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SHELL LIST NO. 1--K-AR AND RB-SR AGE DETERMINATIONS OF CALIFORNIA, NEVADA AND UTAH ROCKS AND MINERALS

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This list covers K-Ar and Rb-Sr age determinations run at the Exploration and Production Research Center of Shell Development Company (3737 Bellaire Blvd., Houston, TX 77025) for Shell Canadian Exploration Company (both companies are subsidiaries of Shell Oil Company).

After crushing the rock minerals were separated from separate sieve samples according to their magnetic properties and density. All mineral concentrates were hand picked under a low-power binocular microscope to upgrade their purity.

Potassium, rubidium and strontium concentrations were determined by stable isotope dilution using a 12-inch radius single-focussing mass spectrometer with a 14 stage electron multiplier in the collector circuit. The same mass spectrometer was used to determine the isotopic composition of rubidium and strontium. Potassium concentration was also measured by precipitation with tetra-phenyl boron. Agreement between the two different determinations was consistently better than 2%.

Argon was measured by isotope dilution with pure Argon 38 in a 4 1/2-inch radius single-focussing mass spectrometer with a 6 stage electron multiplier in the collector circuit, or with a 6-inch radius single-focussing instrument with a 14 stage electron multiplier. In both cases the instruments were operated dynamically.

The errors quoted in each case are 2σ based on a statistical method which is described in detail in a paper entitled "Potassium-Argon Mineral Age of an Ash Bed in the Pico Formation, Ventura Basin, California" by Robert S. Yeats and W. A. McLaughlin: Geol. Soc. Am., Special Paper 124 (1970).

Constants used in the K-Ar age calculations are: $\lambda_e = 0.584 \times 10^{-10}\ y^{-1}$; $\lambda_\beta = 4.72 \times 10^{-10}\ y^{-1}$; $K^{40}/K_{total} = 0.0119$; and in the Rb-Sr calculations λ for $Rb^{87} = 1.39 \times 10^{-11}\ y^{-1}$.

The geologic data are from the files of Shell Canadian Exploration Company; the person who collected the sample is not always recorded.

SAMPLE DESCRIPTIONS

A. Metamorphic Rocks--California

1. S-EPR4088B/C27 K-Ar (fuchsite) 123±4 m.y.

Maraposite. (Mariposa Co., CA) schist composed of magnesite, fuchsite, quartz, and pyrite. Analytical data: K = 5.33%; $\overset{*}{Ar}^{40} = 2.71 \times 10^{-5}$ cc/g; $\overset{*}{Ar}^{40}/\Sigma Ar^{40} = 42\%$.

B. Intrusive Rocks--Nevada

Lone Mountain, Esmeralda County

2. S-EPR4085O/1010 K-Ar (biotite) 63±7 m.y.

Lone Mountain composite pluton. Coarse-grained, biotite granite (38°02'40"N, 117°27'40"W; Sec. 10(?), T2N, R40E; Lone Mountain, Esmeralda Co., NV) from the large intrusive body exposed at higher elevations on Lone Mountain. Analytical data: K = 4.26%; $\overset{*}{Ar}^{40} = 10.8 \times 10^{-6}$ cc/g; $\overset{*}{Ar}^{40}/\Sigma Ar^{40} = 32\%$.

