ± 0.6 m.y.**

16. *T-291* K-Ar

*Silberman and others, 1978*

Fine-grained intergrowth of quartz-adularia-sericite replacing porphyritic dacite of the Mizpah Formation in the Tonopah mining district. (C SE¼ S35,T3N, R42E; 38°04'07"(04.12')N, 117°13'35"(13.58')W; Nye Co., NV). *Analytical data:* $K_2O$ = 7.36%, $^{40}Ar^*$ = 1.979 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.53. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* The sample represents altered wall rock. The age is younger than, but nearly within analytical uncertainty, of a 19.1 m.y. age reported by Bonham and others (1972) on purified adularia from a vein in the nearby Belmont Mine.

***(adularized whole rock) 18.8 ± 0.7 m.y.**
**18.6 ± 0.7 m.y.**

17. *T-229* K-Ar

*Silberman and others, 1978*

Fine-grained quartz-adularia-sericite replacing porphyritic dacite of the Mizpah Formation. (C W½ S35, unsurveyed T4N,R42E; 38°09'34"(09.57')N, 117°14'05"(14.08')W; Nye Co., NV). Frazier's Well area, 10 km north of Tonopah. *Analytical data:* $K_2O$ = 9.21%, $^{40}Ar^*$ = 2.328 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.46. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* The relationship of this alteration-mineralization to that at Tonopah is unknown, but apparently slightly younger.

***(adularized whole rock) 17.0 ± 0.7 m.y.**
**17.4 ± 0.7 m.y.**

18. *SIE-1* K-Ar

*Silberman and others, 1978*

Air-fall tuff in the Siebert Formation. (SW¼ SW¼ NE¼ S3,T2N,R42E; 38°03'29"(03.48')N, 117°14'56"(14.93')W; Esmeralda Co., NV). *Analytical data:* (sanidine) $K_2O$ = 9.50%, $^{40}Ar^*$ = 2.768 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.71 (biotite) $K_2O$ = 7.85%, $^{40}Ar^*$ = 1.872 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.20. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* K-Ar age for the sanidine is too old, based on other dates and geologic considerations. This erroneous age is probably due to contamination of the sample by older accidental sanidine crystals. The biotite determination appears to be a more reasonable age.

***(sanidine) 19.5 ± 0.4 m.y.**
**20.0 ± 0.4 m.y.**
***(biotite) 16.1 ± 1.0 m.y.**
**16.5 ± 0.4 m.y.**

19. *SIE-2* K-Ar

*Silberman and others, 1978*

Fine-grained porphyritic trachyandesite from Siebert Formation. (SW¼ S3,T2N,R42E; 38°03'09"(03.15')N, 117°15'15"(15.25')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 2.54%, $^{40}Ar^*$ = 6.101 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.66. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Sample is from a trachyandesite flow interbedded in the Siebert Formation.

***(whole rock) 16.2 ± 0.6 m.y.**
**16.6 ± 0.6 m.y.**

20. *SIE-3A* K-Ar

*Silberman and others, 1978*

Air-fall tuff containing biotite and alkali feldspar crystals in a pumiceous matrix; Siebert Formation. (SW¼ SW¼ NE¼ S3,T2N,R42E; 38°03'32"(03.52')N, 117°14'51"(14.85')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 2.15%, $^{40}Ar^*$ = 6.371 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.20. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* The age is too old for the Siebert Formation. Some contamination by older feldspar crystals during eruption or emplacement may have occurred, a common problem in tuffaceous rocks.

***(alkali feldspar) 20.0 ± 1.2 m.y.**
**20.5 ± 1.2 m.y.**

21. *11550-1* K-Ar

*Silberman and others, 1978*

Columnar-jointed porphyritic rhyolite with phenocrysts of biotite and alkali feldspar; Oddie Rhyolite. (NE¼ NE¼ NE¼ S35,T3N,R42E; 38°04'38"(04.63')N, 117°13'21"(13.35')W; Nye Co., NV). *Analytical data:* $K_2O$ = 8.49%, $^{40}Ar^*$ = 2.12 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.42. *Collected by:* M. L. Silberman and F. J. Kleinhampl, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Sample collected from between Mt. Oddie and Ararat Mountain in the main part of the Tonopah mining district.

