K-Ar and fission-track ages (dates) of volcanic, intrusive, altered, and metamorphic rocks in the Mohave Mountains area, west-central Arizona


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INTRODUCTION

The Mohave Mountains and adjacent ranges of west-central Arizona (fig. 1) occupy a key area for unraveling the evolution of Tertiary tectonics in the Colorado River extensional corridor. The area lies in the east part of the north-trending, 100-km-wide corridor, and flanks a belt of metamorphic core complexes that define the center of the corridor (Davis and others, 1980; Howard and John, 1987). Field studies in the Mohave Mountains area indicate a record of extension-related Tertiary intrusion, volcanism, sedimentation, detachment faulting, tectonic fragmentation, and tilting (Howard and others, 1982a, in press; Pike and Hansen, 1982; Nakata, 1982; Light and others, 1983; Nielson, 1986; Nielson and Glazner, 1986; Howard and John, 1987; Nielson and Beratan, 1990). The dating was carried out partly to support an appraisal of mineral-resource potential (Light and others, 1983). Preliminary K-Ar dates reported earlier (Light and others, 1983; Nielson, 1986; Nielson and Glazner, 1986; Howard and John, 1987; Nielson and Beratan, 1990) are here fully documented, and in some cases have been corrected. Corrections follow discovery by Nakata of a spike calibration error.

In this paper we report 57 conventional K-Ar and 7 fission-track ages (dates) on 52 rock samples located in figure 2. We term those with mixed cooling histories dates, following Armstrong (1966), to emphasize that they do not necessarily correspond to emplacement ages. Dated rocks include 13 volcanic, 14 dike, 6 granitoid, and 9 gneissic rocks and 6 rocks that experienced alteration related to mineralizing processes. Materials dated by K-Ar were: biotite, sanidine, plagioclase, muscovite, sericite, hornblende, and whole rock. Zircon was dated by fission tracks. Figure 3 divides the dated rocks into four sample groups and presents histograms of the ages, identified by the material dated.

These ages help to calibrate the time of Tertiary deposition and deformation, constrain the timing of different styles of Tertiary magmatism, and provide age information helpful for interpreting Tertiary uplift, Mesozoic alteration and intrusion, and cooling of Proterozoic rocks. We interpret ages of events from these dates within the framework of our working model established by field studies from 1979 to 1987.
determined from biotite and zircon (fission-track) on Proterozoic rocks are all younger than the original crystallization age.

If cooling is relatively slow and excess radiogenic products are not incorporated by the minerals, those species with lower blocking temperatures will give younger ages than those with higher blocking temperatures. A common order of progressively decreasing closure or annealing temperatures is: hornblende (K-Ar), muscovite (K-Ar), biotite (K-Ar) and zircon (fission-track) (Armstrong 1966; Turner and Forbes 1976; Harrison and others 1979; and Hurford 1986). This order varies depending upon the extraction technique used to determine the blocking temperature (Harrison and Fitzgerald 1986; Gaber and others 1988). Other factors that complicate interpretation of the numerical age include rate of cooling, mineral structure, and availability of excess radiogenic argon from external sources.

FIGURE 2. Simplified geologic index map of the Mohave Mountains area showing sample localities and dates except for sample number 26, which was collected from the Whipple Mountains west of the map area. The northwest-southeast trending Mohave Mountains dike swarm is not portrayed for graphic simplicity. The mineral and rock abbreviations are as follows: B = biotite, H = hornblende, P = plagioclase, San = sanidine, Ser = sericite, WR = whole rock, WM = white mica, Z = zircon.

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FIGURE 3. Histograms of dates, divided into four groups of samples. Abbreviations: (K-Ar) WR = whole rock, H = hornblende, P = plagioclase, San = sanidine, B = biotite, M = muscovite, Ser = sericite; (fission-track) Z = zircon.
GEOLOGIC FRAMEWORK

The Mohave, Buck, and Bill Williams Mountains expose Proterozoic gneisses and intrusive rocks, Mesozoic intrusive rocks, Tertiary dikes, and Neogene volcanic and sedimentary rocks (fig. 2). Paleozoic and Mesozoic strata that are present elsewhere in the region were stripped prior to the middle Tertiary, so that the pre-Tertiary rocks are overlain nonconformably by volcanic and clastic rocks of Miocene and Oligocene(? ) age. In the Mohave Mountains a swarm of northwest-trending dikes intrudes the pre-Tertiary rocks and lower parts of the Tertiary section. The dikes occupy about 16 percent of the central Mohave Mountains east of Lake Havasu City, where their total thickness is about 2 km (Nakata, 1982).

Angular unconformities in the lower Miocene section document progressive westward tilting due to extensional growth faults. The younger strata are little tilted or faulted, in contrast to the older units, which commonly dip at steep angles and are locally overturned. Tilting of fault blocks was unidirectional to the southwest. The Crossman Peak fault and the probably equivalent Powell Peak fault are both normal faults with moderate dips. They juxtapose numerous fault-bounded blocks 1 to 2 km thick in their hanging walls against large rotated crustal blocks as much as 15 km across. These large blocks form the central Mohave Mountains (Crossman block), Bill Williams Mountains, and Powell Peak/Tumarion Peak area. The structurally equivalent Whipple Mountains and Chemehuevi faults, in exposures near the Colorado River, project beneath these large rotated blocks (Howard and others, 1982a, 1987, in press; Howard and John, 1987).

VOLCANIC ROCKS

Conventional K-Ar ages of volcanic rocks (figs. 3a and 4) help to constrain the time of tilting and faulting as well as to calibrate the magmatism. Nielsen (1986) divided the pre-Pliocene Tertiary section into four sequences numbered: I, II, III and IV, from oldest to youngest.

The Peach Springs Tuff of Young and Brennan (1974) is the only unit of regional extent found in the Mohave Mountains area. It is a single cooling unit of welded tuff that outcrops in an area of at least 280 by 170 km (Glazner and others, 1986; Wells and Hillhouse, 1989). The Peach Springs has yielded a spread of K-Ar ages (Young and Brennan, 1974, Glazner and others, 1986), but studies using the 40Ar/39Ar technique indicate its emplacement age is 18.5 ± 0.2 Ma (Nielsen and others, 1990).

