Eighteen new $^{40}Ar/^{39}Ar$ thermochronologic analyses from southern and central Arizona

by

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INTRODUCTION

Sixteen rock samples were collected from several mountain ranges in southern and central Arizona to determine their cooling history as revealed by $^{40}Ar/^{39}Ar$ thermochronology. This was done by separating minerals, mostly the micas biotite and mucsovite, from the rock samples, and analyzing the minerals to determine how much argon they contain (in one case the rock itself was used). The contained argon that is derived from the radioactive decay of naturally occurring potassium-40 can be used to determine how long it has been since the rock cooled below an approximate temperature that is specific to the type of mineral analyzed. At higher temperatures the minerals lose argon that is produced by radioactive decay, whereas at lower temperature they retain it. For a given mineral, the temperature below which argon retention occurs is referred to as the "closure temperature." Closure temperatures are generally considered to be about 300° ± 50° C for biotite, 400° ± 50° C for muscovite, and 500° ± 50° C for hornblende. [McDougall and Harrison (1988) estimated closure temperature at about 325° ± 15° C for biotite (cooling rate 10° to 100° C/m.y.), ~350° C for muscovite, and 525° ± 25° C for hornblende (cooling rate ~100° C/m.y.)]. All analyses were done at the Nevada Isotope Geochronology Laboratory at the University of Nevada in Las Vegas, and were analyzed under the direction of Terry Spell.

Fifteen of the eighteen mineral separates analyzed for this study were done as part of a mapping project in the Tortolita Mountains and adjacent areas in Pima and Pinal Counties in southwestern Arizona. Another mineral separate from the Buckeye Hills in Maricopa County was analyzed as part of a mapping study west of Phoenix. These two mapping projects were done under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992. Mapping and laboratory studies were jointly funded by the Arizona Geological Survey and the U.S. Geological Survey under STATEMAP Program Contract #01HQAG0098. The remaining two samples are from areas that were mapped earlier as part of related mapping programs and for which geochronologic data was needed for regional map interpretation and for better understanding of geologic history.

This report is primarily intended to release the data produced by the laboratory analyses. Geologic interpretations are summarized here and do not take into account previous geochronologic studies. A more thorough interpretation of the geologic significance of these analyses will incorporate other thermochronologic and geochronologic studies and a more complete analysis of geologic field relations. A summary of analytical results is presented in Table 1, sample locations are given in Table 2, and a complete listing of data is given in Appendix A.

Table 1a. Geochronologic data, Tortolita Mountains area, southeastern Arizona.

Field Sample#	Lab Sample#	Material	Total gas date	Plateau date	Isochron date	area	Description and comments	Collector
Tortolita Mountains and Desert Peak								
BJ 243	30-2-8	muscovite	25.49 +/- 0.15	25.39 +/- 0.16	25.29 +/- 0.15	Tortolita Mts.	Leucogranite, medium-grained, massive to weakly foliated with 0-2% biotite, 5-10% biotite, garnet, and <10% pegmatite dikes. From north of Fresnal Canyon near the northern edge of the Tortolita Mountains.	Brad Johnson
CAF-02-2668	30-2-22	biotite	26.36 +/- 0.15	24.21 +/- 0.15	24.07 +/- 0.13	Tortolita Mts.	Fine- to medium-grained quartz monzonite dike with about 5% biotite. The undeformed dike intrudes mylonitic and protomylonitic leucogranite and granodiorite in the north-central part of the Tortolita Mountains.	Charles Ferguson
CAF-02-3636	30-2-18	biotite	27.86 +/- 0.16	24.19 +/- 0.18	23.69 +/- 0.15	Tortolita Mts.	Medium grained, granite of Tortolita Mts., with 10% biotite (youngest pluton in the Tortolita Mts.). Sampled from the south-central part of the range.	Charles Ferguson
CAF-02-3710	30-2-21	biotite	29.96 +/- 0.15		22.36 +/- 0.15	Tortolita Mts.	Potassium-feldspar porphyritic, biotite-rich quartz syenite to quartz monzonite of Wild Burro Canyon. Sample from southern edge of Tortolita Mountains.	Charles Ferguson
SMR-0795	30-2-12	hornblende	47.66 +/- 0.25			Desert Peak	Fine-grained, hornblende>biotite, granoblastic gabbro or diorite. Hornblende looks fresh, biotite not as good. Steps 5 through 11 (yielding 88% of ^{39}Ar) all yielded dates of 40.4 +/- 1.6 Ma.	Steve Richard
Santa Catalina Mountains								
12-31-01-1	30-2-4	muscovite	25.62 +/- 0.62	25.3 +/- 0.17	24.96 +/- 0.13	Santa Catalina Mts.	Muscovite leucogranite sill hosted by granite of Alamo Canyon	Jon Spencer
11-27-01-1	30-2-16	biotite	24.18 +/- 0.13	23.57 +/- 0.14	23.41 +/- 0.15	Santa Catalina Mts.	Biotite in pegmatite hosted by granite of Alamo Canyon. (mistakenly sent to UNLV labeled as muscovite).	Jon Spencer
Durham Hills and Suizo Mountains								
SMR-0692	30-2-5	muscovite	23.82 +/- 0.15	23.71 +/- 0.16	23.5 +/- 0.13	Northern Suizo Mts.	Medium-grained muscovite leucogranite, contains 5-7%, 2mm muscovite, trace garnet, 30-40% quartz and abundant chalky anhedral feldspar.	Steve Richard
SMR-0692	30-2-15	biotite	26.66 +/- 0.14		23.44 +/- 0.23	Northern Suizo Mts.	Medium-grained muscovite leucogranite, contains 5-7%, 2mm muscovite, trace garnet, 30-40% quartz and abundant chalky anhedral feldspar.	Steve Richard
SMR-0518	30-2-9	hornblende	52.8 +/- 0.3			Durham Hills	Diorite to granodiorite of Durham Hills, 5-10% 1-2mm quartz, 60% anhedral plagioclase, ~2mm, ~30% biotite+hornblende, hornblende looks greenish, biotite still black. Rock cut by pegmatites. Spectra irregular. However, 9 steps (all but first 4), yielding 76.5% of gas (^{39}Ar) all gave dates between 35 and 49 Ma (42 +/- 7 Ma).	Steve Richard
SMR-0518	30-2-17	biotite	29.05 +/- 0.16	25.12 +/- 0.18	24.82 +/- 0.16	Durham Hills	Diorite to granodiorite of Durham Hills, 5-10% 1-2mm quartz, 60% anhedral plagioclase, ~2mm, ~30% biotite+hornblende, hornblende looks greenish, biotite still black. Rock cut by pegmatites	Steve Richard
Black Mountain and Black Hills								
2-1-02-2	30-2-7	muscovite	40.66 +/- 0.25	40.61 +/- 0.28		Black Mountain	Muscovite from pegmatitic leucogranite dikes intruding middle Proterozoic granite.	Jon Spencer
1-25-02-6	30-2-13	biotite	74.99 +/- 0.44		72.56 +/- 0.37	Black Mountain	Biotite from middle Proterozoic biotite granite from Tipperary Wash, approx 1 mile northeast of Tipperary Tank and Black Mountain fault.	Jon Spencer
TO2-100	30-2-3	muscovite	1033.21 +/- 5.02			Black Mountain	Younger, finer grained, more leucocratic granite than host middle Proterozoic biotite granite, Fortified Peak area.	Tim Orr
3-29-02-2	30-2-23	biotite	1364.89 +/- 6.7			Black Hills	Black Hills north of Oracle, footwall of Cloudburst detachment	Jon Spencer

Table 1b. Geochronologic data, central and western Arizona.

Field Sample#	Lab Sample#	Material	Total gas date	Plateau date	Isochron date	area	Description	Collector
Harquahala Mountains								
3-3-87-5	30-2-11	hornblende	194.65 +/- 0.99			Harquahala Mts.	Hornblende granodiorite or monzogranite. Although weathered, hornblende appears fresh. All but first 4 steps, consisting of 9 steps that yielded 85.5% of ^{39}Ar, yielded dates of 186 to 198 Ma.	Steve Richard
Buckeye Hills								
12-13-01-1	30-2-19	biotite	1140.50 +/- 5.93			Buckeye Hills	Corgett Wash Granite, Buckeye Hills. Spectra irregular. However all 12 steps yield dates between 1070 and 1190 Ma	Steve Skotnicki
Sierra Ancha								
7-18-00-1	30-2-25	whole rock	37.36 +/- 0.5			Sierra Ancha	Tertiary basalt interbedded with rim gravels, central Arizona. Very erratic spectra. All but first step yielded dates between 42 and 20 Ma.	Steve Skotnicki

Table 2. Sample locations					
Field Sample#	Grid Zone	UTME	UTMN	NAD	Date
Tortolita Mountains and Desert Peak					
BJ 243	12N	492764	3603115	27	3-Apr-02
CAF-02-2668	12N	494560	3599118	27	20-Mar-02
SMR-0795	12N	476947	3606170	27	18-Feb-02
CAF-02-3636	12N	495575	3593690	27	5-May-02
CAF-02-3710	12N	488718	3593124	27	19-Aug-02
Santa Catalina Mountains					
12-31-01-1	12N	504545	3581749	27	31-Dec-01
11-27-01-1	12N	506882	3584129	27	27-Nov-01
Durham Hills and Suizo Mountains					
SMR-0692	12N	488861	3617508	27	14-Feb-02
SMR-0692	12N	488861	3617508	27	14-Feb-02
SMR-0518	12N	485293	3617295	27	17-Dec-01
SMR-0518	12N	485293	3617295	27	17-Dec-01
Black Mountain and Black Hills					
2-1-02-2	12N	501275	3621494	27	1-Feb-02
1-25-02-6	12N	503168	3621761	27	25-Jan-02
TO2-100	12N	509448	3620367	27	18-Oct-01
3-29-02-2	12N	523217	3620972	27	29-Mar-02
Harquahala Mountains					
3-3-87-5	12N	266378	3726192	27	3-Mar-87
Buckeye Hills					
12-13-01-1	12N	355080	3684535	27	13-Dec-01
Sierra Ancha					
7-18-00-1	12N	508705	3768530	27	18-Jul-00
UTME = Universal Transverse Mercator Easting					
UTMN = Universal Transverse Mercator Northing					
NAD = North American Datum					

SUMMARY OF RESULTS AND GEOLOGIC INTERPRETATION

Tortolita Mountians area

Tortolita Mountains. Four analyses of biotite and muscovite from the Tortolita Mountains yielded isochron ages ranging from 25.29 ± 0.15 Ma in the northern part of the range to 22.36 ± 0.15 Ma in the southwestern part of the range (Table 1). The mountain range is composed of two plutonic suites separated by a septum of highly sheared and metamorphosed (up to sillimanite grade) sedimentary rocks of Paleoproterozoic, Mesoproterozoic, and Paleozoic age. Each plutonic suite consists of an older biotite-rich quartz monzonite or granodiorite intruded by leucogranite with extensive strongly mylonitic dike swarms that invade the older pluton which typically exhibits only weak protomylonitic fabrics. Based on unequivocal field relationships, the northern suite is entirely younger than the southern suite. The youngest pluton in the range, the leucogranite of the southern suite, is the granite of Tortolita Mountains (quartz monzonite of Tortolita Mountains of Banks, 1980), which yielded a biotite $^{40}Ar/^{39}Ar$ isochron age of 23.69 ± 0.15 Ma. The quartz monzonite of Wild Burro Canyon, the older pluton of the southern suite, yielded a biotite $^{40}Ar/^{39}Ar$ isochron age of 22.36 ± 0.15 Ma, which is 1.33 m.y. younger. This relationship, younger biotite $^{40}Ar/^{39}Ar$ isochron age from the older rock, suggests that cooling is related to tectonic exhumation rather than the direct effects of post-magmatic cooling. This is consistent with the fact that the younger age is from a sample that is from a more southwesterly location, closer to the mylonitic rocks that were the most deeply and recently exhumed by normal faulting.

An undeformed, north-northwest striking, nearly vertical quartz monzonite dike in the central Tortolita Mountains cuts both units of the northern suite, and is interpreted to emanate from the pluton formed by the granite of Tortolita Mountains. The undeformed dike yielded a biotite $^{40}Ar/^{39}Ar$ isochron age of 24.07 ± 0.13 Ma, which could reflect the crystallization age of the dike or could be younger and related to cooling following magmatism or tectonic exhumation.

Our oldest date from the Tortolita Mountains is a muscovite $^{40}Ar/^{39}Ar$ isochron age of 25.29 ± 0.15 Ma from the granite of Fresnal Canyon, the leucogranite of the northern suite. As with the date on the quartz monzonite dike, this date could reflect (1) the crystallization age of the granite, (2) younger tectonic exhumation, or (3) cooling following intrusion of younger granitoids.

