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APPARENT PALEOZOIC AGES FROM SOUTHERN ARIZONA: K-AR AND RB-SR GEOCHRONOLOGY

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For approximately the past 13 years, the Isotope Geochemistry Laboratory of the University of Arizona has been conducting a geochronological reconnaissance program in Arizona. Igneous rocks collected throughout Arizona have been dated, generally by the K-Ar method. As a part of this program two areas have yielded K-Ar ages of approximately 300 m.y. Since the lack of Paleozoic ages in the western U. S. is well known (Gilluly, 1965), additional samples were collected for Rb-Sr study to confirm this date. The Sierra Estrella is one of the two areas of apparent 300 m.y. ages and was chosen for the Rb-Sr study.

The Sr^{87}/Sr^{86} ratios were determined using a six-inch radius, 60° sector mass spectrometer utilizing triple rhenium filaments and equipped with an expanded scale circuit. The standard deviation for individual analyses is usually 0.0005 or less. The Sr^{87}/Sr^{86} ratios are corrected for a value of 0.7080 for the E and A $SrCO_3$ standard. The Rb and Sr concentrations were analyzed by x-ray fluorescence except for the plagioclase and epidote concentrates in which these were determined by isotope dilution. Details of the isotopic and x-ray analyses are given by Damon and associates (1967).

The argon determinations were made with an all-metal six-inch, 60° sector single-focusing Nier type mass spectrometer using very pure Ar^{38} spikes. Potassium analyses were done by flame photometry using a lithium internal standard and sodium buffering. Details of the technique are given by Damon and associates (1967).

The following constants were used in this study: $\lambda_\epsilon = 5.89 \times 10^{-11} yr^{-1}$; $\lambda_\beta = 4.76 \times 10^{-10} yr.^{-1}$; $K^{40} = 1.21 \times 10^{-4}$ gm/gm K; $\lambda_{Rb}{}^{87} = 1.39 \times 10^{-11} yr.^{-1}$.

This work was supported by National Science Foundation Grant GA-31438 and the State of Arizona. This data has been obtained over several years and several people have participated in its collection. Among those are Robert Palmer, Donald Livingston, M. Shafiqullah, Richard Mauger, Robert Scarborough, and Kathleen Roe.

GEOLOGIC DISCUSSION

The Sierra Estrella is one of the ranges lying within the Basin and Range area of Arizona. It trends NW-SE and lies a few tens of miles south of Phoenix in Pinal County (Fig. 1). The area has received only very sketchy geologic study. A preliminary survey indicates that the bulk of the range is made up of schistose metamorphic rocks and that a granitic pluton occupies the southern end (Wilson, 1969). This general description was verified during the collection of the samples for this study, but no field mapping was attempted.

Four separate samples of granite and one of schist were collected. Sample PED-14-65 of granite was split into three fractions and aliquots taken for analyses before the three fractions were recombined for mineral separation. Therefore seven total-rock points were obtained in addition to four mineral points.

The granite total-rock points do not form a well-defined isochron since only a limited range of Rb^{87}/Sr^{86} values was obtained (Fig. 2). If an initial ratio of 0.705 is assumed, a 1380 m.y. isochron can be drawn through the points with a tolerable fit. The schist lies very close to this isochron. It was collected from the west side of the range and a short but unknown distance north of the granite. The contact between the granite and the schist was observed during the sample collection to be gradational rather than a sharp intrusive one. Inclusion of the schist point alters the isochron to give an age of 1310 m.y. and an initial ratio of 0.7080.

