K-Ar ages of selected Tertiary igneous rocks in southwestern Montana

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K-AR AGES OF SELECTED TERTIARY IGNEOUS ROCKS IN SOUTHWESTERN MONTANA

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This paper presents the results of K-Ar age determinations on nine igneous rocks from eight localities in southwestern Montana (Figure 1). The ages were determined in conjunction with a mapping project and other geologic studies initiated by the U. S. Geological Survey. Inasmuch as the results of these geologic studies will not be available until sometime in the future, we are publishing the radiometric ages now for the benefit of other geologists working in that region.

The age determinations were made in the laboratories of the U. S. Geological Survey, Denver, Colorado. Mineral concentrates for K-Ar analysis were prepared by G. T. Cebula. Argon content was determined by R. F. Marvin and H. H. Mehnert using standard isotope dilution procedures (Dalrymple and Lanphere, 1969). V. M. Merritt determined potassium content by flame photometry using a lithium internal standard. The estimated analytical uncertainties for K-Ar ages are quoted at two standard deviations. Constants used in the age calculations are $\lambda_\epsilon = 0.585 \times 10^{-10}$ yr^{-1}, $\lambda_\beta = 4.72 \times 10^{-10}$ yr^{-1}, K^{40}/K total $= 1.22 \times 10^{-4}$ g/g.

GEOLOGIC DISCUSSION

The K-Ar ages reveal a more complex Tertiary igneous history than was previously known. In the Virginia City area, the difference of about 16 to 17 m.y. between the Eocene andesite-dacite porphyry (50 m.y.) and the overlying Oligocene basalts (33-34 m.y.) was not apparent from the geologic mapping. The basalts occurring at various places along the crest of the Gravelly Range, from the area of Virginia City southward to the vicinity of Black Butte, would have been considered contemporaneous; however, if the Black Butte plug was a source of adjacent basalt flows, the volcanic activity spanned about 10 m.y., from mid-Oligocene (34 m.y.) to early Miocene (23 m.y.). The basalts from the Virginia City-Black Butte areas could have also been reasonably correlated with those basalts at localities 4, 6, and 7. However, the radiometric ages show that the basalt at localities 6 and 7 is Pliocene in age (4 m.y.). The basalt at locality 4 is probably correlative with the Oligocene basalts near Virginia City. The 45-m.y. age of the rhyolite of sample locality 5 indicates yet another igneous pulse in southwestern Montana during the Tertiary.

SAMPLE DESCRIPTIONS

(Numbers are same as locality numbers on Figure 1)

1A. Sample KW-66-66 K-Ar (biotite) 49.3±2.5 m.y

A light-gray andesite-dacite porphyry (45°17′55″N, 111°56′05″W; rock quarry N of Virginia City, Madison Co., MT). Analytical data: $K_2O = 8.19\%$ and 8.31%, $*Ar^{40} = 6.091 \times 10^{-10}$ moles/gm; $*Ar^{40}/\Sigma Ar^{40} = 88\%$. Collected by: K. L. Wier. Comment: Euhedral to subhedral phenocrysts of andesine, commonly 1 to 3 mm in diameter, make up about 30 percent of the porphyry, and biotite and magnetite, generally in crystal sizes less than 2 mm are present in amounts of several percent. The phenocrysts are surrounded by a cloudy microcrystalline felsic groundmass. The porphyry overlies Precambrian gneisses in thin isolated patches and is believed to represent erosional remnants of a volcanic flow.

1B. Sample KW-19-66 K-Ar (biotite) 51.1±1.9 m.y.
(plagioclase) 51.0±3.8 m.y.

Andesite-dacite porphyry (from same rock quarry as sample KW-66-66 above). Analytical data: (biotite) $K_2O = 8.20\%$, $*Ar^{40} = 6.275 \times 10^{-10}$ moles/gm, $*Ar^{40}/\Sigma Ar^{40} = 86\%$; (plagioclase) $K_2O = 0.53\%$ and 0.52%, $*Ar^{40} = 0.3953 \times 10^{-10}$ moles/gm, $*Ar^{40}/\Sigma Ar^{40} = 87\%$. Collected by: K. L. Wier.