***(biotite) 16.9 ± 0.5 m.y.**
**17.3 ± 0.5 m.y.**

22. *Od-1-Bo* K-Ar

*Silberman and others, 1978*

Oddie Rhyolite. (C SE¼ NE¼ S35,T3N,R42E; 38°04'26"(04.43')N, 117°13'26"(13.43')W; Nye Co., NV). *Analytical data:* $K_2O$ = 8.91%, $^{40}Ar^*$ = 2.176 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.64. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* E. H. McKee, U.S. Geological Survey.

***(biotite) 16.5 ± 0.5 m.y.**
**16.9 ± 0.5 m.y.**

23. *BQL-1* K-Ar

*Silberman and others, 1978*

Brougher Rhyolite. (SE¼ NW¼ SE¼ S2,T2N,R42E; 38°03'18"(03.82')N, 117°13'42"(13.70')W; Nye Co., NV). *Analytical data:* (sanidine) $K_2O$ = 10.95%, $^{40}Ar^*$ = 2.617 x $10^{-10}$ mole/g, $^{40}Ar^*/^{40}Ar$ = 0.95; (biotite) $K_2O$ = 8.67%, $^{40}Ar^*$ = 2.055 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.60. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman and E. H. McKee, U.S. Geological Survey.

***(sanidine) 16.1 ± 0.5 m.y.**
**16.5 ± 0.5 m.y.**
***(biotite) 16.0 ± 0.5 m.y.**
**16.4 ± 0.5 m.y.**

24. *BQL-2* K-Ar

*Silberman and others, 1978*

Brougher Rhyolite. (C S½ S27, unsurveyed T4N,R42E; 38°10'12"(10.20')N, 117°14'56"(14.93')W; Nye Co., NV). *Analytical data:* (alkali feldspar) $K_2O$ = 6.41%, $^{40}Ar^*$ = 1.348 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.48; (biotite) $K_2O$ = 8.98%, $^{40}Ar^*$ = 1.761 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.48. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* This age is younger than those from Brougher Rhyolite intrusions near Tonopah (generally 16 m.y.), but the ages are strongly discordant. The data suggest that there has been post-crystallization argon loss—perhaps due to a later thermal event in this immediate area.

***(alkali feldspar) 14.5 ± 0.4 m.y.**
**14.9 ± 0.4 m.y.**
***(biotite) 13.2 ± 0.4 m.y.**
**13.6 ± 0.4 m.y.**

25. *D-1* K-Ar

*Silberman and others, 1978*

Porphyritic biotite-hornblende dacite or andesite, Divide Andesite. (NW¼ SW¼ NW¼ S33,T2N,R43E; 37°59'14"(59.23')N, 117°10'00"(10.00')W; Esmeralda Co., NV). *Analytical data:* (biotite) $K_2O$ = 6.54%, $^{40}Ar^*$ = 1.632 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.64; (hornblende) $K_2O$ = 0.86% (X-ray fluorescence), $^{40}Ar^*$ = 2.113 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.58; (plagioclase) $K_2O$ = 0.495%, $^{40}Ar^*$ = 1.093 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.60. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Plagioclase is vermicular; the biotite and hornblende ages are believed to be near to the age of emplacement.

***(biotite) 16.8 ± 0.5 m.y.**
**17.2 ± 0.5 m.y.**
***(hornblende) 16.6 ± 0.8 m.y.**
**17.0 ± 0.8 m.y.**
***(plagioclase) 14.9 ± 0.4 m.y.**
**15.3 ± 0.4 m.y.**

26. *D-3* K-Ar

*Silberman and others, 1978*

Porphyritic biotite-hornblende dacite or andesite, Divide Andesite. (NW¼ NW¼ S33,T2N,R43E; 37°59'20" (59.33')N, 117°09'39"(09.65')W; Nye Co., NV). *Analytical data:* $K_2O$ = 0.934%, $^{40}Ar^*$ = 2.338 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.33. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(hornblende) 16.9 ± 0.7 m.y.**
**17.3 ± 0.7 m.y.**