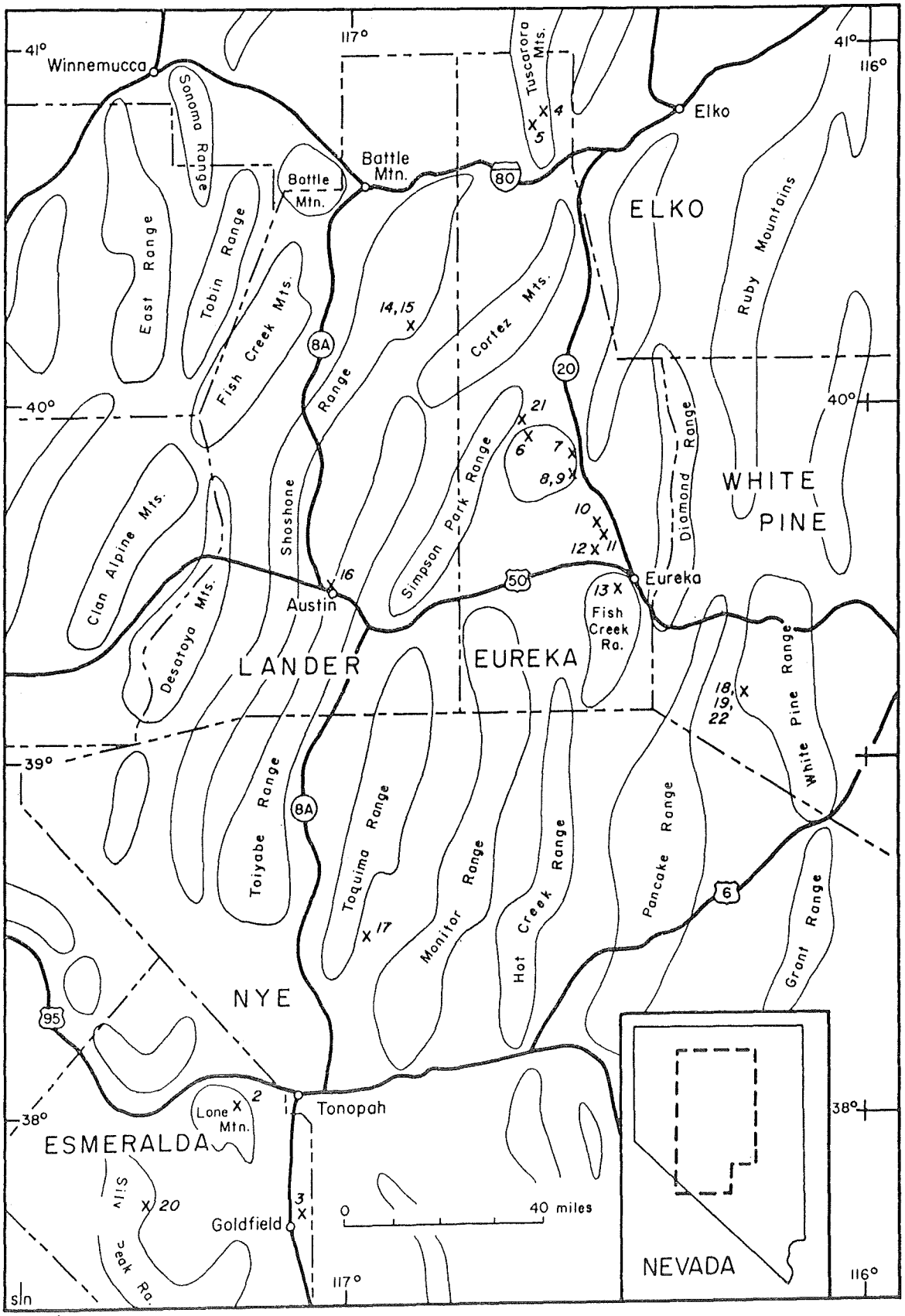

Figure 1.. Map showing location of dated rock samples (numbers keyed to sample descriptions).

Goldfield Mining District, Esmeralda County

3. S-EPR4085A/875 K-Ar (biotite) 173±6 m.y.

Vindicator pluton. Coarse-grained granite (37°51′39″N, 117°12′03″W; center W/2 Sec. 30, T2S, R43E; in valley between Ruby Hills and Vindicator Mtn.; Goldfield mining district, Esmeralda Co., NV). Analytical data: K = 6.34%; $\overset{*}{A}r^{40}$ = 4.57 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 68%.

Tuscarora Mountains, Eureka County

4. S-EPR4079B/D3R – NE of Beowawe K-Ar (biotite) 108±6 m.y.

Medium-grained, biotite granodiorite from a stock (40°51′19″N, 116°18′16″W; NE/4 NE/4 T34N, R50E; Tuscarora Mts., Eureka Co., NV). Analytical data: K = 2.48%; $\overset{*}{A}r^{40}$ = 1.10 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 30%. Comment: Biotite is severely chloritized.

5. S-EPR4079C/D4R NE of Beowawe K-Ar (whole rock) 91±7 m.y.

Rhyolite porphyry from a stock (40°48′2″N, 116°18′10″W; SE/4 T34N, R50E; Tuscarora Mts., Eureka Co., NV). Phenocrysts of plagioclase in a matrix of quartz, orthoclase, and rare muscovite and biotite. Analytical data: K = 3.17%; $\overset{*}{A}r^{40}$ = 1.18 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 24%. Comments: Plagioclase is chloritized and sericitized. Stock previously dated as 121 m.y. (Hausen and Kerr, 1968). Age should be considered a minimum.

Roberts Mountains, Eureka County

6. S-EPR4064E/N-KR-44B K-Ar (whole rock) 14.5±1.8 m.y.

Diabase dike (39°55′10″N, 116°20′54″W; NW/4 Sec. 33, T24N, R50E; 1 mi NE of Western Peak, N end Roberts Mts., Eureka Co., NV). Medium-grained, ophitic texture. Analytical data: K = 1.63%; $\overset{*}{A}r^{40}$ = 9.5 x 10^{-7} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 10%. Comment: Part of diabase dike swarm that extends south-southeast from this point for 12 miles.