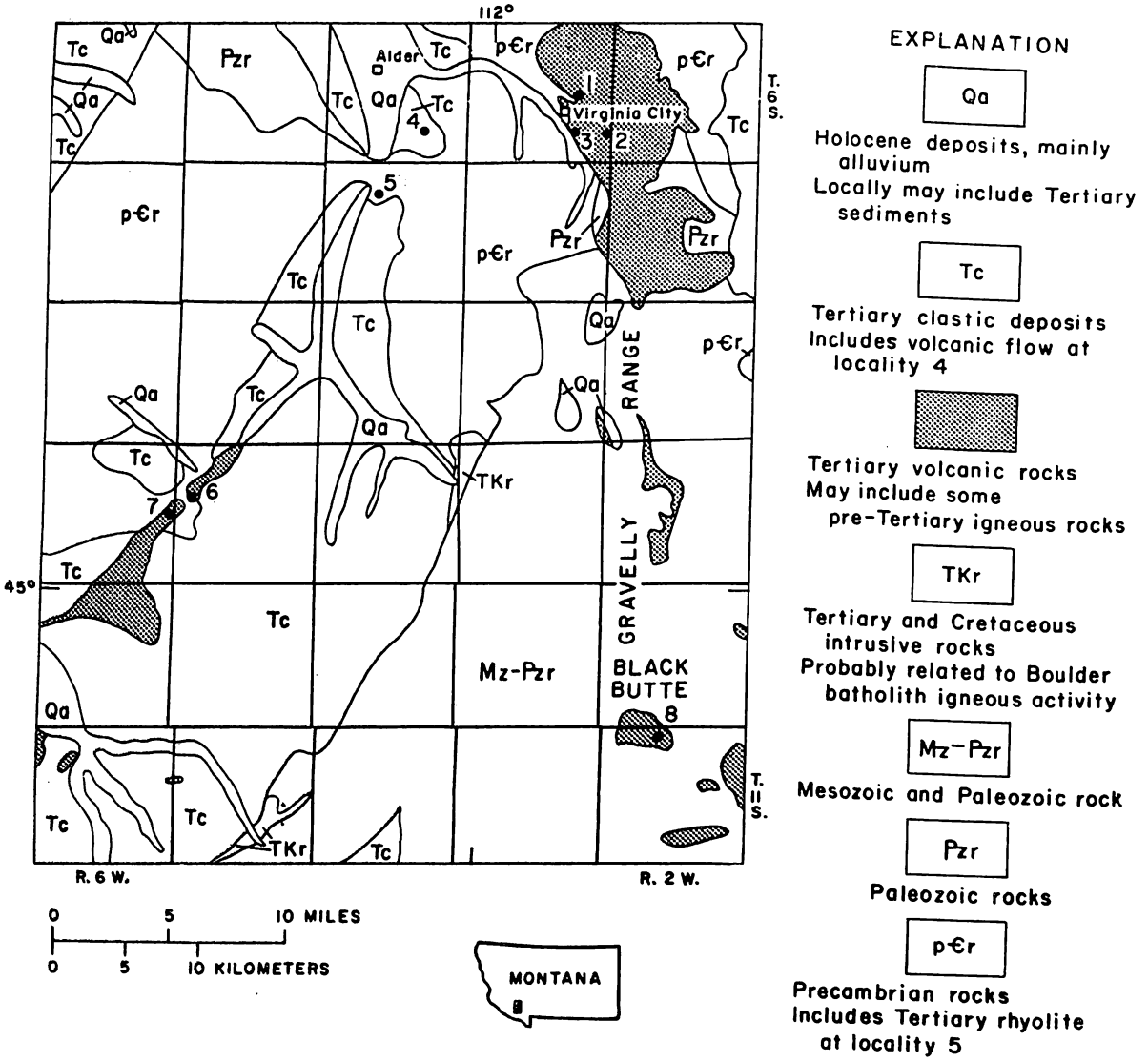

Figure 1. Geologic map showing collection localities for rock samples. Map modified slightly from geologic map of Montana (Ross and others, 1955).