Santa Catalina Mountains. The 70 Ma (U-Pb zircon, Clark Isachsen, written communication, 2003) biotite granite of Alamo Canyon, exposed in the southwestern Santa Catalina Mountains, is foliated and intruded by muscovite leucogranite sills and locally biotite-bearing, syn-tectonic and post-tectonic pegmatites (Spencer and Pearthree, 2002). Both the leucogranite and pegmatites are thought to be part of the Eocene Wilderness Suite leucogranites (Keith et al., 1980; Force, 1997). A pegmatite yielded a biotite $^{40}Ar/^{39}Ar$ isochron age of 23.41 ± 0.15 Ma and muscovite from a leucogranite sill yielded a $^{40}Ar/^{39}Ar$ isochron age of 24.96 ± 0.13 Ma (Table 1). These dates are from rock samples collected at ~6 and ~9 km, respectively, southwest of the ~26 Ma Catalina Granite. Possibly the 23.41 Ma biotite date from the sample that was closer to the Catalina Granite reflects post-magmatic cooling related to emplacement of the Catalina Granite, although this seems unlikely given the 6 km distance to the granite. This is even

less likely for the 24.96 Ma muscovite date, which is from a sample collected further from the Catalina Granite. There are no other known middle Tertiary intrusive rocks near these samples. Therefore, these two dates are interpreted as reflecting cooling during early Miocene tectonic denudation associated with displacement on the Catalina detachment fault (e.g., Dickinson, 1991). Younger dates would be expected for more southwesterly locations, based on the interpretation that these areas cooled later during exhumation below a southwest-dipping low-angle normal fault. However, the slightly older date is from the more southwesterly location. This could reflect the higher closure temperature of the muscovite sample that yielded an older date than the biotite sample (Table 1).

Suizo Mountains, Durham Hills, and Desert Peak. A sample of a medium-grained, muscovite leucogranite in the Suizo Mountains, north of the Tortolita Mountains, yielded a biotite $^{40}Ar/^{39}Ar$ isochron age of 23.44 ± 0.23 Ma and muscovite $^{40}Ar/^{39}Ar$ isochron age of 23.50 ± 0.13 Ma (Table 1). This muscovite granite is suspected to be Eocene, so these dates are interpreted as cooling dates related to tectonic exhumation from beneath the Suizo Mountains detachment fault, which is thought to be correlative with the Catalina detachment fault (Dickinson, 1991). Furthermore, a sample of hornblende granodiorite from the nearby Durham Hills yielded a biotite $^{40}Ar/^{39}Ar$ isochron age of 24.82 ± 0.16 Ma (Table 1), which is also suspected to be a result of cooling due to tectonic exhumation.

Inference of an Eocene age for the muscovite granite in the Suizo Mountains is based on its lithologic similarity to the Eocene Wilderness Suite granites in the Santa Catalina Mountains and similarity to pegmatitic leucogranite dikes ~11 to 12 km to the northeast at Black Mountain that yielded a muscovite $^{40}Ar/^{39}Ar$ plateau age of 40.61 ± 0.28 Ma (Table 1). These pegmatitic granite dikes intrude Proterozoic granite that yielded two older $^{40}Ar/^{39}Ar$ dates from nearby areas (75 Ma from biotite and 1033 Ma from muscovite; Table 1), so the 40.6 Ma $^{40}Ar/^{39}Ar$ date on muscovite is considered to reflect immediately post-magmatic cooling and the approximate age of the leucogranite dikes.

Inference of an Eocene or older age for the hornblende granodiorite from the Durham Hills is consistent with a hornblende $^{40}Ar/^{39}Ar$ total gas age of 52.8 ± 0.30 Ma from the same rock sample that yielded the 24.82 Ma biotite date (Table 1). The $^{40}Ar/^{39}Ar$ incremental release spectrum for the hornblende is irregular, but all 9 heating steps after the first 4 (13 steps total) are in the range of 42 ± 7 Ma (76.5% of gas). Most likely, the hornblende granodiorite is Laramide and retains little or no argon from before intrusion and regional heating by Eocene muscovite granites. Hornblende diorite from Desert Peak yielded a similarly complex $^{40}Ar/^{39}Ar$ incremental release spectrum from hornblende, with a total gas age of 47.7 ± 0.3 Ma. Eighty-eight percent of the gas released from the hornblende, released during 7 heating steps (after the first 4), all gave ages in the range of 40.4 ± 1.6 Ma. It seems likely that this rock unit is also Laramide or older and that it retains little or no argon from before regional heating associated with widespread emplacement of Eocene muscovite granites.

Conclusion. In conclusion, nine biotite and muscovite $^{40}Ar/^{39}Ar$ incremental-release dates, all derived from isochrons, fall in a three million year range from 22.36 to 25.29 Ma. These dates, which come from eight widely spaced rock samples, are interpreted to record a rapid and extensive regional cooling event associated with tectonic

exhumation of the crystalline rocks in the Tortolita Mountains and surrounding areas. Exhumation was due to tens of kilometers of displacement on the Catalina and Suizo detachment faults, which may be correlative. This displacement accommodated lithospheric extension and led to uplift of mylonitic rocks in the Catalina metamorphic core complex (Davis, 1980; Spencer and Reynolds, 1989; Dickinson, 1991).

Exhumed crystalline rocks record suggestive evidence of early Tertiary thermal history in the retained argon in two hornblende samples. These samples are likely late Cretaceous or early Tertiary in age (Laramide), as suggested by their metaluminous character, but appear to have lost all or nearly all argon at the time of regional Eocene peraluminous magmatism. Eocene pegmatitic granite dikes at the southwest foot of Black Mountain yielded an Eocene $^{40}Ar/^{39}Ar$ plateau date on muscovite that is interpreted as the approximate age of the granite. Finally, three samples from the northeasternmost sampled areas yielded Cretaceous or Proterozoic ages. These rocks were not greatly affected by either Eocene heating and magmatism or by cooling during early Miocene tectonic exhumation. They were tectonically exhumed in the Miocene (Orr et al., 2002a, b), but were below the biotite and muscovite argon closure temperatures before exhumation.

Little Harquahala Mountains

Data are accumulating slowly to document the crystallization ages of igneous rocks and the cooling history of igneous and metamorphic rocks of the Hercules thrust plate in the western Harquahala, Little Harquahala, and Granite Wash Mountains of western Arizona. These rocks are interleaved in a complex structural zone that separates Proterozoic crystalline rocks overlain by Paleozoic strata of the Colorado Plateau from Jurassic Volcanic rocks overlain by Cretaceous clastic rocks of the McCoy Basin to the southwest (Reynolds et al., 1980; Reynolds et al., 1986). A porphyritic monzodiorite in the Hercules thrust plate of the northern Little Harquahala Mountains (Spencer et al., 1985) has yielded a U-Pb zircon lower intercept discordia age of 163.2±2.9 Ma (Isachsen et al., 1999). This rock unit has been correlated lithologically with texturally similar granitoids of the Sore Fingers igneous suite (Richard, 1988) which includes texturally variable diorite to granodiorite, porphyritic and equigranular granite, and fine-grained leucogranite exposed in the southern and central Little Harquahala and western Harquahala Mountains. Similar rocks are exposed in the northeastern Eagletail Mountains to the south (Spencer et al., 1992). Hornblende in the porphyritic monzogranite of the Sore Fingers suite in the southern Little Harquahala Mountains is nearly everywhere altered to secondary biotite. Rehrig and Reynolds (1980) reported a biotite K-Ar age of 140 Ma from this unit. The sample analyzed in the present study (3-3-87-5) is from a small area in which the original igneous hornblende is preserved. The sample yielded a disturbed $^{40}Ar/^{39}Ar$ age spectra that is consistent with a Jurassic crystallization age for the Sore Fingers monzogranite in the southern Little Harquahala Mountains, but is inconsistent with correlation of this monzogranite with monzodiorite in the northern Little Harquahala Mountains.

Buckeye Hills

Geologic mapping in the Buckeye Hills (Skotnicki, 2002a, b) identified several plutons, all of which are foliated in a manner that suggests correlation with other 1700

Ma granitoids in central Arizona. The biotite $^{40}Ar/^{39}Ar$ total gas age of 1140.5 ± 5.93 Ma (Table 1) indicates that the history of this sample is more complex than simple cooling through closure after intrusion, but there is insufficient other cooling data from the region to constrain the various possibilities. These include long-term residence deep enough in the crust that temperatures remained above biotite closure temperature for some 500 Ma after intrusion, or reheating and argon loss at some time after 1140 Ma.

Sierra Ancha

Conglomerate known as Rim Gravels was deposited along the southern edge of the Colorado Plateau in the early Tertiary by northeastward flowing streams that emanated from topographic highlands in what is now the topographically lower Basin and Range Province (Cather and Johnson, 1984; Potochnik, 1989; Spencer and Reynolds, 1989; Skotnicki, 2002c, d). Possible Rim Gravels in the northern Sierra Ancha contain a basalt lava flow that was sampled for $^{40}Ar/^{39}Ar$ geochronologic analysis. A single whole-rock analysis yielded a total-gas age of 37.4 ± 0.5 Ma, but the incremental release spectrum for this sample is highly irregular. The youngest date from an individual increment is 20.1 ± 0.5 Ma, which could be interpreted as a *maximum* age for the rock if it is assumed that the complex $^{40}Ar/^{39}Ar$ incremental release spectrum is due to retention of excess ^{40}Ar (see below). Given the complex $^{40}Ar/^{39}Ar$ spectrum from this sample, we conclude that no useful geochronologic information was derived from the analysis.

LABORATORY PROCEDURES AND DATA ANALYSIS

Sample Irradiation

Samples analyzed by the $^{40}Ar/^{39}Ar$ method at the University of Nevada Las Vegas were wrapped in Al foil and stacked in 6 mm inside-diameter Pyrex tubes. Individual packets averaged 3 mm thick and neutron fluence monitors (FC-2, Fish Canyon Tuff sanidine) were placed every 5-10 mm along the tube. Synthetic K-glass and optical grade CaF_2 were included in the irradiation packages to monitor neutron induced argon interferences from K and Ca. Loaded tubes were packed in an Al container for irradiation. Samples irradiated at the Nuclear Science Center at Texas A&M University were in proximity to the reactor core for 14 hours in the D3 position on the core edge (fuel rods on three sides, moderator on the fourth side) of the 1MW TRIGA type reactor. Irradiations are performed in a dry tube device, shielded against thermal neutrons by a 5 mm thick jacket of B_4C powder, which rotates about its axis at a rate of 0.7 revolutions per minute to mitigate horizontal flux gradients. Correction factors for interfering neutron reactions on K and Ca were determined by repeated analysis of K-glass and CaF_2 fragments. Measured $(^{40}Ar/^{39}Ar)_K$ values were 0.0002 (± 0.0002). Ca correction factors were $(^{36}Ar/^{37}Ar)_{Ca} = 2.82\ (\pm 1.51) \times 10^{-4}$ and $(^{39}Ar/^{37}Ar)_{Ca} = 6.77\ (\pm 0.81) \times 10^{-4}$. J factors were determined by fusion of 3-5 individual crystals of neutron fluence monitors, which gave reproducibility's of 0.07% to 0.40% at each standard position. Variation in neutron flux along the 100 mm length of the irradiation tubes was <4%. An error in J of 0.5% was used in age calculations. No significant neutron-flux gradients were present within individual packets of crystals as indicated by the excellent reproducibility of the single-crystal flux-monitor fusions.

Mass spectrometry

Irradiated crystals together with CaF_2 and K-glass fragments were placed in a Cu sample tray in a high-vacuum extraction line and were fused using a 20 W CO_2 laser. Sample viewing during laser fusion was by a video camera system and positioning was done using a motorized sample stage. Samples analyzed by the furnace step-heating method utilized a double-vacuum resistance furnace similar to the design of Staudacher et al. (1978). Reactive gases were removed by a single MAP and two GP-50 SAES getters prior to being admitted to a MAP 215-50 mass spectrometer by expansion. The relative volumes of the extraction line and mass spectrometer allow 80% of the gas to be admitted to the mass spectrometer for laser fusion analyses and 76% for furnace heating analyses. Peak intensities were measured using a Balzers electron multiplier by peak hopping through 7 cycles; initial peak heights were determined by linear regression to the time of gas admission. Mass spectrometer discrimination and sensitivity was monitored by repeated analysis of atmospheric argon aliquots from an on-line pipette system. Measured $^{40}Ar/^{36}Ar$ ratios were 290.40 ± 0.21 % during this work, thus a discrimination correction of 1.01757 (4 AMU) was applied to measured isotope ratios. The sensitivity of the mass spectrometer was ~6 x 10^{-17} mol mV^{-1} with the multiplier operated at a gain of 52 over the Faraday. Line blanks averaged 2.09 mV for mass 40 and 0.01 mV for mass 36 for laser fusion analyses and 8.59mV for mass 40 and 0.03 mV for mass 36 for furnace heating analyses. Discrimination, sensitivity, and blanks were relatively constant over the period of data collection. Computer-automated operation of the sample stage, laser, extraction line, and mass spectrometer as well as final data reduction and age calculations were done using LabSPEC software written by B. Idleman of Lehigh University. An age of 27.9 Ma (Steven et al., 1967; Cebula et al., 1986) was used for the Fish Canyon Tuff sanidine flux monitor in calculating ages for samples.

Discrimination values used during sample analyses.