27. *L-1* K-Ar

*Silberman and others, 1978*

Fine-grained, grey quartz latite, volcanics of Donovan Peak. (SW¼ SW¼ SW¼ S20,T1N,R43E; 37°55'08" (55.13')N, 117°11'03"(11.05')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 3.94%, $^{40}Ar^*$ = 9.297 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.75. *Collected by:* M. L. Silberman and R. P. Ashley, U.S. Geological Survey, and H. F. Bonham, Nevada Bureau of Mines. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(whole rock) 15.9 ± 0.5 m.y.**
**16.3 ± 0.5 m.y.**

28. *FBR-2* K-Ar

*Silberman and others, 1978*

Rhyolite, volcanics of Donovan Peak. (SW¼ NW¼ S32, T2N,R43E; 37°59'06"(59.10')N, 117°11'02"(11.03')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 8.46%, $^{40}Ar^*$ = 2.048 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.42. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(biotite) 16.3 ± 0.7 m.y.**
**16.7 ± 0.7 m.y.**

29. *HL-1* K-Ar

*Silberman and others, 1978*

Rhyodacite, volcanics of Donovan Peak. (SW¼ NW¼ S32,T2N,R43E; 37°59'00"(59.00')N, 117°11'02" (11.03')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 0.862%, $^{40}Ar^*$ = 1.889 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.26. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(hornblende) 14.8 ± 0.6 m.y.**
**15.2 ± 0.6 m.y.**

30. *TD-2* K-Ar

*Silberman and others, 1978*

Altered Fraction Tuff, Tonopah Summit Member; alteration is transitional between propylitic and sericitic, the original biotite now consists of mixed layer chlorite and sericite. (C SW¼ S26,T2N,R42E; 37°59'44"(59.73')N, 117°14'11"(14.18')W; Esmeralda Co., NV; mine dump sample, from Gold Zone shaft, Divide

mining district). *Analytical data:* $K_2O$ = 2.322%, $^{40}Ar^*$ = 5.392 x $10^{-11}$, 5.400 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.59, 0.52. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Alteration age, Divide mining district.

***(sericite/chlorite) 15.7 ± 0.2 m.y.**
**16.1 ± 0.2 m.y.**

31. *TD-3* K-Ar

*Silberman and others, 1978*

Quartz-sericite alteration of Fraction Tuff, Divide district. (NW¼ SW¼ NW¼ S27,T2N,R42E; 38°00'08" (00.13')N, 117°15'25"(15.42')W; Esmeralda Co., NV; outcrop sample). *Analytical data:* $K_2O$ = 5.86%, $^{40}Ar$ = 1.325 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.37. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* From the Belcher vein system, at Tonopah Divide Shaft, 1 km north of Hasbrouck Peak. Alteration age.

***(sericite) 15.3 ± 0.6 m.y.**
**15.7 ± 0.6 m.y.**

32. *THA-6* K-Ar

*Silberman and others, 1978*

Sericitic alteration of lapilli tuff in the Siebert Formation. (SE¼ SW¼ SE¼ S28,T2N,R42E; 37°59'32" (59.53')N, 117°15'59"(15.98')W; Esmeralda Co., NV. Sample taken in adit of Tonopah Hasbrouck Mine). *Analytical data:* $K_2O$ = 8.02%, $^{40}Ar^*$ = 1.879 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.56. *Collected by:* M. L. Silberman, U.S. Geological Survey, and John Livermore, A. B. Wallace, and P. E. Dircksen, Cordex Exploration Co. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Hydrothermal alteration age.

***(muscovite) 15.8 ± 0.5 m.y.**
**16.2 ± 0.5 m.y.**

33. *THA-25R* K-Ar

*Silberman and others, 1978*

Silicified and adularized pumice breccia?, Siebert Formation. (NW¼ NE¼ S33,T2N,R42E; 37°59'27" (59.45')N, 117°16'00'(16.00')W; Esmeralda Co., NV; Hasbrouck Peak, Divide mining district). *Analytical data:* $K_2O$ = 5.61%, $^{40}Ar^*$ = 1.369 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.48. *Collected by:* M. L. Silberman, U.S. Geological Survey, and John Livermore, A. B. Wallace, and P. E. Dircksen, Cordex Exploration Co. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Alteration age, Divide mining district. Detrital sanidine is present in the sample, but it probably lost pre-alteration argon during the silicification, as indicated by the concordance of the age of this whole rock with an adularia separate from the same sample (THA-25C, no. 34).