2. Sample KW-911-67 K-Ar (whole rock) 34.4±3.0 m.y.
Dark-greenish-gray basalt (45°16′52″N, 111°54′18″W; roadcut on Montana Highway 287, Madison Co., MT). Analytical data: K_2O = 1.48%, 1.46%, 1.41%, and 1.39%, $*Ar^{40}$ = 0.7414 x 10^{-10} moles/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 30% (sample was not subjected to the usual degassing at 100°C for 14 hours preceding the fusion of the sample, thus the lower percentage of radiogenic argon). Collected by: K. L. Wier. Comment: The basalt consists of about 10 percent scattered phenocrysts of pyroxene, olivine, and plagioclase, commonly from ½ to 1 mm in diameter, and a finer-grained matrix of plagioclase, pyroxene, and iron oxide crystals. The flow is not well enough exposed to allow determination of its thickness, but it belongs to a sequence of flows which individually are about 10 feet to several tens of feet thick and in aggregate make up a thickness of volcanic rocks at least several hundred feet to perhaps 1,000 feet that overlies Precambrian rocks east of Virginia City.

3. Sample KW-912-67 K-Ar (whole rock) 32.7±1.4 m.y.
Dark-gray to black basalt (45°17′18″N, 111°56′27″W; Alder Gulch at the placer gold discovery site monument which is ½ mi S of Virginia City, Madison Co., MT). Analytical data: K_2O = 1.54% and 1.55%, $*Ar^{40}$ = 0.7487 x 10^{-10} moles/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 86%. Collected by: K. L. Wier. Comment: The basalt consists of about 5 percent pyroxene phenocrysts, generally less than 1 mm in diameter, scattered in a groundmass of plagioclase laths, pyroxene crystals, and iron oxide granules. The flow seems to be about 20 or 30 feet thick and directly overlies Precambrian gneiss. However, its stratigraphic position may not be at or near the base of the thick volcanic sequence lying east of Virginia City; it may be a valley flow which accumulated in a late Tertiary gulch that had been incised through older flows and into Precambrian rocks.

4. Sample KW-913-67 K-Ar (whole rock) 30.3±1.6 m.y.
Dark-gray to black mottled vesicular basalt (45°16′55″N, 112°03′26″W; Williams Gulch Road, Madison Co., MT). Analytical data: K_2O = 1.68%, 1.67%, 1.64%, 1.65%, 1.62%, 1.63%, 1.63%, 1.60%, 1.59%, and 1.60%, $*Ar^{40}$ = 0.7343 x 10^{-10} moles/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 58%. Collected by: K. L. Wier. Comment: The basalt consists of about 5 percent small olivine and plagioclase crystals, commonly less than 1 mm in diameter, in a matrix of smaller plagioclase laths and pyroxene crystals. Basalt is from a flow interbedded with Tertiary sediments. Petkewich (1972) correlated this flow on Williams Creek with part of the Renova Formation of Kuenzi and Fields (1971), a formation in the Bozeman Group of Tertiary age in southwestern Montana.

5. Sample KW-914-67 K-Ar (biotite) 44.7±1.7 m.y.
Light-gray porphyritic rhyolite (45°14′48″N, 112°05′54″W; from quarry, Madison Co., MT). Analytical data: K_2O = 8.60% and 8.57%, $*Ar^{40}$ = 5.720 x 10^{-10} moles/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 85%. Collected by: K. L. Wier. Comment: The rhyolite consists of about 25 percent oligoclase and several percent each of biotite and quartz phenocrysts, commonly ranging from ¼ to 1 mm in diameter, in a cloudy groundmass of felsic crystallites. The rhyolite intrudes Precambrian rocks and forms an irregular-shaped body 2,000 or 3,000 feet in maximum diameter.