$^{40}Ar/^{36}Ar$	4 AMU discrimination
290.40 ± 0.21%	1.01757
289.94 ± 0.42%	1.01920
289.90 ± 0.26%	1.01932
290.60 ± 0.19%	1.01685

Data analysis

For $^{40}Ar/^{39}Ar$ analyses, a plateau segment consists of 3 or more contiguous gas fractions having analytically indistinguishable ages (i.e. all plateau steps overlap in age at ± 2σ analytical error) and comprising a significant portion of the total gas released (typically >50%). Total gas (integrated) ages are calculated by weighting by the amount of ^{39}Ar released, whereas plateau ages are weighted by the inverse of the variance. For each sample, inverse isochron diagrams are examined to check for the effects of excess argon. Reliable isochrons are based on the MSWD criteria of Wendt and Carl (1991) and, as for plateaus, must comprise contiguous steps and a significant fraction of the total

gas released. All analytical data are reported at the confidence level of 1σ (standard deviation).

Isochrons are the most desirable treatment of $^{40}Ar/^{39}Ar$ data. This is because the isochron actually defines the isotopic composition of the initial argon in the sample (non-radiogenic argon). Ages calculated for an age spectrum are referred to as "apparent ages" because they are calculated assuming the initial argon is atmospheric in composition - thus, if there is excess argon ($^{40}Ar/^{36}Ar > 295.5$) the age will be overestimated. Isochrons have their measure of reliability, known as the mean square of weighted deviates (MSWD) which is a statistical goodness-of-fit parameter. If it is greater than a certain value (which changes depending on the number of points, see Wendt and Carl, 1991, The statistical distribution of the mean squared weighted deviation: Chemical Geology, v. 86, p. 275-285) then there is more scatter than can be explained by analytical errors and it is not a statistically valid isochron. If we provide an isochron it means that the statistical test is valid, if not then no valid isochron was obtained. Also, there are issues of number of data points defining the isochron - the more the better. Four points should be considered a bare minimum for statistical reasons, three points are marginally useful. This can be understood simply by considering two points - a perfectly fit straight line can be put through any two points, so completely accidental data can have a perfect line fit. It follows that with three points there is less of a chance of an accidental line fit, but it is still a very real possibility (especially if analytical errors are fairly large), this possibility gets exponentially smaller as the number of points defining the line (isochron) goes up, thus more points give a more reliable isochron.

If there is no isochron, then a plateau age is next in preference. This is because a sample that gives ages which are analytically indistinguishable from step to step is exhibiting what is known as "ideal" behavior, which suggests it has a simple geologic history, e.g., rapid cooling as a basalt lava, followed by no reheating or alteration, both of which may produce disturbed (discordant) age spectra. A reliable plateau is 3 or more consecutive steps which are indistinguishable in age at the 2 sigma level and comprise >50% of the total ^{39}Ar released. The lack of an isochron or a plateau does not mean the sample provides no useful information, but their presence gives greater confidence in the ages obtained and requires less subjective interpretation.

DATA INTERPRETATION

Samples were run as conventional furnace step-heating analyses, which produce what is referred to as an apparent age spectrum. The "apparent" derives from the fact that ages on an age spectrum plot are calculated assuming that the non-radiogenic argon (often referred to as trapped, or initial argon) is atmospheric in isotopic composition ($^{40}Ar/^{36}Ar = 295.5$). If there is excess argon in the sample ($^{40}Ar/^{36}Ar > 295.5$) then these ages will be older than the actual age of the sample. U-shaped age spectra are commonly associated with excess argon, and this is often verified by inverse isochron analysis, which utilizes the analytical data generated during the step heating run, but makes no assumption regarding the composition of the non-radiogenic argon. Thus, isochrons can verify (or rule out) excess argon, and isochron ages are usually preferred if a statistically valid regression is obtained (as evidenced by the MSWD value). If such a sample yields no reliable isochron, then strictly speaking the best estimate of the age is that the minimum on the age spectrum is a maximum age for the sample (it could be affected by excess argon, the extent depending on the radiogenic yield). For older samples with very high radiogenic yields ($\%^{40}Ar^*$) the composition of the initial argon is largely irrelevant as the radiogenic argon comprises virtually all of the argon budget, so that concerns about excess argon are greatest for younger, lower K samples in general. $^{40}Ar/^{39}Ar$ total gas ages are equivalent to K/Ar ages. Plateau ages are sometimes found, these are simply a segment of the age spectrum which consists of 3 or more steps, comprising >50% of the total gas released, which overlap in age at the $\pm 2\sigma$ analytical error level (not including the $\pm$ 0.5% J-factor error, which is common to all steps). Such ages are preferred to total gas or maximum ages if obtained. However, in general an isochron age is the best estimate of the age of a sample, even if a plateau age is obtained. If the age spectrum is discordant, and no plateau or isochron is defined, the total gas age may be the only estimate. In these cases (pointed out below) the reliability of the age must be considered substantially lower.

Tortolita Mountains and Desert Peak

BJ 243 Muscovite. This sample was very well behaved, with a very flat, ideal age spectrum, and the comments as made for SMR-0518 biotite apply. The isochron age of 25.3 ± 0.2 Ma is the most reliable, however, this sample apparently has no excess argon, thus the isochron, plateau, and total gas age are all indistinguishable.

CAF-02-2668 Biotite. The age spectrum for this sample gave very discordant ages for the first ~50% gas released, followed by consistent ages of ~24 Ma. A "pseudo plateau" age of 24.2 ± 0.2 Ma can be calculated from steps 7-10 (we call anything with less than 50% gas released a pseudo plateau). The same steps define a valid isochron age of 24.1 ± 0.1 Ma. This isochron suggests a small amount of excess argon is present, which may account for the discordant initial part of the age spectrum. The isochron age is the most reliable for this sample.

CAF-02-3636 Biotite. This sample was very well behaved, yielding both a plateau age and an isochron. As for other similar samples, the isochron age of 23.7 ± 0.2 Ma is the most reliable, especially as this sample clearly contains some excess argon.

CAF-02-3710 Biotite. The age spectrum for this biotite gave a discordant ages with high initial ages which decrease to ages of ~25-23 Ma with the final 80% gas released. There is no plateau age defined. A valid isochron age of 22.4 ± 0.2 Ma is defined by steps 4-9 and shows that this sample contains excess argon. The isochron age is the most reliable for this sample.

SMR-0795 Amphibole (Desert Peak). This sample has a fairly flat age spectrum, especially for an amphibole. High initial ages drop to ages of ~40 Ma after the first 4 steps (~10% gas released). There is some variability in the ages of the final ~90% gas released, thus no plateau age is defined, and unfortunately no isochron was obtained. The total gas age would clearly be an overestimate of the age, due to the high age initial steps. There are two possibilities in dealing with this sample, one is to simply take the average of steps 5-13 and assume excess argon is not a problem here, or alternatively consider that the form of this age spectrum may suggest excess argon (although not confirmed by an isochron) and use the minimum age on the age spectrum as a maximum age for the sample. With no knowledge of geologic constraints the latter is the safest approach.

Southwestern Santa Catalina Mountains

12-31-01-1 Muscovite. The comments made for SMR-0692 muscovite above generally apply. The only difference is that the age spectrum for this sample is distinctly U-shaped, suggesting the presence of excess argon. The isochron shows this is the case, with $^{40}Ar/^{36}Ar = 308$. The isochron age is the most reliable.

11-27-01-1 Biotite. This sample gave an age spectrum with high initial ages which are then consistent at ~24 Ma for the last ~90% gas released. Steps 9-13 define a plateau age of 23.6 ± 0.1 Ma. Steps 6-12 define a valid isochron age of 23.4 ± 0.2 Ma, and indicates some excess argon is present. The isochron age is the most reliable for this sample.

Durham Hills and Suizo Mountains

SMR-0692 Muscovite (Suizo). The age spectrum for this muscovite was very concordant, with the exception of a slightly higher age first step. Steps 2-9 define a plateau age of 23.7 ± 0.2 Ma, which is indistinguishable from the total gas age of 23.8 ± 0.2 Ma. This sample also had a valid isochron defined by all 10 steps and giving an age of 23.5 ± 0.1 Ma, and indicating a small amount of excess argon may be present. The isochron is the most reliable age for this sample, although clearly it makes little difference, as all ages calculated are indistinguishable at the 1σ level.

SMR-0692 Biotite (Suizo). This sample gave an age spectrum similar to 11-27-01-1 biotite. However, there is no plateau age defined. Steps 5-9 define a valid isochron age of 23.4 ± 0.2 Ma, and the lower intercept of the isochron indicates that excess argon is present ($^{40}Ar/^{36}Ar = 344$). This isochron age is the most reliable estimate of the time of cooling through biotite closure temperature.

SMR-0518 Hornblende (Durham). This hornblende gave a very discordant age spectrum, with ages varying from ~190 Ma to 36 Ma. No meaningful plateau or isochron age could be obtained. Such an age spectrum could be the result of excess argon present in the sample, this is suggested by the $^{40}Ar/^{36}Ar = 314$ from the biotite isochron. In such a case the most reasonable interpretation is that the total gas age of 53 Ma is an overestimate, and that the minimum age on the age spectrum, i.e., <35.2 Ma is the best estimate of the time of cooling through the hornblende closure temperature.

SMR-0518 Biotite (Durham). This sample was very much identical to CAF-02-3636 biotite, and the same comments basically apply. The isochron age of 24.8 ± 0.2 Ma is the most reliable, and this sample also contains some excess argon.

Black Mountain and Black Hills

2-1-02-2 Muscovite. This muscovite sample gave a flat, nearly ideal age spectrum, with a "pseudo" plateau age of 40.6 ± 0.3 Ma (pseudo because it represents less than 50% of the total ^{39}Ar released). This age is indistinguishable from the total gas age. The same steps that define the plateau also define a valid isochron age of 40.5 ± 1.2 Ma. The isochron does not suggest excess argon is a problem, although the $^{40}Ar/^{36}Ar$ intercept is poorly constrained due to the high, and similar, radiogenic yields of the steps defining the isochron. Given this observation, and the fact that ages are indistinguishable regardless of how they are calculated, it would be acceptable to use either the isochron or the plateau age.

1-25-02-6 Biotite. This sample gave a U-shaped age spectrum with high initial ages, dropping to ages of ~72 Ma, then rising to high final step ages, suggesting excess argon is present. There is no plateau age defined by these data. Steps 1-5 define a valid isochron age of 72.6 ± 0.4 Ma, and confirms the presence of excess argon with $^{40}Ar/^{36}Ar = 319$. As is the usual case, the isochron age is the most reliable, especially when excess argon is present.

TO2-100 Muscovite. This sample gave a very discordant age spectrum, with ages ranging from ~280 Ma to ~1350 Ma. There is no plateau and no isochron defined. Without knowing the geology it is difficult to say much, but the sample appears to record a Proterozoic crystallization event, with overprinting or recrystallization in the Mesozoic, or at some younger age.

3-29-02-2 Biotite. The step heating age spectrum for this whole rock sample gave a slightly discordant age spectrum which was mildly U-shaped, with an initial age of 1086 Ma, and most remaining steps at ~1350-1400 Ma. There is no plateau age defined, and no isochron, basically due to the extremely high radiogenic yields (all data cluster on the x-axis). The total gas age of 1365 Ma is the most reasonable estimate of the age of this sample. The only alternative would be to ignore the first two lower age steps (<6% of the total gas released) and calculate an average age from the remaining, more consistent steps. Because of the discordant age spectrum this age must be considered to not be of the highest confidence.

Little Harquahala Mountains, La Paz County

3-3-87-5 Amphibole. The age spectrum (except for the first step) for this sample shows progressively increasing ages from ~110 Ma to ~200 Ma. There is no plateau age and no isochron age. The erratic variation of the apparent K/Ca ratio during degassing suggests that the analyzed separate may have contained multiple mineral phases (different amphibole phases, plagioclase contamination?). The simplest interpretation of the spectra is that the sample experienced a thermal event resulting in argon loss after an initial rapid cooling. The 109 Ma apparent age of the youngest gas fraction is consistent with a 50-80 Ma thermal event, the most likely timing based on regional relationships. The minimum age for initial cooling of the sample below closure temperature would be the 198 Ma apparent age of the two highest temperature fractions, including the 1270 °C fraction that probably represents fusion of the sample, with release of 20% of the total ^{39}Ar. All of these apparent ages are based on the assumption that all inherited argon in the sample is atmospheric; this can not be tested. Presence of inherited argon with a higher initial ratio (potentially generated by metamorphic degassing of Proterozoic country rock intruded by the granitoid) would lower the calculated cooling ages. This hypothetical poly-phase cooling history is consistent with the absence of an isochron. It is interesting the that apparent minimum crystallization age of the Sore Fingers Monzogranite (198 Ma) suggested by this amphibole cooling data is older than the U-Pb age determined for the Sore Fingers monzodiorite (163 Ma) in the northern Little Harquahala Mountains. Although by no means definitive, results from this sample are consistent with a Jurassic crystallization age for the Sore Fingers monzogranite in the southern Little Harquahala Mountains, and are inconsistent with correlation of this monzogranite with monzodiorite in the northern Little Harquahala Mountains.

Buckeye Hills, Maricopa County

12-13-01-1 Biotite. The age spectrum for this biotite was discordant with ages ranging from 1070 Ma to 1180 Ma. There was no isochron or plateau defined. The total gas age of 1141 ± 6 Ma (equivalent to a K/Ar age) is the best age estimate for this sample, although the reliability of this age is somewhat questionable due to the discordant age spectrum.