***(adularized whole rock) 16.4 ± 0.5 m.y.**
**16.8 ± 0.5 m.y.**

34. *THA-25C* K-Ar

*Silberman and others, 1978*

Hydrothermal alteration, Siebert Formation, Divide district, Hasbrouck Peak. (Location same as sample THA-25R, no. 33). *Analytical data:* $K_2O$ = 9.51%, $^{40}Ar^*$ = 2.300 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.56. *Collected by:* M. L. Silberman, U.S. Geological Survey, and John Livermore, A. B. Wallace, and P. E. Dircksen, Cordex Exploration Co. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Purified K-feldspar concentrate, separated from sample THA-25R, no. 33. Concordance of ages indicates that detrital K-feldspar has not affected the result.

***(adularia) 16.3 ± 0.5 m.y.**
**16.7 ± 0.5 m.y.**

35. *A-1* K-Ar

*Bonham and Garside, 1979*

Hydrothermal alteration, Divide mining district. Coarse, vein adularia from a quartz vein. (NE¼ SE¼ S28,T2N, R42E; 117°15'55"(15.92')N, 37°59'50"(59.83')W, Esmeralda Co., NV). *Analytical data:* $K_2O$ = 8.11%, $^{40}Ar^*$ = 1.890 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.56. *Collected by:* P. E. Dircksen, Cordex Exploration Co. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(adularia) 15.7 ± 0.5 m.y.**
**16.1 ± 0.5 m.y.**

36. *LM-2* K-Ar

*Silberman and others, 1978*

Trachyandesite, volcanics of Lime Mountain. (SE¼ NE¼ S4, unsurveyed T4N,R42E; 38°13'59"(13.98') N, 117°15'42"(15.70')W; Nye Co., NV). *Analytical data:* (hornblende) $K_2O$ = 0.802%, $^{40}Ar^*$ = 1.856 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.31; (plagioclase) $K_2O$ = 0.375%, $^{40}Ar^*$ = 9.261 x $10^{-12}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.34. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* Plagioclase phenocrysts are vermicular; see LM-3, no. 38.

**15.6 ± 0.5 *(hornblende) 15.7 ± 0.6 m.y.**
**16.1 ± 0.6 m.y.**
**16.8 ± 0.5 *(plagioclase) 16.6 ± 0.8 m.y.**
**17.0 ± 0.8 m.y.**

37. *LM-3* K-Ar

*Silberman and others, 1978*

Trachyandesite, volcanics of Lime Mountain. (SE¼ S4, unsurveyed T4N,R42E; 38°13'45"(13.75')N, 117°15' 45'(15.75')W; Nye Co., NV). *Analytical data:* $K_2O$ = 0.726%, $^{40}Ar^*$ = 1.699 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.40. *Collected by:* L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey. *Comment:* See sample LM-2, no. 36.

***(hornblende) 15.8 ± 0.5 m.y.**
**16.2 ± 0.5 m.y.**

38. *TM-1* K-Ar

*Silberman and others, 1978*

Trachyandesite of Thunder Mountain. (C NW¼ NW¼ NE¼ S22,T4N,R44E; 38°11'33"(11.55')N, 117°01' 39"(01.65')W; Nye Co., NV). *Analytical data:* $K_2O$ = 1.91%, $^{40}Ar^*$ = 4.473 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.54. *Collected by:* H. F. Bonham and L. J. Garside, Nevada Bureau of Mines and Geology. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(whole rock) 15.8 ± 0.5 m.y.**
**16.2 ± 0.5 m.y.**

39. *RMB 2* K-Ar

*Silberman and others, 1978*

Trachyandesite of Red Mountain. (NE¼ SW¼ NW¼ S29,T3N,R43E; 38°05'21"(05.35')N, 117°10'52" (10.87')W; Nye Co., NV). *Analytical data:* $K_2O$ = 0.891, $^{40}Ar^*$ = 2.000 x $10^{-11}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.45. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and R. P. Ashley and M. L. Silberman, U.S. Geological Survey. *Dated by:* M. L. Silberman, U.S. Geological Survey.