The youngest rocks dated are olivine basalt (sample no. 1) at 11.1 ± 0.3 Ma (whole rock), and an underlying silicic tuff (no. 2) dated at 12.7 ± 0.6 Ma (sanidine); both are included in sequence IV. These rocks have southwest dips of 5° to 15° and contain normal faults with down-to-the northeast displacements in contrast with much steeper to overturned beds in the underlying Miocene strata. The change in dip marks the waning stages of deformation following extreme extensional faulting and tilting that affected the older rocks. Suneson and Lucchitta (1979, 1983) reported similar ages for basalt and rhyolite that occur a few kilometers to the southeast of samples no. 1 and 2, in the Castaneda Hills; they reported an age of 8.6 Ma for an undeformed basalt flow 8 km southwest of sample no. 1 (fig. 2).

A 14.6 ± 0.4 Ma whole-rock age was determined on a steeply dipping olivine basalt lava flow in a fault block in

FIGURE 4. K-Ar ages (error bars) for volcanic rocks, arranged by sample number along the ordinate in approximate order of increasing stratigraphic age. A geologically anomalous date of 48.0 ± 1.2 Ma (no. 13) is not shown.

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the northern Mohave Mountains (no. 3). The basalt overlies and dips the same direction as volcanic rocks of sequence I in the Crossman block of the central Mohave Mountains (fig. 2), occurred earlier. Gently dipping (10°) rocks dated at 17.9 ± 0.7 Ma (plagioclase, no. 7) and 19.9 ± 0.5 Ma (biotite, no. 8) unconf ormably overlie vertical to moderately tilted older Miocene strata (sequence I) that are part of that upended block. Within the map area the Peach Springs Tuff yielded K-Ar sanidine dates of 17.6 ± 0.4 and 18.0 ± 0.5 Ma (nos. 4 and 5), and a rock tentatively identified as belonging to the Peach Springs Tuff yielded a biotite age of 18.7 ± 0.7 Ma (no. 6). The young K-Ar dates on the sanidine may reflect incomplete recovery of argon during extraction because of high sample viscosities, as suggested by McDowell (1983) and G. B. Dalrymple (written communication, 1986). The Peach Springs Tuff in other fault blocks of the study area commonly dips at moderate angles, and overlies sequence I with slight angular discordance. Within the map area the Peach Springs Tuff yielded K-Ar sanidine dates of 17.6 ± 0.4 and 18.0 ± 0.5 Ma (nos. 4 and 5), and a rock tentatively identified as belonging to the Peach Springs Tuff yielded a biotite age of 18.7 ± 0.7 Ma (no. 6). The young K-Ar dates on the sanidine may reflect incomplete recovery of argon during extraction because of high sample viscosities, as suggested by McDowell (1983) and G. B. Dalrymple (written communication, 1986). The Peach Springs Tuff below the Peach Springs Tuff yielded K-Ar dates ranging most reasonably between 18 and 21 Ma. A basalt (no. 9) Peach Springs Tuff is absent. It may be a sill that post- textured porphyry with altered composition (no. 14) yielded a geologically reasonable whole-rock age of 19.8 biotite ages of 19.2 ± 0.5, 19.1 ± 0.6 and 20.5 ± 1.6 0.4, 17.2 ± 0.7 and 18.8 ± 0.5 Ma; repeated extrac- tion found that 35 percent of their 45 biotite-hornblende pairs younger hornblende dates of 16.3 ± tion have shown similar results. Miller and Morton (1980) from the southern Mohave Desert, California, yielded temperature (1,200° C to 1,400°C) the refractory horn- were run before the availability of water-cooled extraction bottles which allow higher fusing temperatures. All our younger than biotite by as much as 15%, suggesting incomplete recovery of argon. A whole-rock K-Ar age of 21.5 Ma was reported by W. Rehrig for a ma fice lava flow in sequence I (Pike and Hansen, 1982; Niel son, 1986; Nielson and Beratan, 1990). One sillicic breccia (no. 13) yielded an anomalously old date on biotite of 48 ± 1.2 Ma, from which contamination by xenocrystic biotite is suspected. Based on ages that we consider the most reliable, the age of the part of the volcanic section lower than the Peach Springs Tuff (sequence I of Nielson, 1986) is concluded to be about 19 to 22 Ma. This age span matches that for fresh rocks of similar stratigraphic position dated from the Turtle and Stepladder Mountains, 50 km west of the study area (Howard and others 1982b; Nielson and Glazner, 1986).

We conclude, based on these data and on biotite ages from dikes and stocks, that a suite of basaltic, andesitic, dacitic, la t t ic, and rhyolitic rocks were intruded and erupted in the early part of the extensional event between about 19 and 22 Ma. After the rhyolitic Peach Springs Tuff was deposited across the area at 18.5 Ma, magmatism in the area produced mainly olivine basalt and rhyolite through the late stages of deformation from 15 to 12 Ma and the cessation of deformation between 8 and 12 Ma. DIKES AND STOCKS Dike rocks yielded a wide variety of dates, only a few of which seem consistent with geological evidence for the age of emplacement. Most of the dates appear to be too old, and may reflect excess argon derived from the Proterozoic host rocks and incorporated in the younger intrusive rocks. For nonvolcanic rocks we regard the K-Ar ages on potash-rich mica as minimum ages and relatively insensit ive to excess argon.

A 15.1-Ma plagioclase age is taken as the emplacement age of a distinctive thick rhyolitic dike (no. 15) that cuts Miocene volcanic and sedimentary rocks. Its trend, outcrop style, and subvolcanic character are different from dikes in the Mohave Mountain dike swarm. The Mohave Mountains dike swarm is interpreted as hav ing intruded at about 20 Ma on the basis of: (a) similar biotite ages (19.8 ± 0.5, 19.8 ± 0.2, 20.8 ± 0.5 Ma, nos. 24, 25, 27) on d aci tic dikes; (b) a biotite age of (19.8 ± 0.5 Ma, no. 26) on a similar dike from the possibly correlative Chambers Well dike swarm in the Whipple Mountains, California; (c) intrusion of the swarm into the lower part of the volcanic section of sequence I. A diorite dike in Proterozoic rocks, which cuts other dikes of the Mohave Mountains swarm, yielded hornblende dates of 22.6 ± 0.7 Ma (no. 16), 26.9 ± 0.7 Ma (flux added to no. 16), and 21.7 ± 0.7 Ma (no. 17). These dates (no. 16 and no. 16 w/flux) are older than seem likely for the emplacement age because the dike swarm is intrusive into part of sequence I. Other intermediate-composition dikes from the Mohave Mountains dike swarm yielded discordant hornblende, plagioclase, and whole-rock dates ranging from 11.3 ± 0.3 to 78.1 ± 2.0 Ma (nos. 18–23). We do not interpret these as emplacement ages. A small body of quartz diorite (no. 28) that grades into a mafic dike of the dike swarm yielded a biotite age of 21.5 ± 0.5 Ma, in agreement with most other biotite ages from dikes and with the geologically interpreted emplacement age.