Sierra Ancha, Gila County

7-18-00-1 Basalt groundmass. The age spectrum for this sample is very discordant, with high initial ages, falling to ages which vary between ~20 Ma and 35 Ma. There is no plateau age and no isochron. This is, unfortunately, not so unusual for basalt lava, as they can be the most difficult rocks to get a good $^{40}Ar/^{39}Ar$ age on. The radiogenic yields are all quite low, never exceeding ~14%. This suggests the groundmass may not be completely fresh, so the possibility of some alteration is indicated, or there may be glass (?) in the groundmass. Again, this is common, and can be very difficult to assess, even in thin section for some fine grained samples. The age spectrum could also indicate some excess argon is present. Because of this it is likely the most reliable interpretation is that the minimum age on the spectrum (20 Ma) is a maximum age for the eruption.

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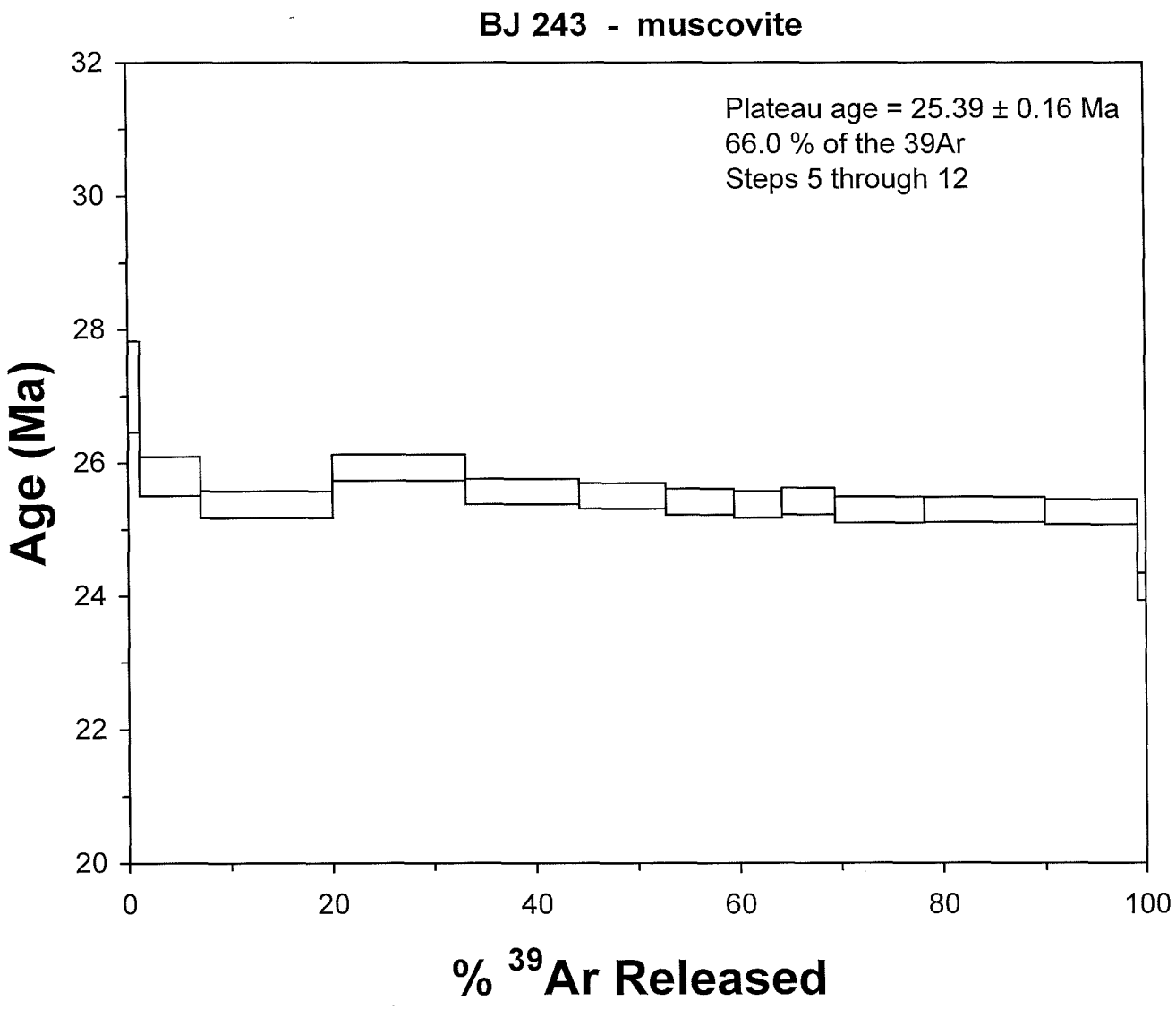
APPENDIX A

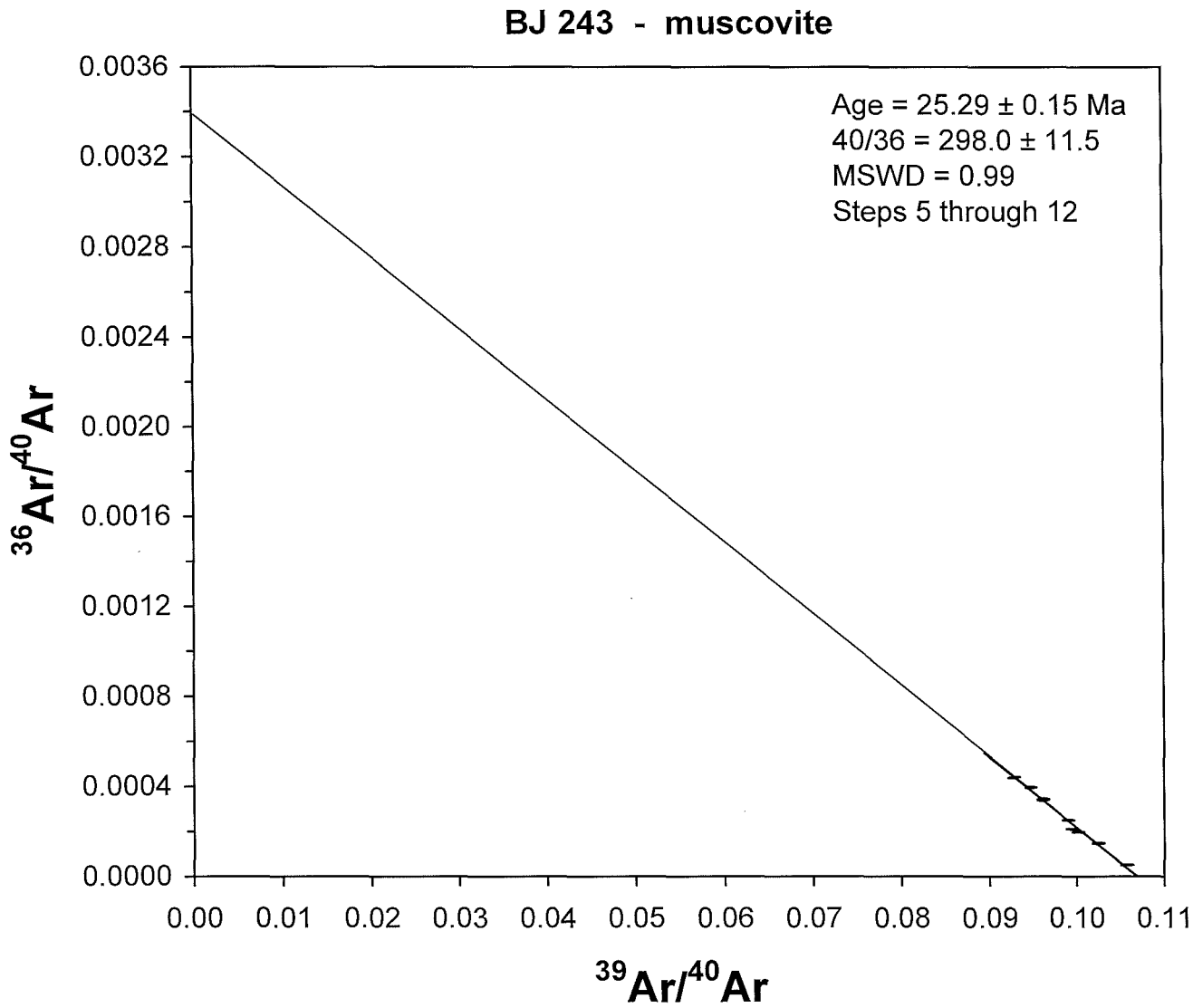
Data for "Eighteen new $^{40}Ar/^{39}Ar$ thermochronologic analyses from southern and central Arizona"

Spencer-AZGS, BJ 243, muscovite, 8.72 mg, J = 0.001509 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	700	12	3.098	0.051	0.823	19.001	1089.22	17.5	1.1	0.015127734	10.0852	27.14	0.68
2	800	12	3.954	0.046	2.027	101.525	2112.17	45.8	5.9	0.002553662	9.3455	25.80	0.29
3	830	12	1.485	0.066	3.176	222.668	2512.25	83.0	13.0	0.001670569	9.1905	25.37	0.20
4	850	12	0.645	0.03	3.01	224.756	2334.43	92.2	13.1	0.000752295	9.3930	25.93	0.20
5	870	12	0.432	0.034	2.534	190.582	1920.75	93.8	11.1	0.001005484	9.2612	25.57	0.19
6	890	12	0.312	0.032	1.933	145.44	1457.29	94.2	8.5	0.001240065	9.2372	25.50	0.19
7	910	12	0.315	0.029	1.536	114.648	1163.53	92.6	6.7	0.00142564	9.2051	25.41	0.19
8	935	12	0.313	0.034	1.08	81.03	848.569	89.9	4.7	0.002364893	9.1894	25.37	0.20
9	980	12	0.454	0.018	1.256	89.971	974.837	87.0	5.2	0.001127582	9.2080	25.42	0.20
10	1040	12	0.659	0.044	2.061	150.633	1595.17	88.3	8.8	0.001646307	9.1616	25.29	0.20
11	1100	12	0.325	0.037	2.632	201.647	1973.58	95.5	11.8	0.001034161	9.1620	25.29	0.19
12	1170	12	0.108	0.035	2.077	157.97	1499.55	98.5	9.2	0.001248739	9.1496	25.26	0.19
13	1400	12	0.097	0.068	0.2	13.913	155.779	86.4	0.8	0.027546721	8.7401	24.14	0.21
							Cumulative %39Ar rlsd =		100.0		Total gas age =	25.49	0.15
											plateau age =	25.39	0.16
											(steps 5-12)		

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

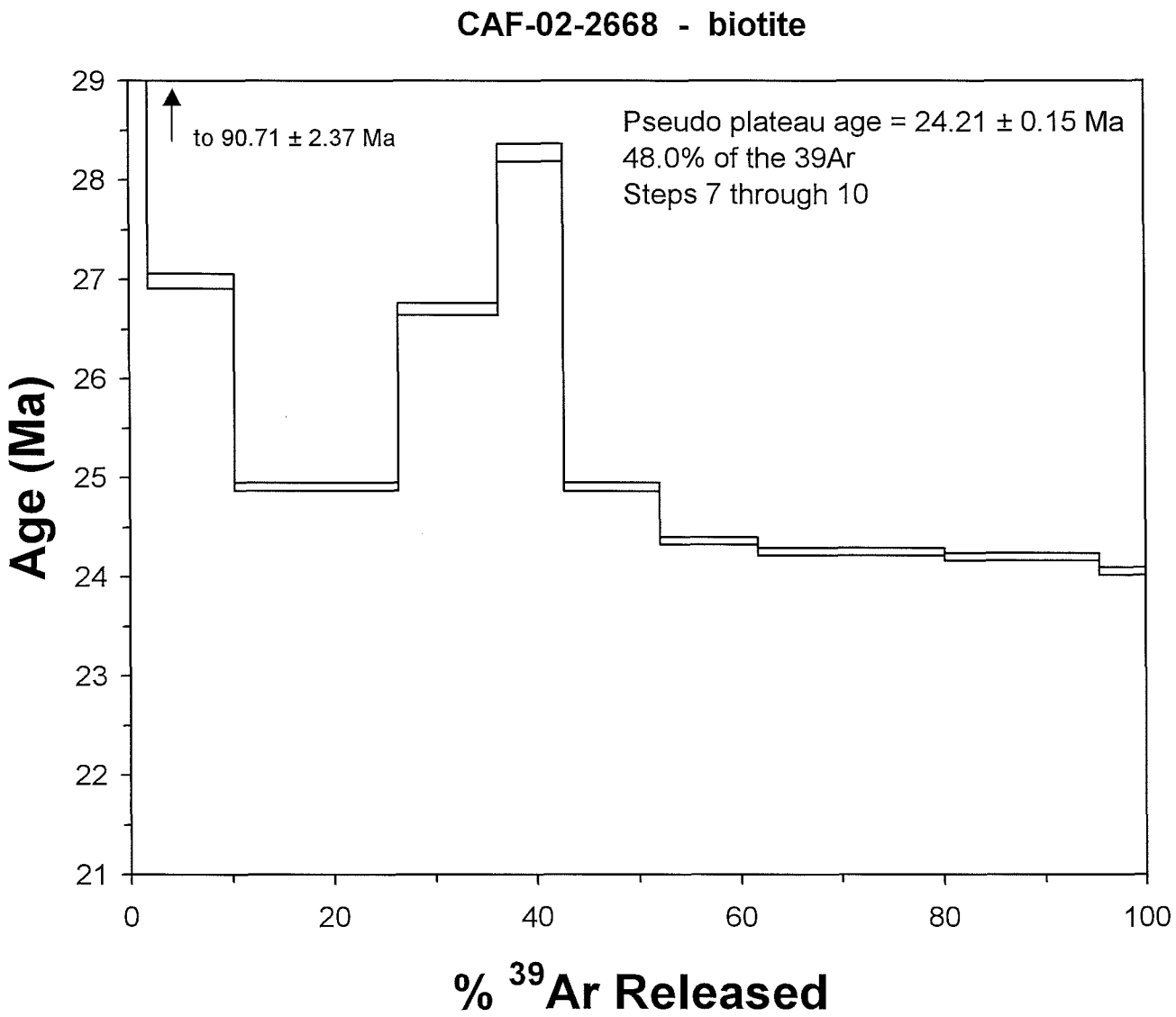

BJ 243 - muscovite
Plateau age = 25.39 ± 0.16 Ma
66.0 % of the 39Ar
Steps 5 through 12
Age (Ma)
32
30
28
26
24
22
20
0
20
40
60
80
100
% 39Ar Released