***(hornblende) 15.1 ± 0.5 m.y.**
**15.5 ± 0.5 m.y.**

40. *GRP-1* Fission-track

*Silberman and others, 1978*

Silicic porphyry dike. (SE¼ SW¼ SW¼ S2, unsurveyed T2N,R40E; 38°03'05"(03.08')N, 117°27'25"(27.42') W; Esmeralda Co., NV). *Analytical data:* Ps = 2.182 x $10^6$ tracks/cm$^2$, ½Pi = 3.598 x $10^6$ tracks/cm$^2$, $\phi$ = 1.19 x $10^{15}$ N/cm$^2$, no. of grains counted = 7. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and M. L. Silberman, U.S. Geological Survey. *Dated by:* R. P. Ashley, U.S. Geological Survey. *Comment:* Silicic porphyry dikes intrude Precambrian carbonate rocks on Lone Mountain. They are hydrothermally altered and appear to be associated with Ag-Pb-Zn mineralization. The zircon age is believed to represent the age of emplacement.

**(zircon) 22.1 ± 3.2 m.y.**

41. *AD-SSAD* K-Ar

Hydrothermal alkali feldspar in sugary vein quartz; some vein material appears to be a replacement of lamellar calcite. (N½ NE¼ NE¼ S11,T16N,R32E; 118°21'06"(21.1')N, 39°16'12"(16.2')W; Churchill Co., NV). *Analytical data:* $K_2O$ = 2.353%, $^*Ar^{40}$ = 6.3844 x $10^{-11}$ mol/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 17.9%. *Collected by:* E. J. Collord, Mackay School of Mines, University of Nevada-Reno. *Dated by:* E. H. McKee, U.S. Geological Survey. *Comment:* The sample is from the main, east-trending quartz vein in the Sand Springs mining district. Free gold and silver chloride are reported from the vein at the Dan Tucker Mine in the district (Vanderburg, 1940). The age is believed to be that of mineralization in the district.

***(alkali feldspar) 19.0 ± 0.5 m.y.**
**19.5 ± 0.5 m.y.**

42. *LP1-AD* K-Ar

Fluorite mineralization, La Plata fluorite prospect (Papke, 1979). (W½ S16,T18N,R33E; 118°17'37" (17.62')N, 39°25'19"(25.32')W; Churchill Co., NV). *Analytical data:* $K_2O$ = 10.04%, $^{40}Ar^*$ = 1.262 x $10^{-9}$, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.675. *Collected by:* H. F. Bonham, Jr., Nevada Bureau of Mines and Geology. *Dated by:* E. H. McKee, U.S. Geological Survey. *Comment:* The muscovite is associated with fluorite-rich zones and veinlets in aplite dikes and sills which intrude Mesozoic carbonate rocks. The data is believed to represent the age of mineralization.

***(muscovite) 83.5 ± 1.0 m.y.**
**85.2 ± 1.0 m.y.**

43. *C3* K-Ar

Hydrothermal barite from a quartz vein which contains uranium and molybdenum mineralization. (C N½ S5, T1N,R37E; 117°53'07"(53.12')N, 37°58'24"(58.4')W; Esmeralda Co., NV). *Analytical data:* $K_2O$ = 0.1%, $^{40}Ar^*$ = 1.11073 x $10^{-13}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.0011. *Collected by:* H. F. Bonham, Jr., Nevada Bureau of Mines and Geology. *Dated by:* E. H. McKee, U.S. Geological Survey. *Comment:* The quartz vein sampled cuts a rhyolitic ash-flow tuff which is dated at approximately 22 m.y. (Robinson and others, table 1, nos. 12, 14). The age of mineralization suggested by the barite date seems to be too young.