Evidence of Laramide-age (Cretaceous to earliest Tertiary) magmatism is provided by ages on a rhyolite dike and a granitoid porphyry apophysis. Except for its north-east-trend, the rhyolite dike (no. 31), resembles rocks of the middle Tertiary dike swarm. It yielded an age of 62.3 ± 1.6 Ma on biotite. The porphyry (no. 32), which yielded a biotite age of 72.0 ± 1.8 Ma, is satellitic to a granodiorite pluton at Powell Peak, which is tentatively correlated to biotite granodiorite of Late Cretaceous age in the Chemehuevi Mountains (Howard and others, 1982a; John, 1988; John and Mukasa, 1990). Further independent support for an age of about 72.0 Ma (no. 32) for
the Powell Peak pluton is a 73.8 ± 7.7 Ma zircon fission-track date on a nearby Proterozoic rock which yielded a biotite date of 863 ± 21.6 Ma (no. 47). We infer that the ambient temperature in the local Proterozoic rocks was colder than the blocking temperature for biotite, but was thermally perturbed by emplacement of the pluton and its satellites at about 72–74 Ma.

Ages on a small diorite stock and associated younger granite, which resembles Late Cretaceous granites in the region, are harder to interpret (nos. 30 and 29). The diorite yielded a hornblende date of 32.0 ± 1.0 Ma and the granite yielded a biotite (K-Ar) date of 18.1 ± 0.5 Ma and zircon fission-track date of 16.6 ± 1.7 Ma. The dates are younger than mica and zircon cooling ages in the Crossman Peak fault block, and suggest the possibility of Tertiary emplacement.

A microdiorite dike which cuts an augen gneiss in the Bill Williams Mountains yielded a hornblende date of 332 ± 16 Ma (no. 39), which is not a crystallization age because Paleozoic sections in nearby regions exhibit no evidence of magmatism (Stone and others, 1983). The dike could be Tertiary, Mesozoic, or most likely Precambrian in age.

**ALTERED ROCKS**

In order to investigate the age of mineralization (fig. 3c), ages were measured on white mica from six intensely altered and sericitized Proterozoic rocks associated with metalliferous mineralization (Light and others, 1983). The white mica replaced feldspars during the alteration event. Four of the white mica samples were muscovite coarser than 0.1 mm. These micas have normal K2O contents of 10.5 to 11.2% (nos. 35, 36, 37, and 38) and yielded dates of 91.4 ± 2.3, 89.7 ± 2.2, 92.0 ± 2.3, and 102 ± 2.6 Ma. The other two samples were sericite mica finer than 0.1 mm, which yielded younger K-Ar dates of 65 and 55 Ma (nos. 34 and 33). The two younger dates correlate approximately linearly with lower K2O contents when compared with the muscovite dates. The sericite that yielded the youngest date (55 Ma) has a K2O content of only 6.7%, whereas the next older (65 Ma) has an intermediate K2O content of 8.9%. McDougall and Harrison (1988) suggest that low K2O sericites may in fact be illite or hydromuscovite. The sericite may record cooling through lower blocking temperatures than does the muscovite. If so, a measure of the sericite blocking temperature for argon retention may be a zircon fission-track date for the sericite sample (no. 34) of intermediate K2O content. Zircons in the sample seem to represent two populations. The fission-track age of 78 ± 9 Ma, although crude, nevertheless slightly exceeds the sericite K-Ar age and suggests that this sericite retained argon only at or below the annealing temperature for fission tracks in zircon, which is approximately 200°C (Harrison and others, 1979; Hurford, 1986). The lower-K2O sericite (no. 33) from the same locality, with the youngest apparent age, may record a lower cooling temperature yet.

The muscovite dates between 90 and 102 Ma are crudely concordant. Because they occur at different pre-tectonic structural depths, we suspect that they may approximate the age of the alteration event rather than younger cooling, which would be expected to vary systematically with structural depth. An age of alteration of about 100 Ma would be consistent with dates obtained from plutons in the Turtle Mountains and from an upper plate adammellite in the Whipple Mountains (Davis and others, 1980; Howard and others, 1982b): both localities are near restored pre-extension positions of the Mohave Mountains fault blocks (Howard and others, 1982a).

**PROTEROZOIC ROCKS**

Dates determined on altered Proterozoic rocks (fig. 3d) can be interpreted as mixed cooling ages. The regional Proterozoic rock suite is known to comprise Early Proterozoic gneisses and granitoids and Middle Proterozoic granitoids and diabase (Lanphere 1964; Howard and others, 1982b; Anderson, 1983, in press; Wooden and others, 1988). Granodiorite, tentatively correlated with the Middle Proterozoic granodiorite of Bowmans Wash of Anderson (1983), yielded a fission-track date on zircon of 46.4 ± 5.4 Ma (no. 43). Rocks assigned to the Early Proterozoic by Howard and others (1982a, in prep.) (samples 40 to 42 and 44 to 52) yielded hornblende K-Ar ages ranging from 104 ± 2.6 to 1372 ± 34 Ma, biotite K-Ar dates ranging from 49.2 ± 10.5 to 863 ± 21.6 Ma, and zircon fission-track dates ranging from 22.6 ± 1.9 to 81.7 ± 8.7 Ma. These dates are taken to imply cooling of some rocks as recently as the Miocene. An analysis of cooling and uplift patterns is in progress.

**ANALYTICAL METHODS**

**K-Ar**

The K-Ar age determinations were made in the isotope laboratories of the U.S. Geological Survey at Menlo Park, California, using the methods described by Dalrymple and Lanphere (1969). Argon was extracted on an ultra-high vacuum system by fusion; the reactive gases were then scrubbed by an artificial molecular sieve, Cu-CuO and Ti metals.