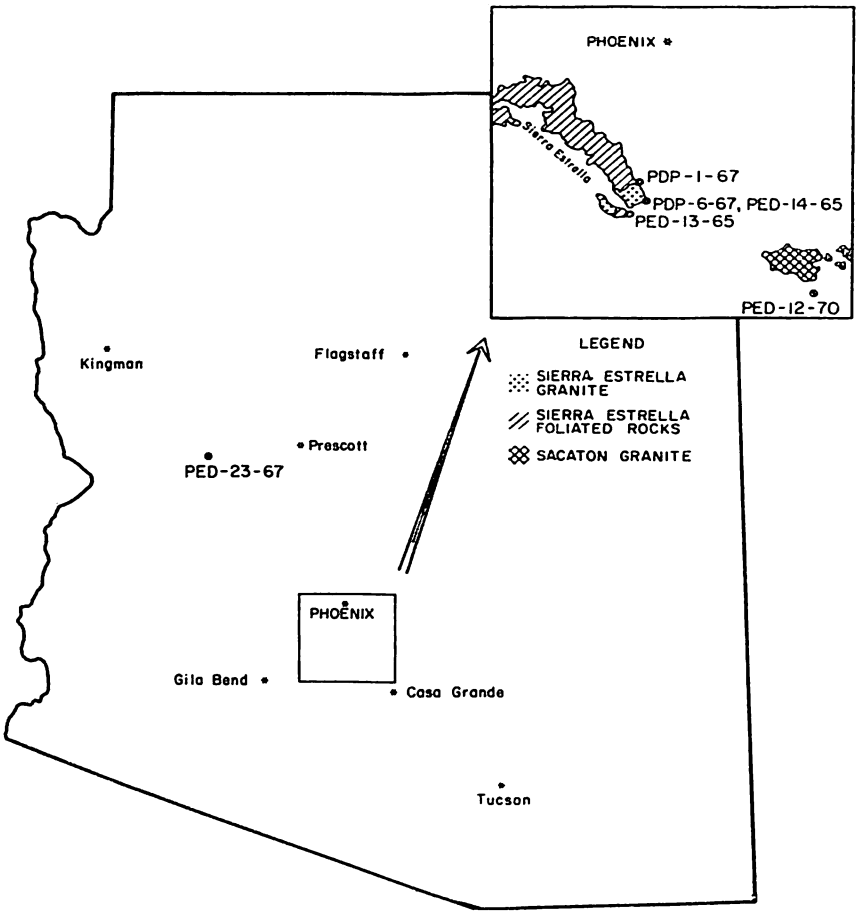

Figure 1. Map of Arizona showing location of areas studied. Bottom edge of insert is 44 miles (71 kms).

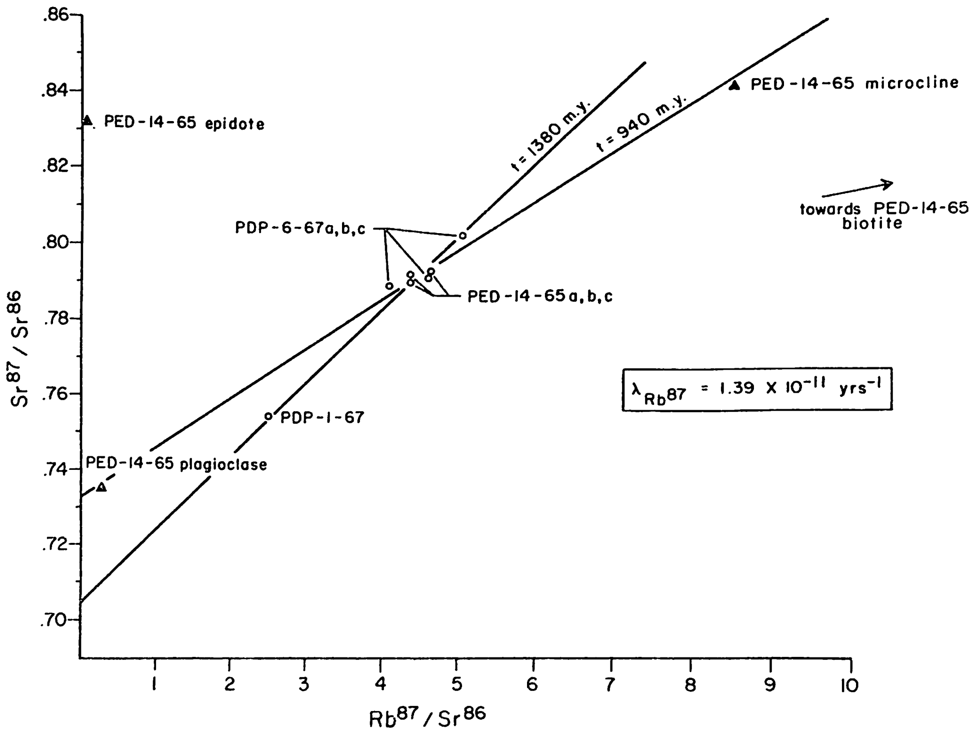

Figure 2. Rb-Sr data for the Sierra Estrella.