***(barite) 0.75 ± 0.8 m.y.**
**0.77 ± 0.8 m.y.**

44. *S-6* K-Ar

Rhyodacite ash-flow tuff, tuff of Coyote Spring. Dark gray to brown rhyodactie tuff. Two cooling units, lower cooling unit poorly welded and glassy, 20% phenocrysts of which 80% are plagioclase, biotite (10%), sanidine (5–10%), lithics (5%). (SW¼ NE¼ S24, T22N,R21E; 39°45'45"(45.75')N, 119°34'04"(34.07') W; Washoe Co., NV). *Analytical data:* (biotite) $K_2O$ = 7.77%, $^{40}Ar^*$ = 3.106 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.37; (plagioclase) $K_2O$ = 1.181%; $^{40}Ar^*$ = 0.4981 x $10^{-10}$ mole/g, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.50. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology, and M. L. Silberman, U.S. Geological Survey. *Dated by:* C. L. Connor and M. L. Silberman, U.S. Geological Survey.

***(biotite) 27.1 ± 0.8 m.y.**
**27.6 ± 0.8 m.y.**
***(plagioclase) 28.5 ± 0.9 m.y.**
**29.1 ± 0.9 m.y.**

45. *S-7* K-Ar

Rhyolite ash-flow tuff, Nine Hill Tuff. Red brown rhyolite tuff, densely welded; black vitrophyre locally present at base of unit. Tuff is locally flow-lineated. Lower part: 2–3% phenocrysts of anorthoclase, quartz and plagioclase; upper part: 15% phenocrysts of anorthoclase, minor quartz and plagioclase and a trace of

biotite. (NE¼ S24,T22N,R21E; 39°45'50"(45.83')N, 119°34'15"(34.25')W; Washoe Co., NV). *Analytical data:* $K_2O$ = 5.85%, $^{40}Ar^*$ = 1.84 x $10^{-10}$, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.58. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology and M. L. Silberman, U.S. Geological Survey. *Dated by:* C. L. Connor and M. L. Silberman, U.S. Geological Survey. *Comment:* Age too young. Bingler (1975) states that the Nine Hill Tuff is approximately 25 m.y. old in the Carson City area on the basis of its stratigraphic relationships with other dated ash-flow tuff units. In the Warm Springs area, stratigraphic relationships also suggest that the Nine Hill Tuff is at least 25 m.y. old.

***(alkali feldspar) 21.3 ± 0.7 m.y.**
**21.7 ± 0.7 m.y.**

46. *S-9* K-Ar

Rhyolite ash-flow tuff, tuff of Piute Creek. Three cooling units, pale red to light gray, 5 to 10% phenocrysts of glassy sanidine (60–65%), plagioclase (35%), biotite (1–5%), traces of quartz and hornblende; pervasive vapor phase crystallization in upper parts of cooling units. (NW¼ S19,T22N,R22E; 39°45'52"(45.87')N, 119°33'30"(33.5')W; Washoe Co., NV). *Analytical data:* $K_2O$ = 6.24%, $^{40}Ar^*$ = 2.590 x $10^{-10}$, $^{40}Ar^*/\Sigma^{40}Ar$ = 0.50. *Collected by:* H. F. Bonham, Nevada Bureau of Mines and Geology and M. L. Silberman, U.S. Geological Survey. *Dated by:* C. L. Connor and M. L. Silberman, U.S. Geological Survey. *Comment:* Age probably minimum. The tuff of Piute Creek unconformably underlies the tuff of Coyote Spring (sample S-6, no. 44).

***(alkali feldspar) 28.0 ± 0.9 m.y.**
**28.6 ± 0.9 m.y.**

## REFERENCES


Ashley, R. P. (1973) Fission track ages for pre-mineralization volcanic and plutonic rocks of the Goldfield mining district, Esmeralda and Nye Counties, Nevada: Isochron/West, no. 8, p. 25–30.

Ashley, R. P., and Silberman, M. L. (1976) Direct dating of mineralization at Goldfield, Nevada by K-Ar and fission track methods: Econ. Geol., v. 71, p. 904–924.