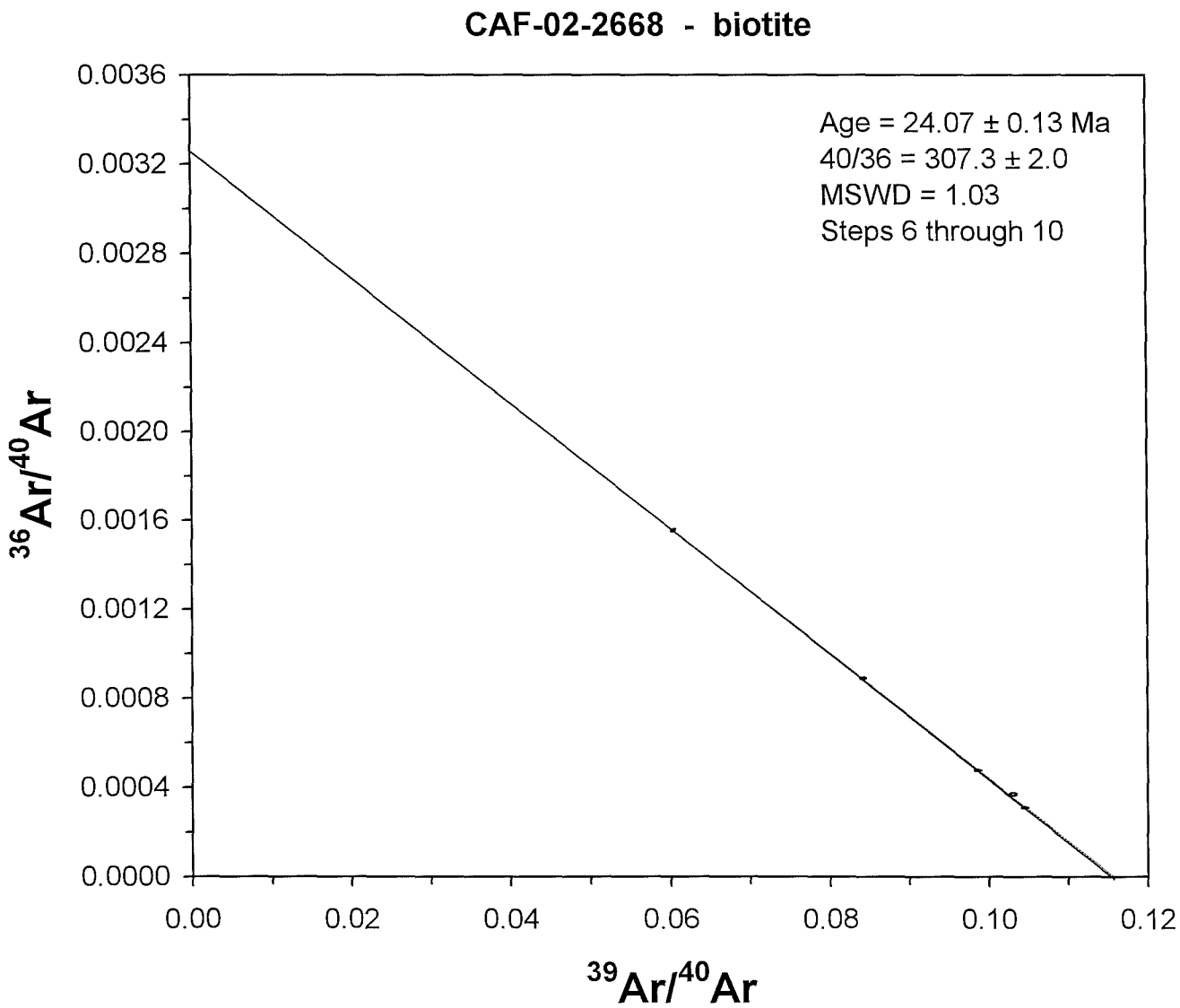

BJ 243 - muscovite
Age = 25.29 ± 0.15 Ma
40/36 = 298.0 ± 11.5
MSWD = 0.99
Steps 5 through 12
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
0.11
39Ar/40Ar

Spencer-AZGS, CAF-02-2668, biotite, 10.25 mg, J = 0.001544 ± 0.5%
4 amu discrimination = 1.01932 ± 0.26%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	625	12	30.865	0.201	6.515	32.328	10018.8	10.7	1.8	0.045890301	33.1731	90.71	2.37
2	710	12	10.937	0.852	4.142	150.188	4622.34	31.4	8.5	0.04187044	9.6945	26.98	0.27
3	790	12	4.336	0.856	4.606	285.922	3805.2	67.0	16.1	0.022096667	8.9431	24.91	0.17
4	860	12	8.098	0.876	3.807	176.17	4032.6	41.8	9.9	0.036700725	9.5939	26.71	0.23
5	935	12	9.218	1.175	3.321	113.705	3822.41	30.1	6.4	0.076272146	10.1623	28.28	0.31
6	1010	12	4.324	1.684	2.938	164.545	2717.8	54.0	9.3	0.075537909	8.9424	24.90	0.18
7	1060	12	1.865	1.861	2.605	171.655	2034.36	73.7	9.7	0.080019911	8.7461	24.36	0.16
8	1110	12	1.642	3.68	4.629	327.318	3310.49	85.9	18.5	0.082982491	8.7067	24.25	0.15
9	1170	12	0.851	8.59	3.67	269.782	2575.64	80.8	15.2	0.235022041	8.6875	24.20	0.15
10	1400	12	0.331	1.372	1.125	82.111	801.547	89.0	4.6	0.123329388	8.6362	24.06	0.16
							Cumulative %39Ar rlsd =		100.0		Total gas age =	26.36	0.15
											pseudo plateau age = (steps 7-10)	24.21	0.15

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

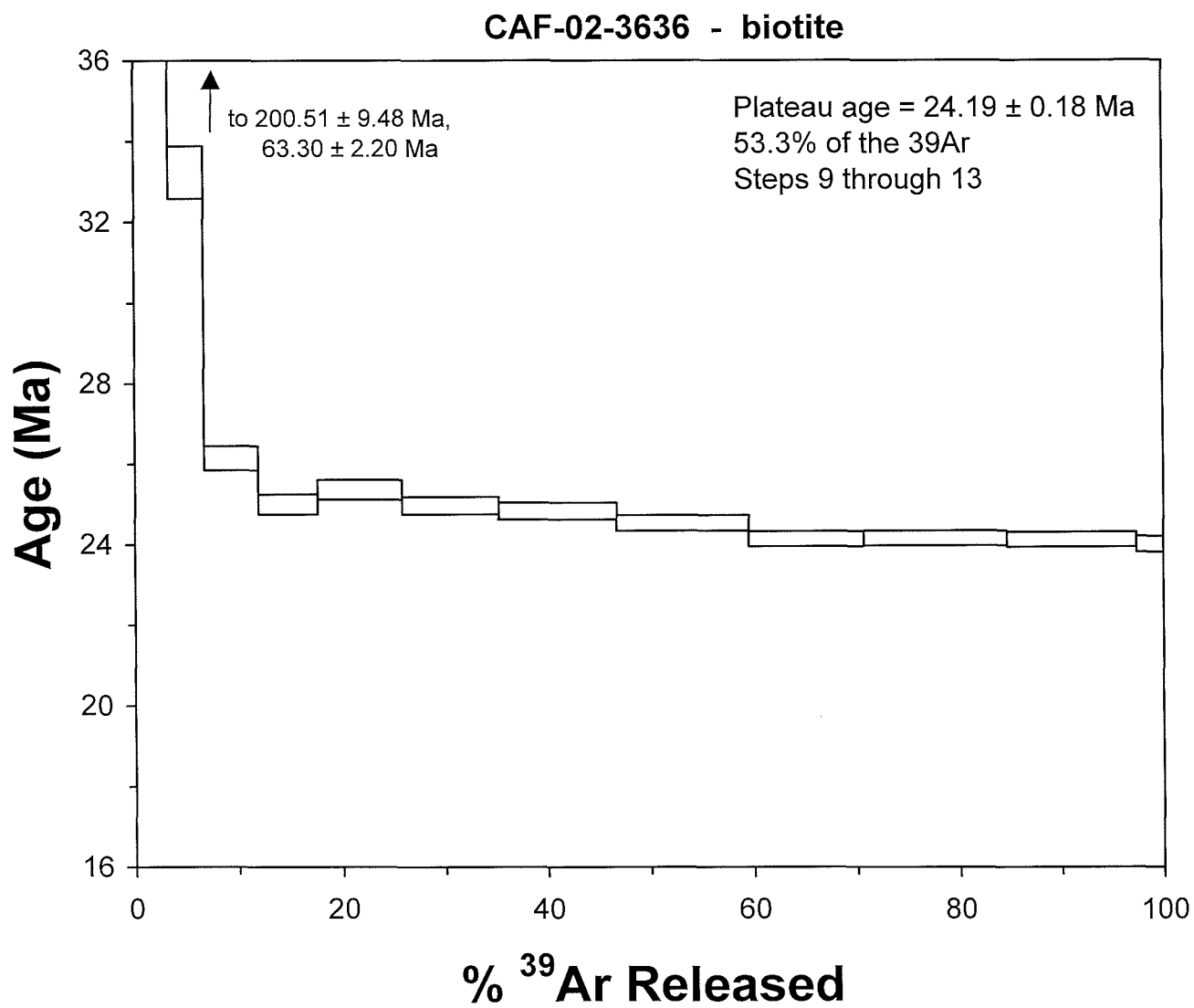

CAF-02-2668 - biotite
to 90.71 ± 2.37 Ma
Pseudo plateau age = 24.21 ± 0.15 Ma
48.0% of the 39Ar
Steps 7 through 10
Age (Ma)
29
28
27
26
25
24
23
22
21
0
20
40
60
80
100
% 39Ar Released


CAF-02-2668 - biotite
Age = 24.07 ± 0.13 Ma
40/36 = 307.3 ± 2.0
MSWD = 1.03
Steps 6 through 10
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00
0.02
0.04
0.06
0.08
0.10
0.12
39Ar/40Ar

Spencer-AZGS, CAF-02-3636, biotite, 9.34 mg, J = 0.0015468 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	48.88	0.630	9.987	17.613	15499.4	8.5	1.2	0.207966579	75.9972	200.51	9.48
2	650	12	17.843	0.519	3.951	31.652	5898.05	12.3	2.2	0.095331806	23.0867	63.30	2.20
3	695	12	6.985	0.508	2.007	49.632	2616.56	22.6	3.4	0.059507112	12.0177	33.23	0.65
4	740	12	3.265	0.563	1.627	76.487	1661.98	43.2	5.2	0.04279426	9.4384	26.15	0.30
5	785	12	1.95	0.473	1.477	83.408	1310.84	57.1	5.7	0.032969845	9.0208	25.00	0.25
6	845	12	2.976	0.71	2.14	120.833	1958.24	56.1	8.2	0.03416146	9.1531	25.36	0.24
7	910	12	2.153	0.955	2.198	139.261	1866.71	66.8	9.5	0.039869266	9.0096	24.97	0.22
8	975	12	1.991	1.441	2.594	168.683	2073.83	72.4	11.5	0.049665901	8.9598	24.83	0.21
9	1025	12	1.46	1.801	2.702	188.82	2078.30	79.9	12.8	0.055453904	8.8526	24.54	0.20
10	1070	12	0.943	2.526	2.292	163.495	1682.88	84.1	11.1	0.089825526	8.7077	24.14	0.19
11	1120	12	0.937	4.408	2.851	205.917	2045.42	87.1	14.0	0.12445857	8.7142	24.16	0.19
12	1170	12	0.691	8.611	2.562	187.09	1808.29	89.5	12.7	0.267606796	8.7008	24.12	0.19
13	1400	12	0.336	6.669	0.584	38.403	424.14	79.0	2.6	1.009919255	8.6597	24.01	0.20
							Cumulative %39Ar rlsd =		100.0		Total gas age =	27.86	0.16
											plateau age =	24.19	0.18
											(steps 9-13)		