Although the data do not allow the determination of a precise isochron, it seems evident that the age of the granitic rocks must be close to 1380 m.y. The mineral isochron described in the next paragraph give a minimum age of 940 m.y. and sets a lower limit for the total-rock isochron. A K-Ar data on a pegmatitic muscovite just to the southwest of the granite yields an age of 1380 m.y. This may be considered as another lower limit for the total-rock isochron. Finally, granitic rocks with this approximate age and with low initial ratios are present in southeastern Arizona, e.g., the Oracle granite (Giletti and Damon, 1961, Damon *et al.*, 1963; Livingston *et al.*, 1967) and the Ruin granite (Livingston, 1969).

Of the four mineral points, the two feldspar points and the average of the three PED-14-65 points define a good mineral isochron indicating an age of 940 m.y. and a high initial ratio of 0.733. The biotite point lies considerably below the feldspars–total-rock isochron, and the epidote considerably above. The epidote is possibly a secondary mineral and may have incorporated strontium from a phase rich in Sr^{87} such as the biotite. The biotite has apparently been affected by later events and lost argon, as indicated by its K-Ar age of about 300 m.y., and probably lost radiogenic strontium at the same time. In fact, a biotite-total rock isochron indicates an age of 296 m.y., in excellent agreement with the biotite K-Ar age. The Sacaton granite of Laramide age (64.5 m.y.) outcrops a few miles to the east of the Sierra Estrella and may have been the cause of the loss of Ar^{40} and Sr^{87} from the Sierra Estrella granitic biotite. The PED-13-65 pegmatite may have escaped being heated by the Sacaton granite and in any case, its large books of muscovite would have been more retentive of argon than the disseminated flakes of biotite in the Sierra Estrella granite.

A three-event history is therefore indicated for the Sierra Estrella plutonic rocks:

1. Intrusion, approximately 1380 m.y. Part of the wall rocks may have become isotopically equilibrated with the granite.
2. Resetting of the mineral isochron, probably by a metamorphic event, approximately 940 m.y. ago. This event may also have caused the total-rock isochron to lose some of its sharpness.
3. A later event, possibly the intrusion of the Sacaton granite 64.5 m.y. ago, which caused the biotite to lose radiogenic isotopes. The ages of approximately 300 m.y. given by the K-Ar and Rb-Sr clocks in the biotite need not reflect an actual event at this time, but may be hybrid ages caused by partial loss of radiogenic isotopes.

Although the results of this study upon the Sierra Estrella cannot be applied in detail to the Yavapai granite gneiss or to other areas of apparent Paleozoic age, it does indicate that Paleozoic K-Ar ages in the western U. S. should not be accepted without further confirmation.

SAMPLE DESCRIPTIONS

1. PED-23-57 — K-Ar — (biotite) 306±5 m.y.; (biotite) 330±5 m.y.

Yavapai granite gneiss (34°28′33″N, 113°19′20″W; Arrastra Mountain NE quadrangle, Yavapai Co., AZ). Analytical data: K = 6.575%; $*Ar^{40}$ = 38.81 x 10^{-10} moles/gm, 42.22 x 10^{-10} moles/gm; atmospheric Ar^{40} = 6.12%, 7.88%.

2. PED-13-65 — K-Ar — (muscovite) 1380±20 m.y.

Quartz-perthite-biotite-muscovite-garnet pegmatite in Pinal schist terrain with NE-SW trend (33°06′00″N, 112°10′10″W; from prospects in foothills at S end Sierra Estrella Mountains, Enid quadrangle, Pinal Co., AZ). Analytical data: K = 8.551%; $*Ar^{40}$ = 311.65 x 10^{-10} moles/gm; atmospheric Ar^{40} = 0.86%.

3. PED-14-65 — K-Ar — (biotite) 304±5 m.y.; (biotite) 299±4 m.y.; (biotite) 296±4 m.y.

Granite (33°07′57″N, 112°08′47″W; freshly-blasted boulders very near gravel road at S end Sierra Estrella Mountains, Montezuma Peak quadrangle, Pinal Co., AZ). Analytical data: K = 7.77%, 7.75%, 7.75%; $*Ar^{40}$ = 44.63 x 10^{-10} moles/gm, 44.66 x 10^{-10} moles/gm, 44.24 x 10^{-10} moles/gm; atmospheric Ar^{40} = 2.6%, 17.3%, 5.3%.