The spectrometry was performed on a Nier-type, 15-cm radius, 60° sector and a multichannel, 23-cm radius, 90° sector mass spectrometer, both operated in the static mode. Argon was analyzed by comparing the liberated gas to a "pure" 39Ar spike of known volume and composition added during fusion. The decay constants used are those published by Steiger and Jager (1977):

\[
\frac{40K}{K} = 1.67 \times 10^{-4} \text{ mol/mol}
\]

\[
\lambda(40K_{a}) = 4.962 \times 10^{-10} \text{ yr}^{-1}
\]

\[
\lambda(40Ar) + \lambda(40Ke) = 0.581 \times 10^{-10} \text{ yr}^{-1}
\]

Using the procedure described by Cremer and others (1984), flame photometry with a lithium internal standard was used to analyze potassium. All samples were run in duplicate to check precision.

Radiogenic argon (^40Ar*) as a percent of total argon (Σ^40Ar) may differ by as much as 17% from replicate analysis of the same sample on different extraction lines, with different bakeout times, spike sets and the total amount of sample used. These factors contribute varying atmospheric components and thereby lead to an apparent discrepancy in the radiogenic argon percentages from one extraction to the next. However, the total atmospheric components are subtracted and the final age calculations are based on radiogenic Ar concentration measured in moles/gram, which differ by no more than 3%.

The 2.5–3.0% (±) error represents a conservative estimate of the overall analytical precision for samples with greater than 10% radiogenic argon. This is based on empirical tests over a period of 14 years at the U.S. Geological Survey Isotope laboratory in Menlo Park, California (Tabor and others, 1985). All samples run prior to 1980 have an error of 3.0%; at this time a change to improved standards and improved precision lead to a change in the analytical method.
3.0% estimates at ±1 standard deviation and 68% confidence level. However, agreement between replicate analysis were usually less than 2%. For those samples with greater than 3% error between replicate analysis, the dates were averaged and a standard deviation was calculated and reported to ±1 standard deviation.

**Fission Track**

The external detector method was used to date the zircons (Naeser, 1976, 1979), which were mounted in Teflon and etched in a eutectic melt of KOH-NaOH (Gleadow and others, 1976) at 215°C for 30–50 hours. The Teflon mounts were covered with a muscovite detector and irradiated along with neutron dose monitors (U-doped glasses SRM 962 also covered with muscovite (Gleadow and others, 1976) at 215°C for 30–50 hours. The neutron dose was determined using track densities in the muscovite detectors and the Cu calibration for SRM 962 (Carpenter and Reimer, 1974). The errors shown for the fission-track dates are ±2 standard deviations.

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**SAMPLE DESCRIPTIONS**

1. **P81MH-8a**
   - **K-Ar**
   - Olivine basalt (34°30'44" N, 114°04'27" W; S31, T14N, R17W; Buck Mountains SE 7.5' quad., Mohave Co., AZ). Analytical data: K2O = 1.326%, 1.317%, 1.337%; 40Ar*/36Ar = 2.16 x 10^-11 mol/g, 2.09 x 10^-11 mol/g; 40Ar*/36Ar = 45%, 34%; argon analysis by M. A. Pernokas. Comments: Gently dipping basalt flow, Sequence IV; caps Black Mountain. Holocrystalline subophitic basalt containing phenocrysts of olivine, clinopyroxene, and plagioclase. Age is revised from 10.6-Ma age reported by Nelson (1986). Collected by: M. A. Pernokas.
   - **(whole rock)** 11.1 ± 0.3 Ma

2. **P82MH-23**
   - **K-Ar**
   - Silicic tuff (34°27'36" N, 114°30'36" W; S17, T13N, R17W; Parker Dam 15' quad., Mohave Co., AZ). Analytical data: K2O = 9.03%, 9.06%; 40Ar*/36Ar = 1.66 x 10^-10 mol/g, 40Ar*/36Ar = 63%; argon analysis by J. K. Nakata. Comments: Flow-banded tuff, sequence IV; caps Black Mountain. Holocrystalline subophitic basalt containing phenocrysts of olivine, clinopyroxene, and plagioclase. Age is revised from 10.6-Ma age reported by Nelson (1986). Collected by: M. A. Pernokas.
   - **(whole rock)** 11.1 ± 0.3 Ma

3. **H81MH-18**
   - **K-Ar**
   - **(whole rock)** 14.6 ± 0.4 Ma

4. **JP80MH-192**
   - **K-Ar**
   - Peach Springs Tuff (34°37'49" N, 114°21'10" W; S22, T15N, R20W; Franconia 7.5' quad., Mohave Co., AZ). Analytical data: K2O = 9.09%, 9.06%, 9.08%; 40Ar*/36Ar = 2.34 x 10^-10 mol/g, 2.30 x 10^-10 mol/g; 40Ar*/36Ar = 72%, 64%; argon analysis by J. K. Nakata. Comments: Salmon-pink crystallithic tuff breccia, unwarped, sequence IV; occurs above bedded tuff (altered pumice fragments). Sanidine is dominant crystal. Age is revised from 16.7-Ma and 17.8-Ma ages reported by Nelson (1986). Collected by: J. E. Nelson.
   - **(sanidine)** 17.6 ± 0.4 Ma

5. **P81MH-2**
   - **K-Ar**
   - Peach Springs Tuff (34°37'54" N, 114°21'21" W; S22, T15N, R20W; Franconia 7.5' quad., Mohave Co., AZ). Analytical data: K2O = 9.36%, 9.35%, 9.32%, 9.46%; 40Ar*/36Ar = 2.40 x 10^-10 mol/g, 2.48 x 10^-10 mol/g; 40Ar*/36Ar = 67%, 87%; argon analysis by M. A. Pernokas. Comments: Strongly welded crystalithic ryolite tuff, sequence II. Phenocrysts are sanidine and lesser biotite, opaques, hornblende, and sphene. Sanidine is euhedral and fresh. Date is revised from 17.4-Ma date reported by Nelson (1986). Collected by: J. E. Nelson.
   - **(sanidine)** 18.0 ± 0.5 Ma

6. **JP81MH-159**
   - **K-Ar**
   - Silicic tuff (34°30'41" N, 114°05'11" W; S31, T14N, R17W; Standard Wash 7.5' quad., Mohave Co., AZ). Analytical data: K2O = 8.04%, 8.05%; 40Ar*/36Ar = 2.22 x 10^-10 mol/g, 2.14 x 10^-10 mol/g; 40Ar*/36Ar = 37%, 54%; argon analysis by M. A. Pernokas. Comments: In fault block that exposes bedded rocks of sequence I of Nelson (1986). Flattened pumice fragments show no preferred orientation. Probably the Peach Springs Tuff, sequence II. Collected by: J. E. Nelson.
   - **(biotite)** 18.7 ± 0.7 Ma

7. **JP81MH-388B**
   - **K-Ar**
   - **(plagioclase)** 17.9 ± 0.5 Ma

8. **JP81MH-378**
   - **K-Ar**
   - **(plagioclase)** 17.9 ± 0.5 Ma

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S33,T15N,R20W; Havasu City North 7.5° quad., Mohave Co., AZ). Analytical data: K2O = 8.34%, 8.33%, 8.32%; 40Ar*/39Ar = 2.34 x 10^{-11} mol/g; 40Ar*/36Ar = 69%; argon analysis by M. A. Pernokas. Comments: Fine-grained groundmass with large (6-mm) phenocrysts and clusters of phenocrysts. Contains relatively unaltered biotite in addition to altered plagioclase and clinopyroxene and amphibole. Collected by: J. E. Nielson.