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

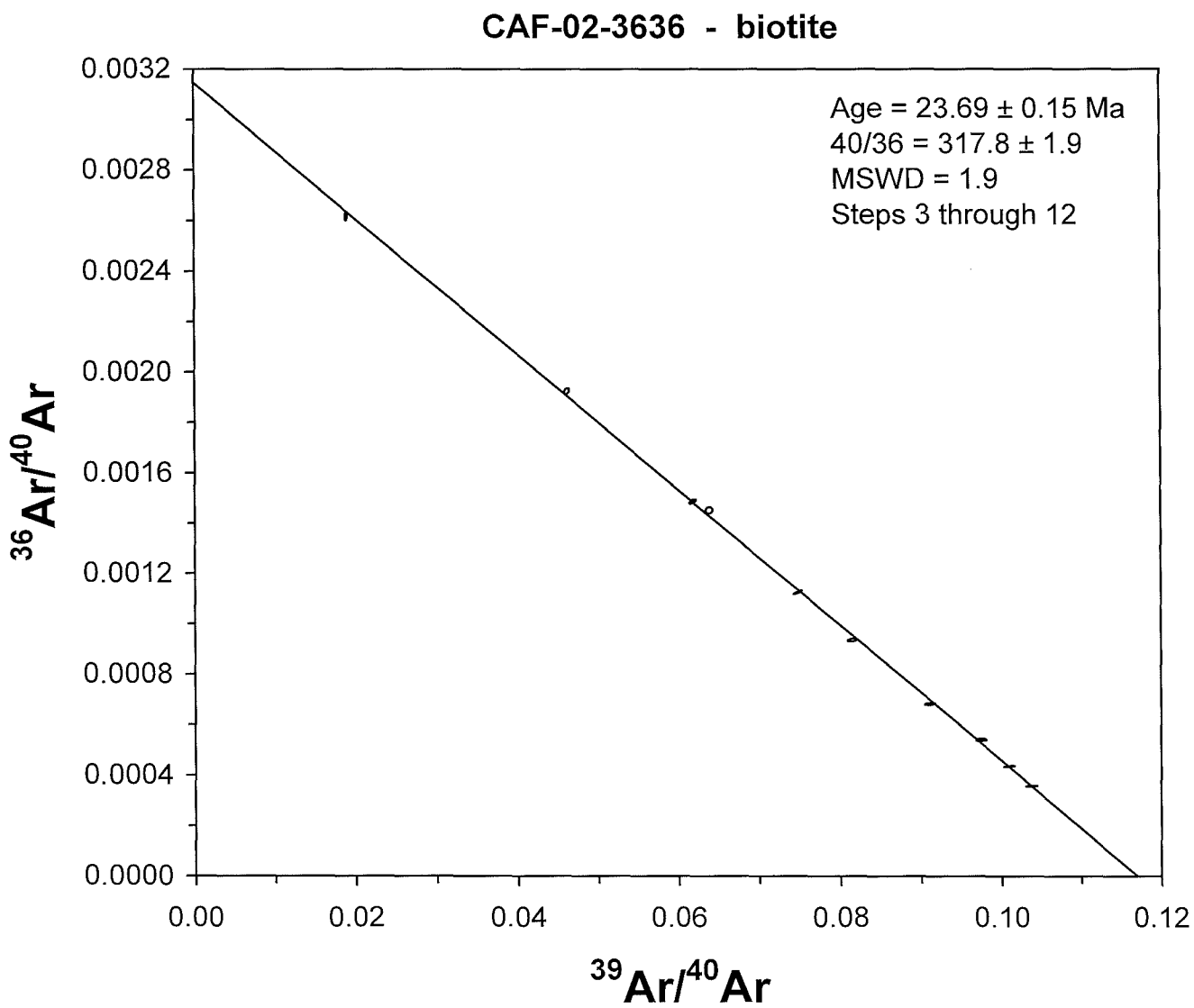

CAF-02-3636 - biotite
to 200.51 ± 9.48 Ma,
63.30 ± 2.20 Ma
Plateau age = 24.19 ± 0.18 Ma
53.3% of the 39Ar
Steps 9 through 13
Age (Ma)
36
32
28
24
20
16
0
20
40
60
80
100
% 39Ar Released

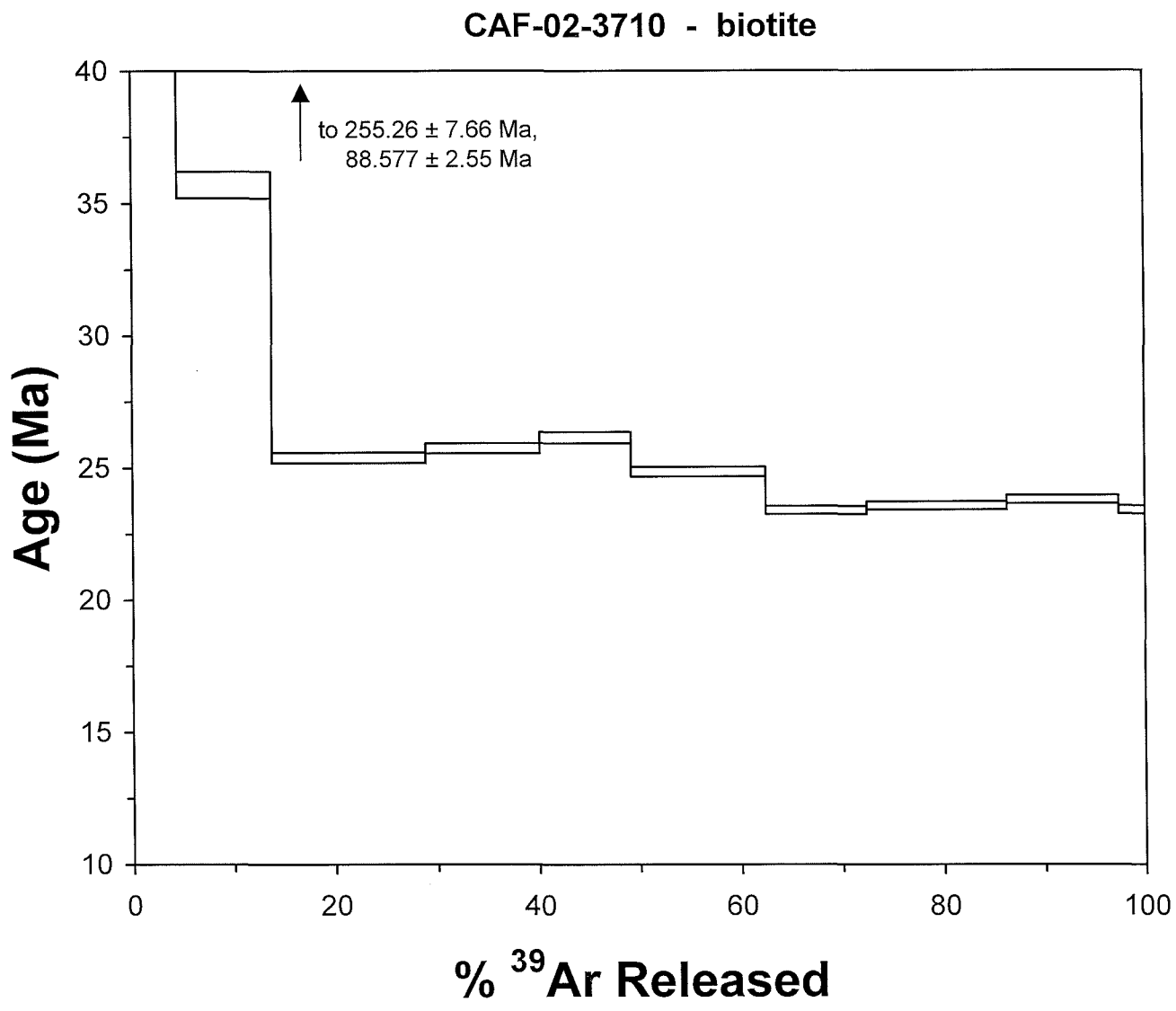
Spencer-AZGS, CAF-02-3710, biotite, 8.85 mg, J = 0.0015536 ± 0.5%
4 amu discrimination = 1.01932 ± 0.26%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

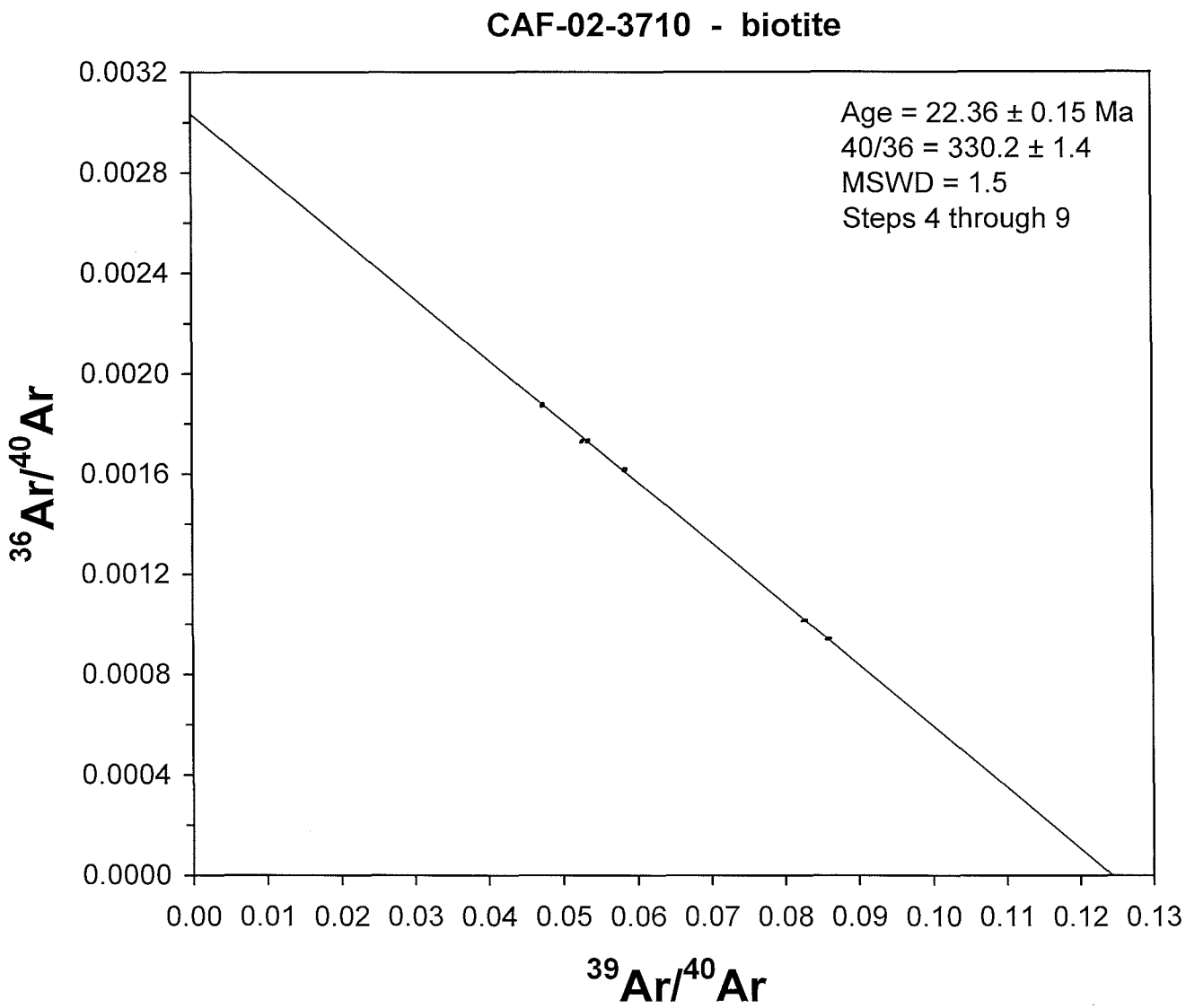
step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	45.749	0.342	8.891	12.409	14472.7	8.3	0.8	0.20129446	97.8290	255.26	7.66
2	650	12	54.90	0.338	11.388	55.295	17703.6	10.1	3.7	0.044642949	32.3916	88.58	2.55
3	710	12	23.90	0.622	6.426	138.893	8710.43	20.4	9.3	0.032706231	12.8651	35.70	0.50
4	780	12	7.394	0.833	4.398	224.799	4186.06	48.8	15.1	0.027062653	9.1199	25.38	0.20
5	850	12	5.612	0.635	3.274	168.171	3177.02	48.8	11.3	0.027576708	9.2502	25.74	0.20
6	925	12	5.415	0.625	2.849	134.47	2826.71	44.6	9.0	0.033944956	9.3964	26.15	0.21
7	1000	12	5.585	0.979	3.652	198.197	3379.58	52.2	13.3	0.036075016	8.9278	24.85	0.19
8	1050	12	1.669	1.041	2.265	148.304	1722.85	72.2	9.9	0.051264977	8.4017	23.40	0.15
9	1100	12	2.582	1.827	3.166	205.823	2480.73	70.0	13.8	0.064828999	8.4613	23.56	0.16
10	1150	12	1.868	4.369	2.516	166.513	1954.44	72.7	11.2	0.191635136	8.5488	23.80	0.16
11	1400	12	0.2	9.019	0.56	38.906	392.763	84.6	2.6	1.693866777	8.4042	23.40	0.15
							Cumulative %39Ar rlsd =		100.0		Total gas age =	29.96	0.15