	Sr (ppm)	Rb (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
total rock (a)	135	218	4.65	0.7934 ± .0004
total rock (b)	126	188	4.39	0.7905 ± .0006
total rock (c)	132	197	4.39	0.7926 ± .0002
microcline	150	434	8.53	0.8426 ± .0004
plagioclase	207	19.7	0.278	0.7350 ± .0002
biotite	12.4	1280	304	2.0243 ± .0010
epidote	770	8.59	0.033	0.8319 ± .0003

4. PED-12-70 K-Ar (biotite) 64.5±1.4 m.y.
Sacaton monzonite porphyry (32°57′10″N, 111°49′10″W; Asarco drill hole S-9 at 754-767 ft., Pinal Co., AZ). Analytical data: K = 8.14%; $^{*}Ar^{40} = 9.406 \times 10^{-10}$ moles/gm; atmospheric Ar^{40} = 12.1%.

5. PDP-6-67a (see fig. 2)
Granite somewhat darker in color than normal (approx. 33°08′N, 112°09′W; from S end Sierra Estrella Mountains, Montezuma Peak quadrangle, Pinal Co., AZ). Analytical data: Sr = 128 ppm; Rb = 184 ppm; Rb^{87}/Sr^{86} = 4.24; Sr^{87}/Sr^{86} = 0.7897±.0004.

6. PDP-6-67b (see fig. 2)
Small pegmatitic lens in granite (approx. 33°08′N, 112°09′W; S end of Sierra Estrella Mountains, Montezuma Peak quadrangle, Pinal Co., AZ). Analytical data: Sr = 169 ppm; Rb = 296 ppm; Rb^{87}/Sr^{86} = 5.15; Sr^{87}/Sr^{86} = 0.8030 ± .0003.

7. PDP-6-67c (see fig. 2)
Granite, somewhat lighter colored than normal (approx. 33°08′N, 112°09′W; S end of Sierra Estrella Mountains, Montezuma Peak quadrangle, Pinal Co., AZ). Analytical data: Sr = 134 ppm; Rb = 214 ppm; Rb^{87}/Sr^{86} = 4.66; Sr^{87}/Sr^{86} = 0.7919 ± .0002.

8. PDP-1-67 (see fig. 2)
Quartz-feldspar-biotite schist (approx. 33°09′N; 112°09′W; NE flank Sierra Estrella Mountains within a few 100 ft. of granite; Montezuma Peak quadrangle, Pinal Co., AZ). Analytical data: Sr = 173 ppm; Rb = 148 ppm; Rb^{87}/Sr^{86} = 2.51; Sr^{87}/Sr^{86} = 0.7547 ± .0003.

REFERENCES

Damon, P. E., Erickson, R. C. and Livingston, D. E. (1963) K-Ar dating of Basin and Range uplift, Catalina Mountains, Arizona: Nuclear Geophysics, Nat. Acad. Sci.–Nat. Res. Council Publ. 1075, Nucl. Sci. Ser. Rpt. 38, p. 113-121.

Damon, P. E., and associates (1967) Correlation and chronology of ore deposits and volcanic rocks: U. S. Atomic Energy Commission Rpt. COO-689-76, contract AT(11-1)-689.

Giletti, B. J. and Damon, P. E. (1961) Rubidium-strontium ages of some basement rocks from Arizona and northwestern Mexico: Geol. Soc. Amer. Bull., Vol. 72, p. 639-644.

Gilluly, J. (1965) Volcanism, tectonism, and plutonism in the western United States: Geol. Soc. Amer. Special Paper 80.

Livingston, D. E. (1969) Geochronology of older Precambrian rocks in Gila County, Arizona: unpublished Ph. D. thesis, University of Arizona.

Livingston, D. E., Damon, P. E., Mauger, R. L. Bennett, R. and Laughlin, A. W. (1967) Argon-40 in cogenetic feldspar-mica mineral assemblages: Jour. Geophys. Res., Vol. 72, p. 1361-1375.

Wilson, E. D. (1969) Mineral deposits of the Gila River Indian Reservation of Arizona: Arizona Bureau of Mines Bull. 179.