6. Sample KW-2-72 K-Ar (whole rock) 4.2±0.2 m.y.
Grayish-black vesicular basalt (45°03′46″N, 112°15′20″W; Madison Co., MT). Analytical data: K_2O = 1.71% and 1.71%, $*Ar^{40}$ = 0.1071 x 10^{-10} moles/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 51%. Collected by: K. L. Wier. Comment: Small pyroxene and olivine phenocrysts, generally less than ½ mm in diameter, make up only a few percent of the rock and are scattered in a finer-grained groundmass mainly of plagioclase laths and pyroxene and iron oxide granules. The sample is from the interior part of what seems to be a 30- to 50-foot-thick flow which overlies Tertiary sediments and Precambrian rocks. This basalt flow, which is northeast of Timber Hill, is part of the Tertiary rocks in the upper Ruby River basin being studied by Ronald A. Riepe, Indiana University. Sample KW-3-72 is from the same flow. This K-Ar age is quoted by Peterson and Kuenzi (1974) in their description of the origin of geomorphic and structural features in this area.

7. Sample KW-3-72 K-Ar (whole rock) 3.8±0.4 m.y.
Dark-gray mottled basalt (45°03′10″N, 112°16′10″W; Madison Co., MT). Analytical data: K_2O = 1.55% and 1.55%, $*Ar^{40}$ = 0.0866 x 10^{-10} moles/gm, $*Ar^{40}/\Sigma Ar^{40}$ = 9%. Collected by: R. A. Riepe from a float block on the erosional surface of the flow. Comment: Basalt is similar in composition to sample KW-2-72 except it is slightly coarser grained. Both samples are from the same flow and were collected about 1 mile apart (northeast of Timber Hill). The flow is flat lying and caps Tertiary sediments.

8. Sample KW-916-11-67 K-Ar (whole rock) 22.9±1.2 m.y.
(whole rock) 24.8±1.5 m.y.

Dark-gray to black, medium-grained basalt (approx. 44°54′15″N, 111°51′15″W; upper part of Black Butte volcanic plug, Madison Co., MT). Analytical data: K_2O = 1.93%, 1.93%, 1.90%, and 1.94%, $*Ar^{40}$ = 0.6517 x 10^{-10} moles/gm (first age) and 0.7055 x 10^{-10} moles/gm (second age), $*Ar^{40}/\Sigma Ar^{40}$ = 86% (first age) and 50% (second age). For the second age, the sample was not subjected to the usual degassing at 100°C for 14 hours preceding the fusion of the sample, thereby yielding the lower percentage of radiogenic argon. Collected by: K. L. Wier. Comment: The basalt consists of 60 to 70 percent plagioclase laths (An 55-60) that range from 1 to 3 mm in length, 25 to 30 percent pyroxene crystals generally less than 2 mm in diameter, and minor amounts of olivine and iron oxide. The Black Butte plug probably represents a source vent for some of the basalt flows in the adjacent areas.

REFERENCES

Dalrymple, G. B., and Lanphere, M. A. (1969) Potassium-argon dating – Principles, techniques, and applications to geochronology: San Francisco, W. H. Freeman and Co.

Kuenzi, W. D., and Fields, R. W. (1971) Tertiary stratigraphy, structure, and geologic history, Jefferson Basin, Montana: Geol. Soc. America Bull., v. 82, p. 3373-3394.

Peterson, J. C., and Kuenzi, W. D. (1974) Origin of the Sweetwater Canyon and other interbasinal canyons, southwestern Montana (Abs.): Geol. Soc. America, Abs. with Program, v. 6, no. 5, p. 467.

Petkewich, R. M. (1972) Tertiary geology and paleontology of the Beaverhead East area, southwestern Montana: Unpublished PhD thesis, University of Montana.

Ross, C. P., Andrews, D. A., and Witkind, I. J. (1955) Geologic map of Montana: U. S. Geol. Survey.