7. S-EPR4094D K-Ar (biotite) 49±2 m.y.

Mt. Hope pluton. Rhyolite porphyry (39°50′00″N, 116°11′40″W; center Sec. 25, T23N, R51E; North Mt. Hope, Eureka Co., NV). Analytical data: K = 6.53%; $\overset{*}{A}r^{40}$ = 1.30 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 34%. Comment: Compare with S-ERP4063A/N-KR-1 and S-ERP4063D/N-KR-41 (below).

8. S-ERP4063A/N-KR-1 K-Ar (biotite) 32.6±1.5 m.y.
Rb-Sr (biotite) 29.9±6 m.y.

Mt. Hope(?) pluton. Dacite porphyry (39°48′36″N, 116°09′12″W; center S/2 Sec. 6, T22N, R52E; 500 ft. NE of State Highway 20 intersection with northernmost road leading SW to Mt. Hope Mine; Eureka Co., NV). Analytical data: K = 7.17%; $\overset{*}{A}r^{40}$ = 9.41 x 10^{-6} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 49%. Rb = 381 ppm; Sr = 63.7 ppm; Sr^{87}/Sr^{86} = 0.717. Comment: Compare with S-EPR4094D (above) and S-ERP4063D/N-KR-41 (below).

9. S-ERP4063D/N-KR-41 K-Ar (whole rock) 39.8±1 m.y.

Mt. Hope pluton. Rhyolite porphyry (39°47′19″N, 116°10′03″W; NE/4 Sec. 19, T22N, R52E; from outcrop immediately above the Mt. Hope Mine; Eureka Co., NV). Analytical data: K = 6.53%; $\overset{*}{A}r^{40}$ = 1.05 x 10^{-6} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 78%. Comment: Compare with S-EPR4094D and S-ERP4063A/N-KR-1 (above); this pluton dated as 36 m.y. by Silberman and McKee (1971, p. 30).

Whistler Mountain, Eureka County

10. S-EPR4064B — K-Ar — (whole rock) 84±2.5 m.y.

Whistler Mountain pluton. Fine-grained quartz diorite (39°39′06″N, 116°05′50″W; SW/4 Sec. 26, T21N, R52E; N end Whistler Mountain; Eureka Co., NV). Analytical data: K = 3.68%; $\overset{*}{A}r^{40}$ = 1.267 x 10^{-6} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 76%. Comment: Compare with S-EPR4064C and S-EPR4064D (below); mafic minerals and plagioclase are highly altered, suggesting that at best this date should be considered a minimum age of intrusion.

11. S-EPR4064C — K-Ar — (orthoclase) 93±9 m.y.
K-Ar — (muscovite) 178±4 m.y.
Rb-Sr — (muscovite) 154±25 m.y.

Whistler Mountain pluton. Porphyritic quartz monzonite (39°37′40″N, 116°04′30″W; NE/4 Sec. 2, T20N, R52E; E side Whistler Mountain; Eureka Co., NV). Analytical data: (Orthoclase, altered) K = 3.04%; $\overset{*}{A}r^{40}$ = 1.158 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 53%. (Muscovite, fresh) K = 7.75%; $\overset{*}{A}r^{40}$ = 5.802 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 80%. Rb = 600 ppm; Sr = 33.1 ppm; Sr^{87}/Sr^{86} = 0.8236. Comment: Compare with S-EPR4064B (above) and S-EPR4064D (below); this pluton dated as 152 m.y. by Armstrong (1970).

12. S-EPR4064D — K-Ar — (muscovite) 148.5±3 m.y.
Rb-Sr — (muscovite) 143±15 m.y.

Whistler Mountain pluton. Porphyritic rhyolite sill (39°34′50″N, 116°04′09″W; SW/4 Sec. 24, T20N, R52E; S end Whistler Mountain; Eureka Co., NV) forming an apophysis of the main pluton mass. Analytical data: (Muscovite, fresh) K = 8.58%; $\overset{*}{A}r^{40}$ = 5.294 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 69%. (Muscovite, fresh) Rb = 273 ppm; Sr = 55.3 ppm; Sr^{87}/Sr^{86} = 0.738. Comment: Compare with S-EPR4064B and S-EPR4064C (above): this pluton previously dated as 152 m.y. by Armstrong (1970).