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

no plateau


CAF-02-3636 - biotite
Age = 23.69 ± 0.15 Ma
40/36 = 317.8 ± 1.9
MSWD = 1.9
Steps 3 through 12
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00
0.02
0.04
0.06
0.08
0.10
0.12
39Ar/40Ar


CAF-02-3710 - biotite
to 255.26 ± 7.66 Ma,
88.577 ± 2.55 Ma
Age (Ma)
40
35
30
25
20
15
10
0
20
40
60
80
100
% 39Ar Released


CAF-02-3710 - biotite
Age = 22.36 ± 0.15 Ma
40/36 = 330.2 ± 1.4
MSWD = 1.5
Steps 4 through 9
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13
39Ar/40Ar

Spencer-AZGS, SMR-0795, amphibole, 13.80 mg, J = 0.001527 ± 0.5%
4 amu discrimination = 1.01757 ± 0.20%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

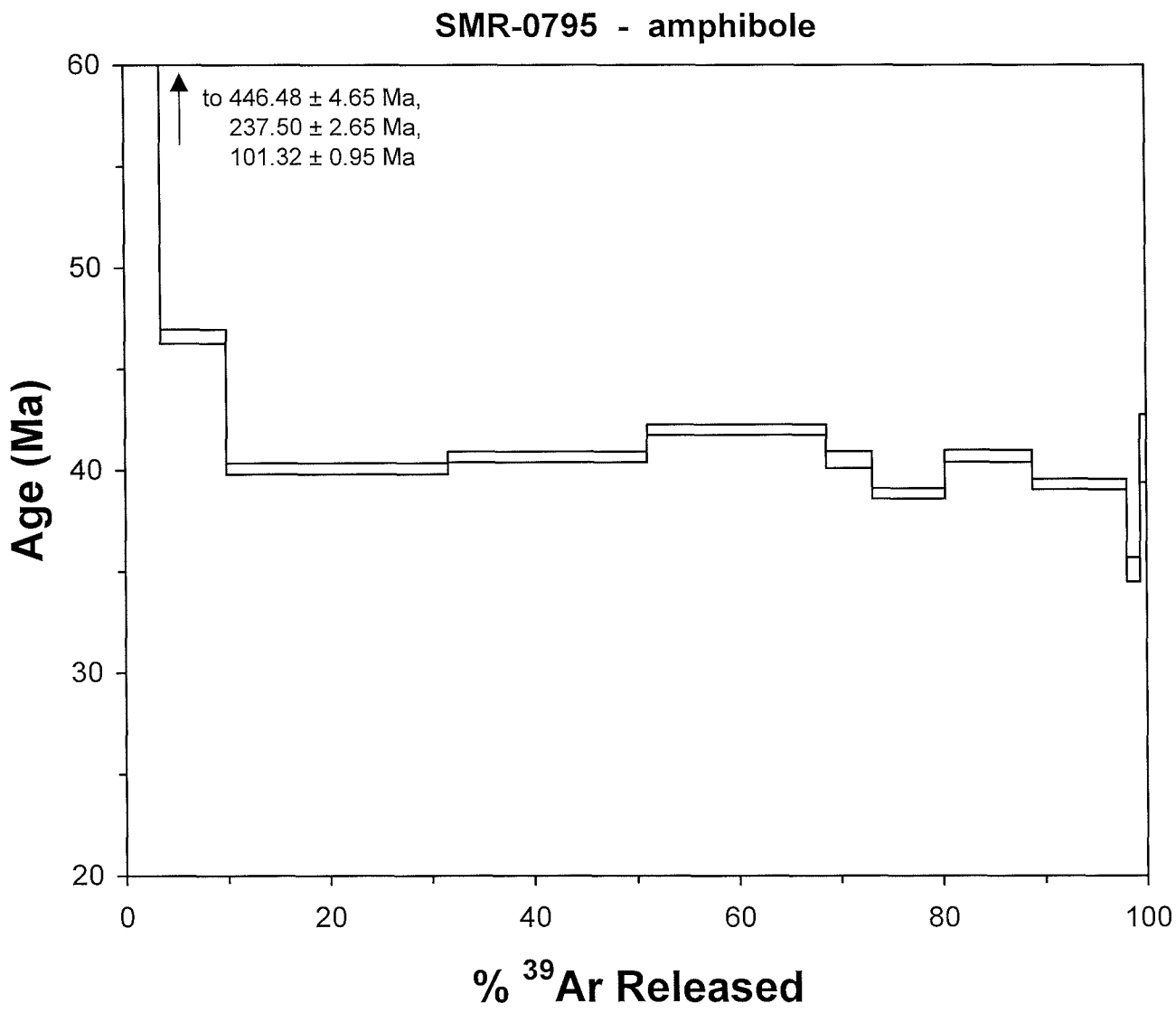
step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	800	12	2.486	2.305	0.479	1.659	1023.0	29.7	1.2	6.908948894	183.8877	446.48	4.65
2	900	12	0.339	1.043	0.095	0.793	167.435	45.3	0.6	6.539588164	92.1429	237.50	2.65
3	1000	12	0.281	11.149	0.087	2.553	172.276	58.3	1.8	21.81279456	37.8307	101.32	0.95
4	1050	12	0.449	42.99	0.22	9.259	276.982	58.5	6.4	23.20116196	17.1425	46.62	0.36
5	1080	12	0.755	143.687	0.576	31.318	646.533	71.5	21.7	22.92418451	14.7096	40.07	0.28
6	1100	12	0.55	122.5	0.477	27.919	546.078	76.8	19.4	21.91673869	14.9290	40.67	0.26
7	1120	12	0.387	106.32	0.433	25.343	480.85	82.1	17.6	20.94937498	15.4259	42.00	0.26
8	1150	12	0.144	27.869	0.121	6.483	132.85	77.2	4.5	21.46975284	14.8759	40.52	0.42
9	1175	12	0.203	45.356	0.178	10.27	196.266	77.5	7.1	22.06087378	14.2551	38.85	0.25
10	1205	12	0.28	52.861	0.205	12.292	254.154	74.2	8.5	21.47808643	14.9409	40.70	0.30
11	1240	12	0.3	57.496	0.241	13.307	267.319	73.6	9.2	21.58010134	14.4235	39.30	0.26
12	1270	12	0.086	8.299	0.045	1.874	47.944	61.6	1.3	22.12190411	12.8631	35.09	0.61
13	1400	12	0.09	4.265	0.021	0.947	35.597	63.2	0.7	22.50010086	15.0797	41.07	1.68
							Cumulative %39Ar rlsd =		100.0		Total gas age =	47.66	0.25
											no plateau		

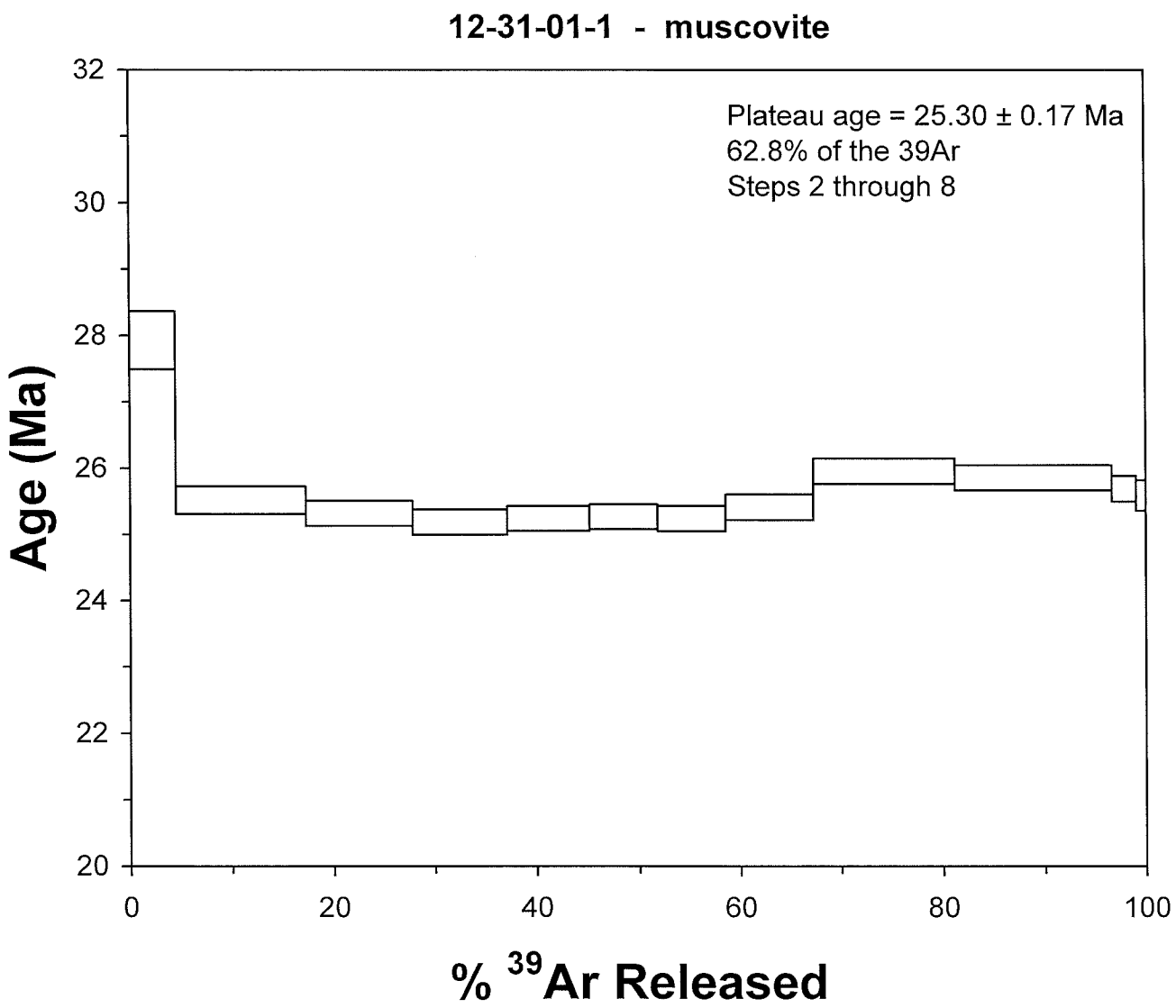
note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