(biotite) 19.9 ± 0.5 Ma

9. JP81MH-14a K-Ar Basalt (34°39'42"N, 114°14'34"W; S3,T13N,R19W; Standard Wash 7.5° quad., Mohave Co., AZ). Analytical data: K2O = .93%, .92%; 40Ar*/39Ar = 2.33 x 10^{-11} mol/g, 2.44 x 10^{-11} mol/g; 40Ar*/36Ar = 37%, 41%; argon analysis by J. K. Nakata. Comments: Flow or dike in sequence I of Nielson (1986). Porphyritic olivine basalt; holocrystalline groundmass. Plagioclase laths, clinopyroxene and olivine in granular opaques and alterations indicate chlorite. Olivine is fine grained. Age is revised from 17.8-Ma age reported by Nielson (1986). Collected by: J. E. Nielson.

(whole rock) 17.9 ± 0.7 Ma

10. P81MH-296 K-Ar Rhyolite flow (34°35'31"N, 114°22'01"W; S33,T15N,R20W; Lake Havasu City N 7.5° quad., Mohave Co., AZ). Analytical data: K2O (biotite) = 8.54%, 8.55%; 40Ar*/39Ar = 2.37 x 10^{-10} mol/g, 2.03 x 10^{-10} mol/g; 40Ar*/36Ar = 48.9%, 13.8%; argon analysis by J. K. Nakata. K2O (hornblende) = 0.866%, 0.858%; 40Ar*/39Ar = 2.03 x 10^{-11} mol/g, 2.02 x 10^{-11} mol/g; 40Ar*/36Ar = 14%, 10%; argon analysis by J. K. Nakata. Comments: In sequence I of Nielson (1986). Medium-grained matrix with large plagioclase phenocrysts and holocrystalline matrix. Mafic phenocrysts are relatively fresh; hornblende is green. Collected by: J. E. Nielson.

(biotite) 19.2 ± 0.5 Ma
(hornblende) 16.3 ± 0.4 Ma

11. P80MH-223 K-Ar Rhyolitic perlite (34°37'31"N, 114°20'02"W; S20,T15N,R20W; Fraconia 7.5° quad., Mohave Co., AZ). Analytical data: K2O (biotite) = 8.34%, 8.32%; 40Ar*/39Ar = 2.31 x 10^{-10} mol/g, 2.31 x 10^{-10} mol/g; 40Ar*/36Ar = 53.5%, 63.6%; argon analysis by M. A. Pernokas. K2O (hornblende) = .82%, .80%; 40Ar*/39Ar = 2.08 x 10^{-11} mol/g, 1.93 x 10^{-11} mol/g; 40Ar*/36Ar = 19%, 22%; argon analysis by M. A. Pernokas. Comments: Base of rhyolite flow in sequence I of Nielson (1986). Dark, perlitic glass, containing 2-mm-sized biotite. Previously reported as sample JP81-123 (Nielson,1986). Collected by: J. E. Nielson.

(biotite) 19.1 ± 0.6 Ma
(hornblende) 17.2 ± 0.7 Ma

12. JP80MH-139 K-Ar Rhyolitic perlite (34°36'01"N, 114°21'12"W; S22,T15N,R20W; Lake Havasu City N 7.5° quad., Mohave Co., AZ). Analytical data: K2O (biotite) = 0.679%, 0.676%; 40Ar*/39Ar = 0.158 x 10^{-10} mol/g; 40Ar*/36Ar = 1.93 x 10^{-11} mol/g; 40Ar*/36Ar = 8.72 x 10^{-11} mol/g, 8.75 x 10^{-11} mol/g; 40Ar*/36Ar = 14%, 10%; argon analysis by J. K. Nakata. Comments: Breccia contains plagioclase and biotite crystals, recrystallized quartz, casts of vitrophyre containing plagioclase, biotite, and magnetite phenocrysts, clasts of porphyry containing biotite and altered plagioclase, and clasts of fuff, sequence I. Date is considered much older than geologically reasonable and may indicate the presence of xenocrystic biotite. Collected by: J. E. Nielson.

(biotite) 48.0 ± 1.2 Ma

13. JP81MH-361 K-Ar Silicic volcanic breccia (34°37'57"N, 114°18'34"W; S24,T15N,R20W; Franconia 7.5° quad., Mohave Co., AZ). Analytical data: K2O = 7.33%, 7.31%; 40Ar*/39Ar = 5.12 x 10^{-10}; 40Ar*/36Ar = 80%; argon analysis by M. A. Pernokas. Comments: Breccia contains plagioclase and biotite phenocrysts, recrystallized quartz, casts of vitrophyre containing plagioclase, biotite, and magnetite phenocrysts, clasts of porphyry containing biotite and altered plagioclase, and clasts of fuff, sequence I. Date is considered much older than geologically reasonable and may indicate the presence of xenocrystic biotite. Collected by: J. E. Nielson.

(biotite) 20.5 ± 1.6 Ma
(hornblende) 18.8 ± 0.5 Ma

15. P81MH-1 K-Ar Rhyolitic dike (34°36'01"N, 114°21'12"W; S28,T15N,R20W; Lake Havasu City N 7.5° quad., Mohave Co., AZ). Analytical data: K2O = 0.679%, 0.676%; 40Ar*/39Ar = 0.158 x 10^{-10} mol/g; 40Ar*/36Ar = 1.88 x 10^{-11} mol/g, 1.88 x 10^{-11} mol/g; 40Ar*/36Ar = 10%, 11%; argon analysis by J. K. Nakata. Comments: Northeast trending dike that cuts other nearby dacitic and andesitic dikes. Fine-grained glassy, perlitic groundmass with abundant plagioclase and biotite phenocrysts and accessory hornblende. Collected by: J. E. Nielson.