Fish Creek Range, Eureka County

13. S-EPR4064A — K-Ar — (biotite) 123±12 m.y.
K-Ar — (orthoclase) 78±3 m.y.

Ruby Hill stock. Fine-grained, equigranular quartz monzonite (SW/4 Sec. 21, T19N, R53E; Ruby Hill, Eureka Co., NV). Analytical data: (Biotite) K = 1.98%; $\overset{*}{A}r^{40}$ = 1.01 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 39%. (Orthoclase, altered) K = 9.91%; $\overset{*}{A}r^{40}$ = 2.879 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 89%. Comment: Minimum age of 100 m.y. reported for this stock (Silberman and McKee, 1971).

Northern Shoshone Range, Lander County

14. S-EPR4078D/67G117R S. of Beowawe K-Ar — (whole rock) 84.1±3 m.y.

Rhyolite sill (40°15′45″N, 116°45′00″W; SE/4 Sec. 25, T28N, R47E; 1 mi W of Gold Acres; Lander Co., NV). Chlorite and kaolinite present as alteration products. Analytical data: K = 9.22%; $\overset{*}{A}r^{40}$ = 3.17 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 75%. Comment: Compare with S-EPR4078C/67G115R (below); similar sill gave alteration date of 94 m.y. (Silberman and McKee, 1970).

15. S-EPR4078C/67G115R S. of Beowawe K-Ar — (whole rock) 88.4±3 m.y.

Rhyolite "intrusive" (40°15′45″N, 116°45′00″W; SE/4 Sec. 25, T28N, R47E; 1 mi W of Gold Acres; Lander Co., NV) similar in composition, texture, and alteration to S-EPR4078D/67G117R (above). Analytical data: K = 9.24%; $\overset{*}{A}r^{40}$ = 3.34 x 10^{-5} cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40}$ = 75%.

Toiyabe Range, Lander County

16. S-EPR4083A/SCE636 — K-Ar (biotite) 130±3 m.y.; K-Ar (orthoclase) 103±2 m.y.

Austin pluton. Coarse-grained quartz monzonite (39°29′26″N, 117°4′18″W; SE/4 Sec. 19, T19N, R44E; at Austin, Lander Co., NV). Analytical data: (Biotite) K = 6.39%; $\overset{*}{A}r^{40} = 3.43 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 72\%$. (Orthoclase, altered) K = 10.15%; $\overset{*}{A}r^{40} = 4.31 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 82\%$. Comment: Pluton dated as 157 m.y. (Krueger and Schilling, 1971, p. 11).

Toquima Range, Nye County

17. S-EPR4094E/SCE1021 SE of Darrough — K-Ar (biotite) 77.3±1.5 m.y.; Rb-Sr (biotite) 75±6 m.y.

Belmont-Toquima pluton. Coarse-grained biotite granite (38°33′03″N, 116°55′37″W; SW/4 Sec. 4, T8N, R45E; near junction State Highways 69 & 82; Nye Co., NV). Analytical data: (Biotite) K = 7.28%; $\overset{*}{A}r^{40} = 2.29 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 65\%$. (Biotite) Rb = 1184 ppm; Sr = 45.3 ppm; $Sr^{87}/Sr^{86} = 0.790$. Comment: Various phases of the pluton dated as 78 m.y. (Silberman and McKee, 1971, p. 30) and 76 and 80 m.y. (Krueger and Schilling, 1971, p. 10 and p. 11).

White Pine Range, White Pine County

18. S-EPR4120A — K-Ar (biotite) 140±8 m.y.

Monte Cristo stock. Porphyritic quartz monzonite (39°14′00″N, 115°34′12″W; SW/4 Sec. 21, T16N, R57E; 2124-2188 ft. depth, Umont-Homestake diamond-drill core hole no. 6; White Pine Co., NV). Analytical data: K = 3.7%; $\overset{*}{A}r^{40} = 1.84 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 64\%$. Collected by: L. J. Stewart, Shell Canadian Exploration Co. Comment: Compare with S-EPR4120B (below).

19. S-EPR4120B — K-Ar (biotite) 94±5.4 m.y.; Rb-Sr (biotite) 86±73 m.y.; K-Ar (muscovite) 113±4.8 m.y.; Rb-Sr (muscovite) 75±58 m.y.