Bingler, E. C. (1978) Abandonment of the name Hartford Hill Rhyolite Tuff and adoption of new formation names for middle Tertiary ash-flow tuffs in the Carson City–Silver City area, Nevada: U.S. Geological Survey Bull. 1457-D, 19 p.

Bonham, H. F., Jr., Garside, L. J., and Silberman, M. L. (1972) K-Ar ages of ore deposition at Tonopah, Nevada: Isochron/West, no. 4, p. 5–6.

Bonham, H. F., Jr., and Garside, L. J. (1979) Geology of the Tonopah, Lone Mountain, Klondyke, and northern Mud Lake quadrangles, Nevada: Nevada Bur. Mines and Geol. Bull. 92, 142 p.

Dalrymple, G. B., and Lanphere, M. A. (1969) Potassium-argon dating: San Francisco, W. H. Freeman Co., 258 p.

Dodge, F. C., Fabbi, B. P., and Ross, D. C. (1970) K and Rb in granitic rocks of central California: U.S. Geological Survey Prof. Paper 700-D, p. D108–D115.

Ekren, E. B., Anderson, R. E., Rogers, C. L., and Noble, D. C. (1971) Geology of northern Nellis Air Force Base Bombing and Gunnery Range, Nye County, Nevada: U.S. Geological Survey Prof. Paper 651, 91 p.

Fleischer, R. L., and Price, P. B. (1964) Decay constant for spontaneous fission of $U^{238}$: Physics Review, v. 133, p. B63–B64.

Ingamells, C. D. (1970) Lithium metaborate flux in silicate analysis: Anal. Chim. Acta, v. 52, p. 323–334.

Keeling, D. L., and Naughton, J. J. (1974) K-Ar dating: Addition of atmospheric argon on rock surface from crushing: Geophys. Res. Letters, v. 1, p. 43–46.

Morton, J. L., Silberman, M. L., Bonham, H. F., Jr., Garside, L. J., and Noble, D. C. (1977) K-Ar ages of volcanic rocks, plutonic rocks, and ore deposits run under the USGS–NBMG Cooperative Program: Isochron/West, no. 20, p. 19–29.

Naeser, C. W. (1976) Fission-track dating: U.S. Geol. Survey open-file report 76-190, 22 p.

Papke, K. G. (1979) Fluorspar in Nevada: Nevada Bur. Mines and Geology Bull. 93, 77 p.

Robinson, P. T., McKee, E. H., and Moiola, R. J. (1968) Cenozoic volcanism and sedimentation, Silver Peak region, western Nevada and adjacent California, *in* Coats, R. R., Hay, R. L., and Anderson, C. A., eds., Studies in volcanology—memoir in honor of Howel Williams: Geol. Soc. America Mem. 116, p. 577–611.

Silberman, M. L., Bonham, H. F., Jr., Garside, L. J., and Ashley, R. P. (1978) Radiometric ages of volcanic and plutonic rocks and hydrothermal alteration–mineralization in the Tonopah mining district and vicinity, Nye and Esmeralda Counties, Nevada: U.S. Geol. Survey open-file report 78-841, 41 p.

_____ (1979) Timing of hydrothermal alteration-mineralization and igneous activity in the Tonopah mining district and vicinity, Nye and Esmeralda Counties, Nevada, *in* Ridge, J. D., ed., Papers on mineral deposits of western North America: Nevada Bur. Mines and Geol. Rept. 33, p. 119–126.

Silberman, M. L., and McKee, E. H. (1971) K-Ar ages of granitic plutons in north-central Nevada: Isochron/West, no. 1, p. 15–32.

_____ (1972) A summary of radiometric age determinations on Tertiary volcanic rocks from Nevada and eastern California, Part II—Western Nevada: Isochron/West, no. 4, p. 7–28.

Steiger, R. H., and Jager, E. (1977) Subcommission on geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Sci. Letters, v. 36, p. 359–362.

Vanderburg, W. D. (1940) Reconnaissance of mining districts in Churchill County, Nevada: U.S. Bur. Mines Inf. Circ. 7093.

Wallace, A. B. (1975) Geology and mineral deposits of the Pyramid district, southern Washoe County, Nevada: Ph.D. dissertation, University of Nevada, Reno.