(biotite) 17.8 ± 0.6 Ma
(hornblende) 17.9 ± 0.6 Ma

16. JN-81MH-90-2 K-Ar Diorite dike (34°33'39"N, 114°06'20"W; S12, T14N,R18W; Buck Mountains SE 7.5° quad., Mohave Co., AZ). Analytical data: K2O (hornblende) = 0.782%, 0.789%; 40Ar*/39Ar = 2.57 x 10^{-11} mol/g, (with flux) 3.06 x 10^{-11} mol/g; 40Ar*/36Ar = 14%; argon analysis by J. K. Nakata (with flux) 25%; argon analysis by J. K. Nakata. Comments: Northeast trending dike that cuts other nearby dacitic and andesitic dikes. Fine-grained, hypidiomorphic granular texture. Hornblende is fresh with some alteration to chlorite. Second analysis used flux and H2O-cooled bottle for fusion, and therefore would be expected to be more accurate. Both dates are suspected to be older than geologic age of emplacement. Collected by: J. K. Nakata.

(hornblende) 22.6 ± 0.7 Ma
(with flux) 26.9 ± 0.7 Ma
21. P81MH-158  
Microdiorite dikes (34°32'58"N, 114°11'38"W; S13, T14N, R1W; Buck Mountains, SE quadr., Mohave Co., AZ). 
*Analytical data:* $K_2O = 2.20\%$, 2.15%; $^{40}Ar^* = 1.36 	imes 10^{-10}$ mol/g, 1.36 $10^{-10}$ mol/g; $^{40}Ar*/^{40}Ar = 70\%$, 70%; argon analysis by M. A. Pernokas. 
*Comments:* Date is considered to be older than the likely geological age of emplacement. *Collected by:* J. K. Nakata.

(whole-rock) 42.9 ± 1.1 Ma

22. H83MH-66  
Microdiorite dikes (34°33'34"N, 114°05'49"W; S13, T14N, R18W; Buck Mountains SE quadr., Mohave Co., AZ). 
*Analytical data:* $K_2O = 0.978\%$, 0.984%; $^{40}Ar^* = 4.15829 	imes 10^{-11}$ mol/g; $^{40}Ar*/^{40}Ar = 39\%$; argon analysis by J. K. Nakata. 
*Comments:* NW-trending dike, east of jeep trail. Cuts gneiss and amphibolite (sampled as H83MH-67). Fine-grained microdiorite consisting of plagioclase, brown hornblende, interstitial epidote and quartz, and secondary calcite. Color index 40. Hornblende is brown, subhedral, acicular; grain size 0.5-2 mm. Date is suspected to be older than the likely geological age of emplacement. *Collected by:* K. A. Howard. 

(whole-rock) 39.9 ± 1.0 Ma

23. BLM-190-8  
Felsic dikes (34°32'N, 114°15'W; S22, T14N, R19W; Mohave Co., AZ). 
*Analytical data:* $K_2O = 8.02\%$, 8.01%, 7.85%, 8.00%; $^{40}Ar^* = 2.24 	imes 10^{-10}$ mol/g, 2.20 $10^{-10}$ mol/g; $^{40}Ar*/^{40}Ar = 70\%$, 66%; argon analysis by M. A. Pernokas. 
*Comments:* Dike 0.5 m thick; cuts augen gneiss. Biotite is fresh, subhedral, and has a grain size of 1 mm. *Collected by:* K. A. Howard.

(biotite) 19.8 ± 0.5 Ma

24. H81MH-39  
Felsic dikes (34°32'29"N, 114°12'21"W; S24, T14N, R19W; Lake Havasu City 7.5' quad., Mohave Co., AZ). 
*Analytical data:* $K_2O = 8.02\%$, 8.01%, 7.85%, 8.00%; $^{40}Ar^* = 2.24 	imes 10^{-10}$ mol/g, 2.20 $10^{-10}$ mol/g; $^{40}Ar*/^{40}Ar = 70\%$, 66%; argon analysis by M. A. Pernokas. 
*Comments:* Dike 0.5 m thick; cuts augen gneiss. Biotite is fresh, subhedral, and has a grain size of 1 mm. *Collected by:* K. A. Howard.

(biotite) 19.8 ± 0.2 Ma

25. H81WH-62  
Felsic dikes (34°16'10"N, 114°29'03"W; S8, T2N, R24E; Whipple Mountains, SW 7.5' quad., San Bernardino Co., CA). 
*Analytical data:* $K_2O = 9.07\%$, 9.09%, 9.07%, 9.08%; $^{40}Ar^* = 2.63 	imes 10^{-10}$ mol/g, 2.58 $10^{-10}$ mol/g; $^{40}Ar*/^{40}Ar = 79\%$, 68%; argon analysis by M. A. Pernokas. 

(biotite) 19.8 ± 0.5 Ma

26. H82MH-15  
Andesitic dikes (34°36'13"N, 114°11'02"W; S13, T14N, R18W; Buck Mountains SE quadr., Mohave Co., AZ). 
*Analytical data:* $K_2O = 8.01\%$, 8.00%, 7.85%, 8.00%; $^{40}Ar^* = 2.24 	imes 10^{-10}$ mol/g, 2.20 $10^{-10}$ mol/g; $^{40}Ar*/^{40}Ar = 70\%$, 66%; argon analysis by M. A. Pernokas. 
*Comments:* In Chambers Well dike swarm (Davis and others, 1980; 1982). Beside Chambers Well road in southern exposures of lower plate of the Whipple Mountains detachment fault (Carr and others, 1980). Microcrystalline groundmass contains 25% phenocrysts of plagioclase, biotite, and altered hornblende. Biotite is fresh, subhedral, and has a grain size 0.5-1 mm. *Collected by:* K. A. Howard.

(biotite) 19.8 ± 0.2 Ma
S31,T15N,R18W; Crossman Peak 7.5’ quad., Mohave Co., AZ). Analytical data: K2O = 7.95%, 7.99%; 40Ar*/36Ar = 2.43 x 10^10 mol/g, 2.35 x 10^10 mol/g; 40Ar*/40Ar = 76%, 71%; argon analysis by M. A. Pernokas. Comments: Dike 5-8 m thick, beside jeep trail. Intrudes granulitic gneiss (sample H82MH-16). Microcrystalline groundmass and 25% phenocrysts of sericitized plagioclase, biotite, K-feldspar, and opaques. Biotite is interleaved with chlorite and opaques. Age is revised from 19.7-Ma age reported by Nielson (1986). Collected by: K. A. Howard.