Monte Cristo stock. Quartz monzonite (39°14′N, 115°34′W; Sec. 21(?), T16N, R57E; 822-40 ft. in diamond-drill core hole no. 9, near core hole no. 6 [see S-EPR4120A, above]; White Pine Co., NV). Analytical data: (Biotite, altered) K = 5.24%; $\overset{*}{A}r^{40} = 2.01 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 38\%$. (Biotite, altered) Rb = 366 ppm; Sr = 153 ppm; $Sr^{87}/Sr^{86} = 0.7182$. (Muscovite) K = 7.34%; $\overset{*}{A}r^{40} = 3.39 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 54\%$. (Muscovite) Rb = 454 ppm; Sr = 151 ppm; $Sr^{87}/Sr^{86} = 0.719$. Comment: Compare with S-EPR4120A (above).

C. Metamorphic Rocks –Nevada

Silver Peak, Esmeralda County

20. S-EPR4083B/SCE637 — K-Ar (biotite) 60±2 m.y.

Gneiss (37°45′53″N, 117°40′56″W; SW/4 Sec. 8, T2S, R39E; 2 mi NW of town of Silver Peak; Esmeralda Co., NV) composed mainly of quartz, microcline, plagioclase, biotite, and minor muscovite, chlorite, and magnetite; the texture is cataclastic. Analytical data: K = 6.14%; $\overset{*}{A}r^{40} = 1.48 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 57\%$.

Roberts Mountains, Eureka County

21. S-EPR4063B/N-KR-3 K-Ar (whole rock) 299±13 m.y.

Meta-andesite (39°50′00″N, 116°22′40″W; center Sec. 7, T23N, R50E; on upper fork Red Canyon, 2¼ mi N of Blue Eagle antimony Mine; Eureka Co., NV). Phenocrysts of subparallel plagioclase laths and minor quartz are in a matrix of plagioclase microlites that form flow lines around the phenocrysts; the rock is highly altered to calcite and analcite. Analytical data: K = 0.64%; $\overset{*}{A}r^{40} = 8.30 \times 10^{-6}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 60\%$. Comment: Rock is a metamorphosed flow from the upper part of the lower member of the Ordovician (440-500 m.y.) Vinini Formation.

White Pine Range, White Pine County

22. S-EPR4120C K-Ar (whole rock) 102±7 m.y.

Metasediment (39°14′N, 115°34′W; Sec. 21(?), T16N, R57E; 780-93 ft. in diamond-drill core hole no. 23 [see S-EPR4120A, above]; White Pine Co., NV) composed of silt-size, equigranular quartz, orthoclase, biotite, epidote, chlorite, and pyrite; quartz healed fractures are abundant; probably metamorphosed argillaceous siltstone. Analytical data: K = 2.16%; $\overset{*}{A}r^{40} = 9.0 \times 10^{-6}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 37\%$. Comment: From the Cambrian Dunderberg or Secret Canyon Shales. These formations were metamorphosed during the emplacement of the Monte Cristo stock; the date thus represents the minimum age of igneous intrusion (compare with S-EPR4120A, and S-EPR4120B, above).

D. Extrusive Rocks–Utah

Dugway Range, Tooele County

23. S-EPR5011A K-Ar (orthoclase) 13±5 m.y.

Tuff (Sec. 33, T9S, R12W; bottom hole sample from drill hole; Tooele Co., UT). Quartz and orthoclase anhedra up to 2 mm in diameter in a cryptocrystalline matrix. Analytical data: K = 12.5%; $\overset{*}{A}r^{40} = 6.52 \times 10^{-6}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 18\%$. Comment: K-Ar ages from orthoclase commonly are young due to Ar leakage.

24. S-EPR5011B K-Ar (orthoclase) 18±1 m.y.

Porphyritic trachyte (Sec. 33, T9S, R12W; bottom hole sample from drill hole; Tooele Co., UT). Microperthitic phenocrysts of plagioclase in a matrix of orthoclase microlites. Analytical data: K = 11.7%; $\overset{*}{A}r^{40} = 8.4 \times 10^{-6}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 27\%$.

E. Intrusive Rocks–Utah

Dugway Range, Tooele County

25. S-EPR5011C K-Ar (orthoclase) 22±1 m.y.

Microgranite(?) (Sec. 33, T9S, R12W; bottom hole sample from drill hole; Tooele Co., UT). Orthoclase, quartz, and biotite. Analytical data: K = 8.12%; $\overset{*}{A}r^{40} = 7.1 \times 10^{-6}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 34\%$. Comment: May be an extrusive rock; should be considered a minimum age.

26. S-EPR5011D K-Ar (biotite) 65±2 m.y.

Biotite granodiorite (Sec. 33, T9S, R12W; bottom hole sample from drill hole; Tooele Co., UT). Analytical data: K = 5.60%; $\overset{*}{A}r^{40} = 1.48 \times 10^{-5}$ cc/g; $\overset{*}{A}r^{40}/\Sigma Ar^{40} = 45\%$.

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