(biotite) 20.8 ± 0.5 Ma

28. H81MH-57B K-Ar Quartz diorite (34°34’14”N, 114°09’04”W; S9,T14N,R18W; Crossman Peak 7.5’ quad., Mohave Co., AZ). Analytical data: K2O = 6.82%, 6.90%. Color index 52. Hornblende is euhedral, and has brown cores and green rims. Collected by: K. A. Howard from Veined rock inside stope, Pittsburg mine area. Quartz is foliated. Hematite disseminated and fills fractures. Sericite is very fine grained (0.01-0.1 mm). Sericite patches may represent more sericite and clays than chlorite and hematite. White mica occurs as fine-grained aggregates. Forsterite and olivine are 3R and cation order 0.49. 40Ar*/36Ar = 5.39 x 10^10 mol/g, 5.35 x 10^10 mol/g; 40Ar*/40Ar = 89%, 92%; argon analysis by M. A. Pernokas. Comments: Highly altered gneiss from shear zone at stope entrance, Pittsburg mine area. Quartz is foliated. Hematite disseminated and fills fractures. Sericite is very fine grained (0.01-0.1 mm). Sericite patches may represent altered feldspar. Collected by: M. A. Pernokas.

(sericite) 54.9 ± 1.4 Ma

33. P81MH-21B K-Ar Sericite-quartz rock (34°31’14”N, 114°14’05”W; S27,T14N,R19W; Crossman Peak 7.5’ quad., Mohave Co., AZ). Analytical data: K2O = 6.70%, 6.73%, 6.66%; 40Ar*/36Ar = 3.93 x 10^10 mol/g, 3.55 x 10^10 mol/g; 40Ar*/40Ar = 98%, 84%; argon analysis by M. A. Pernokas. Comments: Highly altered gneiss from shear zone at stope entrance, Pittsburg mine area. Quartz is foliated. Hematite disseminated and fills fractures. Sericite is very fine grained (0.01-0.1 mm). Sericite patches may represent altered feldspar. Collected by: M. A. Pernokas.

34. P81MH-21C K-Ar Quartz-sericite rock (34°31’14”N, 114°14’05”W; S27,T14N,R19W; Crossman Peak 7.5’ quad., Mohave Co., AZ). Analytical data: K2O (sericite) = 8.90%, 8.86%, 8.82%; 40Ar*/36Ar = 8.48 x 10^10 mol/g, 8.40 x 10^10 mol/g; 40Ar*/40Ar = 85%, 84%; argon analysis by M. A. Pernokas. Fission-track (zircon, 7 grains) Ps = 12.2 x 10^6 tracks/cm^2 (1209); Pi = 9.85 x 10^6 tracks/cm^2 (454); d = 9.55 x 10^4 n/cm^2; U = 289 ppm; counted by J. R. Shannon. Comments: Veined rock inside stope, Pittsburg mine area. Contains some opaques, K-feldspar, and zircon. Sericite is mostly very fine grained, less than 0.05 mm. Zircons examined for fission tracks strongly zoned; appear to be two populations; date is based on grains having poor intersection and geometry. Collected by: M. A. Pernokas.

K-Ar (sericite) 65.0 ± 1.6 Ma

35. P81MH-21A K-Ar Sericitized granitic augen gneiss (34°31’14”N, 114°14’05”W; S27,T14N,R19W; Crossman Peak 7.5’ quad., Mohave Co., AZ). Analytical data: K2O = 10.58%, 10.56%, 10.53%, 10.55%; 40Ar*/36Ar = 1.44 x 10^9 mol/g, 1.41 x 10^9 mol/g; 40Ar*/40Ar = 96%; argon analysis by M. A. Pernokas. Comments: Borders a quartz vein near the Pittsburg mine. Highly altered medium- to coarse-grained gneiss. Contains more sericite and clays than chlorite and hematite. White mica occurs as fine-grained aggregated crystals (0.1-1 mm grain size). Collected by: M. A. Pernokas.

(white mica) 91.4 ± 2.3 Ma

36. P82MH-21D K-Ar Muscovite-quartz vein (34°31’14”N, 114°14’05”W;
37. **K81MH-36**

K-Ar

Sericitized gneiss (34°32′06″N, 114°10′14″W; S20,T14N,R18W; Crossman Peak 7.5′ quad., Mohave Co., AZ). Analytical data: K₂O = 10.48%, 10.49%, 10.42%, 40Ar*/Σ⁴⁰Ar = 94 %; argon analysis by M. A. Pernokas. Comments: White-mica concentration along joints in sericitized granite gneiss, from hanging wall within 1 m of vein, at prospect near Jupiter mine. Sericite is fine- to medium-grained in gneiss, and joint coatings are coarse-grained muscovite books. Collected by: R. D. Knox.

38. **K81MH-62A**

K-Ar

Quartz-sericite rock (34°34′33″N, 114°17′04″W; S6,T14N,R19W; Lake Havasu City N 7.5′ quad., Mohave Co., AZ). Analytical data: K₂O = 11.1%, 11.0%, 11.1%; 40Ar*/Σ⁴⁰Ar = 74 %, 89%; argon analysis by M. A. Pernokas. Comments: Medium grained, seriate gneiss. Color index 15; abundant opaques. Collected by: M. A. Pernokas.

39. **G81BW-167**

K-Ar

Microdiorite dike (34°23′33″N, 114°05′08″W; S12,T12N,R15W; Parker Dam 15′ quad., Mohave Co., AZ). Analytical data: K₂O = 0.821%, 0.823%; 40Ar*/Σ⁴⁰Ar = 80%, 86%; argon analysis by M. A. Pernokas. Comments: Cuts augen gneiss. Fine-grained hornblende diorite, containing biotite, clinopyroxene, and plagioclase. Collected by: W. Goodge.

40. **H87MH-29**

K-Ar


41. **H82MH-16**

K-Ar

Granulitic gneiss (34°36′11″N, 114°11′05″W; S31,T15N,R18W; Crossman Peak 7.5′ quad., Mohave Co., AZ). Analytical data: K₂O = 8.71%, 8.74%; 40Ar*/Σ⁴⁰Ar = 84%, 82%; argon analysis by M. A. Pernokas. Comments: Several dike widths from dike along jeep trail sampled as H82MH-15 (no. 27). Collected by: K. A. Howard.

42. **P81MH-6**

K-Ar and fission-track


43. **P81MH-9**

Fission-track

Granodiorite augen gneiss (34°25′01″N, 114°09′08″W; S16,T13N,R18W; Standard Wash 7.5′ quad., Mohave Co., AZ). Analytical data: K₂O = 0.412%, 0.415%; 40Ar*/Σ⁴⁰Ar = 32%, 32%; argon analysis by J. K. Nakata. Comments: Medium-grained, seriate gneiss. Color index 15; abundant opaques. Collected by: M. A. Pernokas.

44. **P81MH-22**

K-Ar

Porphyritic granite gneiss (34°29′10″N, 114°13′46″W; S10,T13N,R19W; Standard Wash 7.5′ quad., Mohave Co., AZ). Analytical data: K₂O = 9.03%, 9.04%; 40Ar*/Σ⁴⁰Ar = 97%, 97%, 97%; argon analysis by M. A. Pernokas. Comments: Several dike widths from the nearest dike. Medium-grained. Color index 50. Bears opaques, quartz, epidote. Amphibole is green-brown, anhedral, fine-grained (0.1-1 mm), and includes opaques along cleavage. Collected by: M. A. Pernokas.

45. **H83MH-67**

K-Ar

Amphibolite (34°33′22″N, 114°05′55″W; S13,T14N,R18W; Buck Mountains SE 7.5′ quad., Mohave Co., AZ). Analytical data: K₂O = 9.06%, 9.03%; 40Ar*/Σ⁴⁰Ar = 84%, 82%; argon analysis by M. A. Pernokas. Comments: Several dike widths from the nearest dike. Medium-grained. Color index 50. Bears opaques, quartz, epidote. Amphibole is green-brown and is in aggregates consisting of fine (0.1 mm) subhedral grains. Collected by: K. A. Howard.

46. **P81MH-10**

K-Ar

47. 81MH-155 K-Ar and fission-track
Tonalite (34°40'48"N, 114°24'43"W, S36,T16N, R20W; Topoc 7.5’ quad., Mohave Co., AZ). Analytical data: K2O (biotite) = 8.48%, 8.49%, 8.46%, 8.42%; [40Ar*/36Ar] = 1.32 x 10^-8 mol/g, 1.38 x 10^-8 mol/g; [40Ar*/36Ar] = 89%, 98%; argon analysis by M. A. Pernokas. Fission-track (zircon, 7 grains) Ps = 4.28 x 10^6 tracks/cm^2 (1507); Pi = 3.48 x 10^6 tracks/cm^2 (614); d = 1.01 x 10^16 n/cm^2; U = 107 ppm; counted by J. R. Shannon. Comments: Medium-grained biotite tonalite. Collected by: K. A. Howard.

(biotite) 957 ± 11 Ma

48. 811BW-25 K-Ar and fission-track
Gneiss (34°24'20"N, 114°07'14"W, S3, T12N, R18W; Parker Dam 15’ quad., Mohave Co., AZ). Analytical data: K2O (biotite) = 8.97%, 8.91%; [40Ar*/36Ar] = 1.72 x 10^-9 mol/g, 1.18 x 10^-9 mol/g; [40Ar*/36Ar] = 89%, 84%; argon analysis by M. A. Pernokas. Fission-track (zircon, 7 grains) Ps = 3.858 x 10^6 tracks/cm^2 (1465); Pi = 6.20 x 10^6 tracks/cm^2 (544); d = 1.01 x 10^16 n/cm^2; U = 189 ppm; counted by J. R. Shannon. Comments: Medium-grained biotite granite gneiss. Collected by: K. A. Howard.

K-Ar (biotite) 130 ± 3.3 Ma Fission-track (zircon) 81.7 ± 8.7 Ma

49. P81BK-12 K-Ar
Augen gneiss (34°41'32"N, 114°08'19"W, S28,T16N,R18W, Buck Mountains NE 7.5’ quad., Mohave Co., AZ). Analytical data: K2O = 8.70%, 8.57%, 8.86%, 8.75%; [40Ar*/36Ar] = 1.5638 x 10^-8 mol/g, 1.56103 x 10^-8 mol/g; [40Ar*/36Ar] = 89%, 87%; argon analysis by M. A. Pernokas. Comment: Inequigranular biotite granodiorite augen gneiss containing medium- to coarse-grained feldspar augen. Biotite and minor epidote are in fine-grained aggregates. Biotite is interleaved with small amount of chlorite. Collected by: M. A. Pernokas.

(biotite) 120 ± 3.0 Ma

50. P81BK-13 K-Ar
Amphibolite (34°41'50"N, 114°08'22"W; S28,T16N,R18W; Buck Mountains NE 7.5’ quad., Mohave Co., AZ). Analytical data: K2O = 1.029%, 1.024%, 1.029%, 1.026%; [40Ar*/36Ar] = 3.15 x 10^-8 mol/g, 2.93 x 10^-8 mol/g; [40Ar*/36Ar] = 94%, 94%; argon analysis by M. A. Pernokas. Comments: Medium-grained. Contains quartz and minor opaques, biotite, apatite, and sphene. Hornblende is pale to light greenish brown, and occurs as fresh, subhedral to anhedral grains (0.5-1 mm grain size). Collected by: M. A. Pernokas.

(hornblende) 1372 ± 34 Ma

51. 81BK-7A K-Ar and fission-track
Granodiorite gneiss (34°39'34"N, 114°09'27"W, S9,T15N,R18W; Buck Mountains 7.5’ quad., Mohave Co., AZ). Analytical data: K2O (biotite) = 7.66%, 7.72%, 7.70%; [40Ar*/36Ar] = 3.15 x 10^-8 mol/g, 3.14 x 10^-8 mol/g; [40Ar*/36Ar] = 90%, 91%; argon analysis by M. A. Pernokas. Fission-track (zircon, 7 grains) Ps = 7.77 x 10^6 tracks/cm^2 (1497); Pi = 5.84 x 10^6 tracks/cm^2 (562); d = 1.03 x 10^16 n/cm^2; U = 176 ppm; counted by J. R. Shannon. Comments: Medium-grained hornblende-biotite granodioritegneiss. Biotite is unstrained and fresh. Collected by: K. A. Howard.

K-Ar (biotite) 264 ± 8.6 Ma Fission-track (zircon) 81.6 ± 8.6 Ma

52. H87MH-30 K-Ar

(biotite) 116 ± 3 Ma

REFERENCES