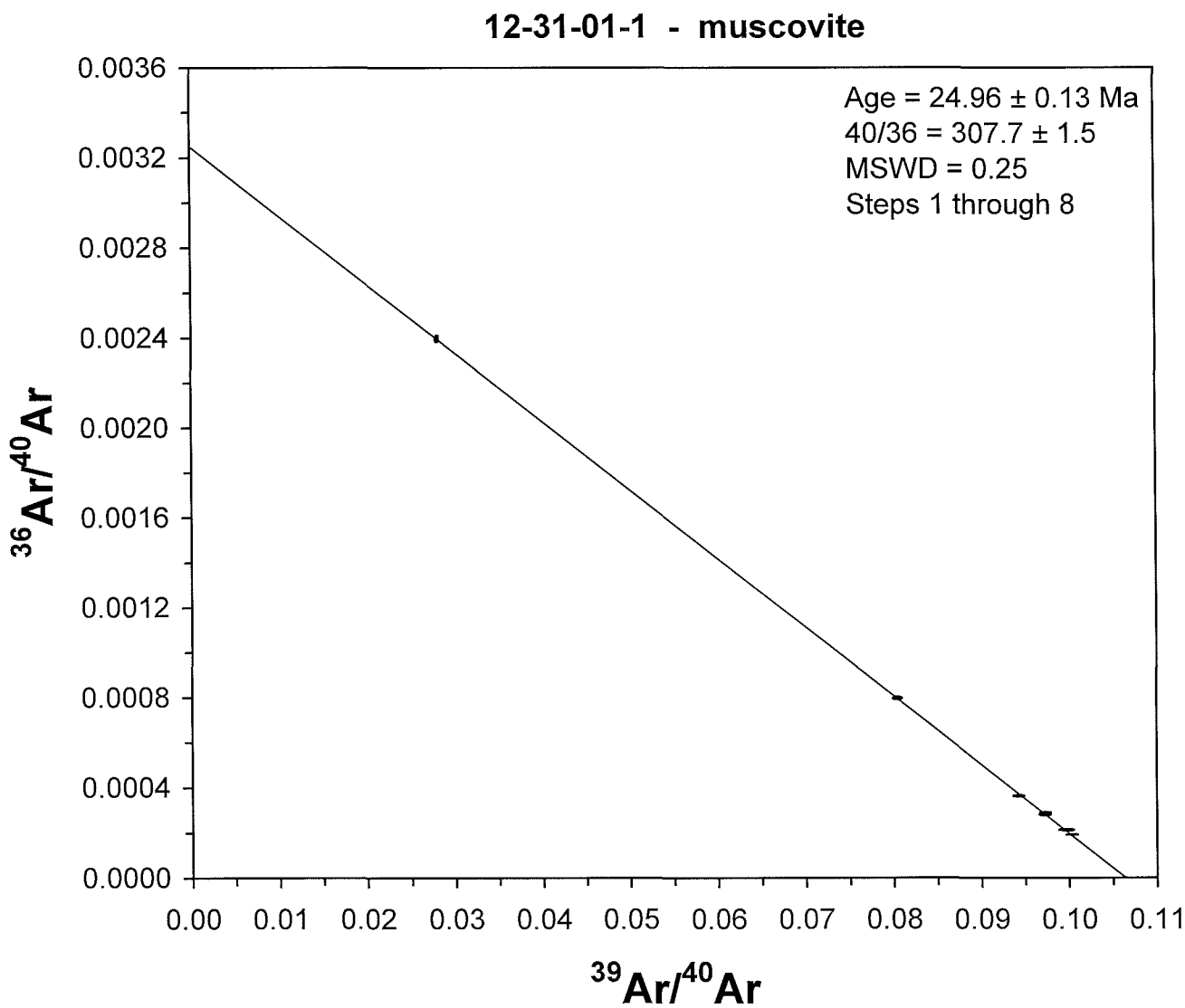
Spencer-AZGS, 12-31-01-1, muscovite, 11.32 mg, J = 0.001484 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	750	12	8.412	0.826	2.830	96.225	3441.36	29.2	4.5	0.054873853	10.5143	27.93	0.44
2	825	12	2.802	0.523	4.101	276.394	3438.87	76.5	12.8	0.012095973	9.5980	25.52	0.21
3	845	12	0.684	0.239	3.022	226.843	2337.33	91.7	10.5	0.00673503	9.5238	25.32	0.19
4	865	12	0.457	0.178	2.711	201.805	2025.32	93.7	9.4	0.005638388	9.4726	25.18	0.19
5	885	12	0.357	0.147	2.335	173.181	1731.54	94.3	8.0	0.005426052	9.4935	25.24	0.19
6	905	12	0.332	0.126	1.884	142.606	1438.37	93.7	6.6	0.005648064	9.5033	25.27	0.19
7	940	12	0.459	0.138	1.924	144.934	1495.6	91.5	6.7	0.006086614	9.4927	25.24	0.19
8	990	12	0.759	0.204	2.57	188.283	2001.93	89.3	8.7	0.006926058	9.5575	25.41	0.19
9	1050	12	0.914	0.222	3.98	299.883	3163.79	91.8	13.9	0.004732252	9.7640	25.95	0.19
10	1120	12	0.31	0.207	4.331	333.854	3301.98	97.5	15.5	0.003963514	9.7253	25.85	0.19
11	1190	12	0.086	0.133	0.639	51.215	513.188	96.8	2.4	0.016600562	9.6617	25.68	0.19
12	1400	12	0.087	0.228	0.286	20.994	229.152	92.4	1.0	0.06942484	9.6238	25.58	0.23
							Cumulative %39Ar rlsd =		100.0		Total gas age =	25.62	0.15
											plateau age =	25.30	0.17
											(steps 2-8)		

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)


SMR-0795 - amphibole
to 446.48 ± 4.65 Ma,
237.50 ± 2.65 Ma,
101.32 ± 0.95 Ma
Age (Ma)
60
50
40
30
20
0
20
40
60
80
100
% 39Ar Released


12-31-01-1 - muscovite
Plateau age = 25.30 ± 0.17 Ma
62.8% of the 39Ar
Steps 2 through 8
Age (Ma)
32
30
28
26
24
22
20
0
20
40
60
80
100
% 39Ar Released

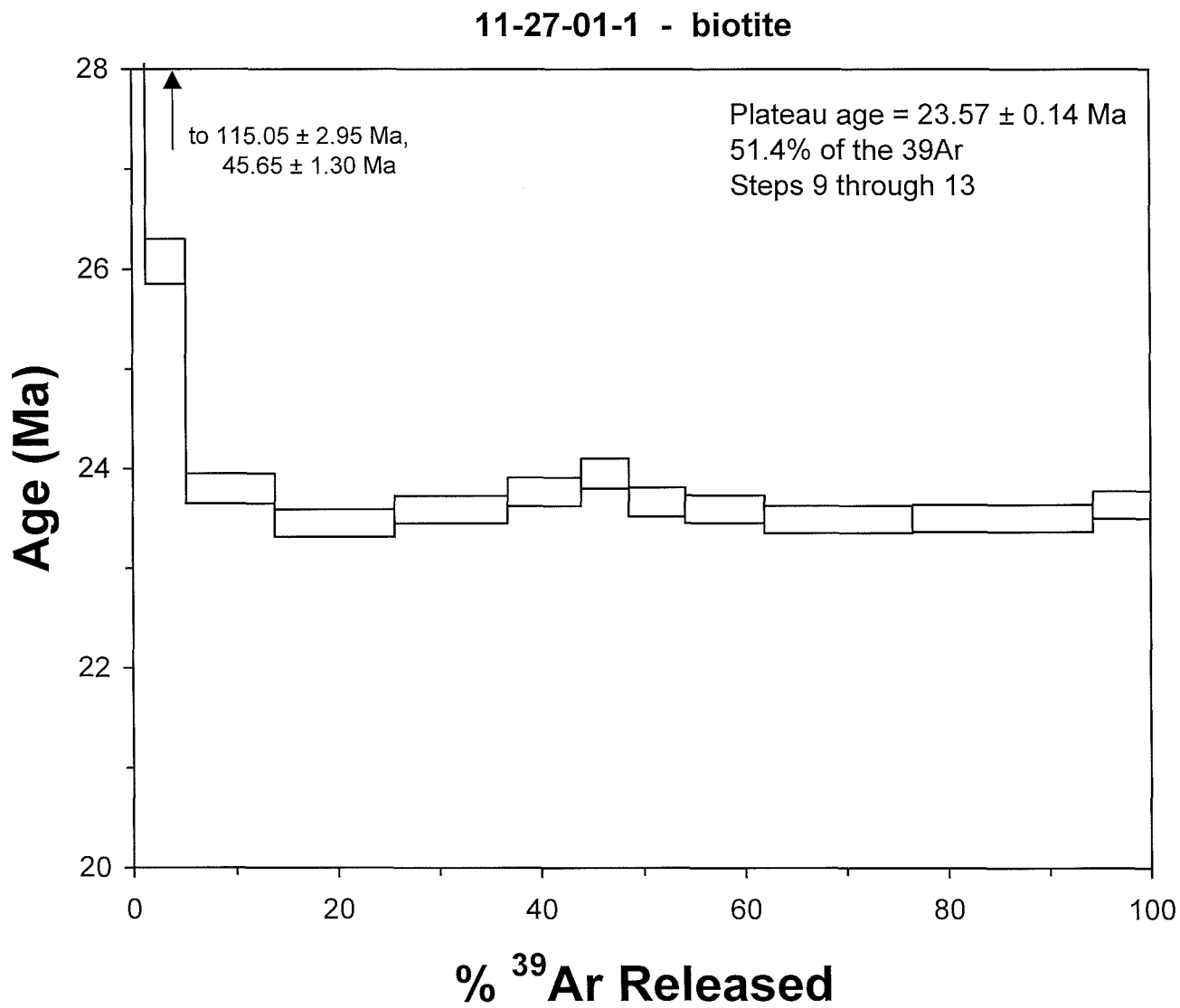

12-31-01-1 - muscovite
Age = 24.96 ± 0.13 Ma
40/36 = 307.7 ± 1.5
MSWD = 0.25
Steps 1 through 8
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
0.11
39Ar/40Ar

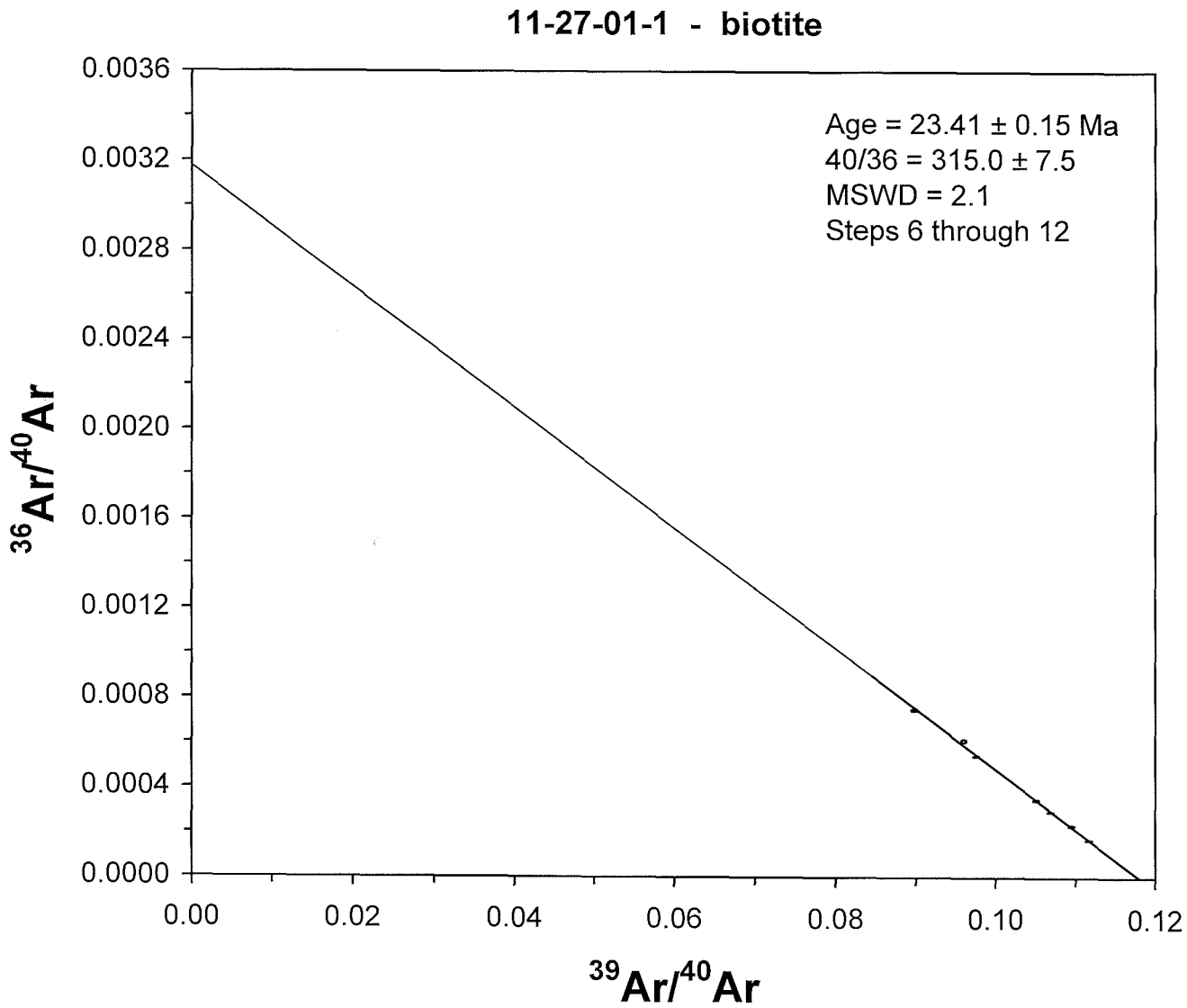
Spencer-AZGS, 11-27-01-1, biotite, 12.64 mg, J = 0.0015410 ± 0.5%

4 amu discrimination = 1.01757 ± 0.20%, 40/39K = ~~0.00~~ 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	8.882	0.390	1.832	6.947	2837.7	10.3	0.3	0.286478401	42.7333	115.05	2.95
2	650	12	9.797	0.206	2.21	24.433	3248.68	12.5	1.0	0.043021267	16.6314	45.65	1.30
3	695	12	6.452	0.198	2.471	93.883	2756.2	32.2	3.9	0.010761351	9.4481	26.08	0.23
4	740	12	2.641	0.183	3.251	209.232	2562.56	70.3	8.6	0.004462834	8.6176	23.80	0.15
5	785	12	1.146	0.205	3.999	286.317	2753.98	88.2	11.8	0.003653376	8.4908	23.45	0.14
6	845	12	0.786	0.209	3.628	270.548	2529.45	91.3	11.2	0.003941755	8.5400	23.59	0.14
7	910	12	1.022	0.283	2.411	174.146	1786.53	84.0	7.2	0.008292036	8.6056	23.77	0.14
8	975	12	0.983	0.592	1.614	111.602	1246.53	77.9	4.6	0.027067018	8.6723	23.95	0.15
9	1025	12	0.908	0.822	1.934	134.603	1404.54	82.0	5.6	0.031160778	8.5684	23.67	0.15
10	1070	12	0.676	0.739	2.58	189.145	1802.56	89.7	7.8	0.01993606	8.5418	23.59	0.14
11	1120	12	0.788	0.768	4.724	353.249	3221.04	93.2	14.6	0.011093507	8.5043	23.49	0.14
12	1180	12	0.689	0.438	5.653	431.267	3854.95	95.0	17.8	0.005182218	8.5083	23.50	0.14
13	1400	12	0.236	0.186	1.846	137.634	1237.85	95.8	5.7	0.006895651	8.5582	23.64	0.14
							Cumulative %39Ar rlsd =		100.0		Total gas age =	24.18	0.13
											plateau age =	23.57	0.14
											(steps 9-13)		

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

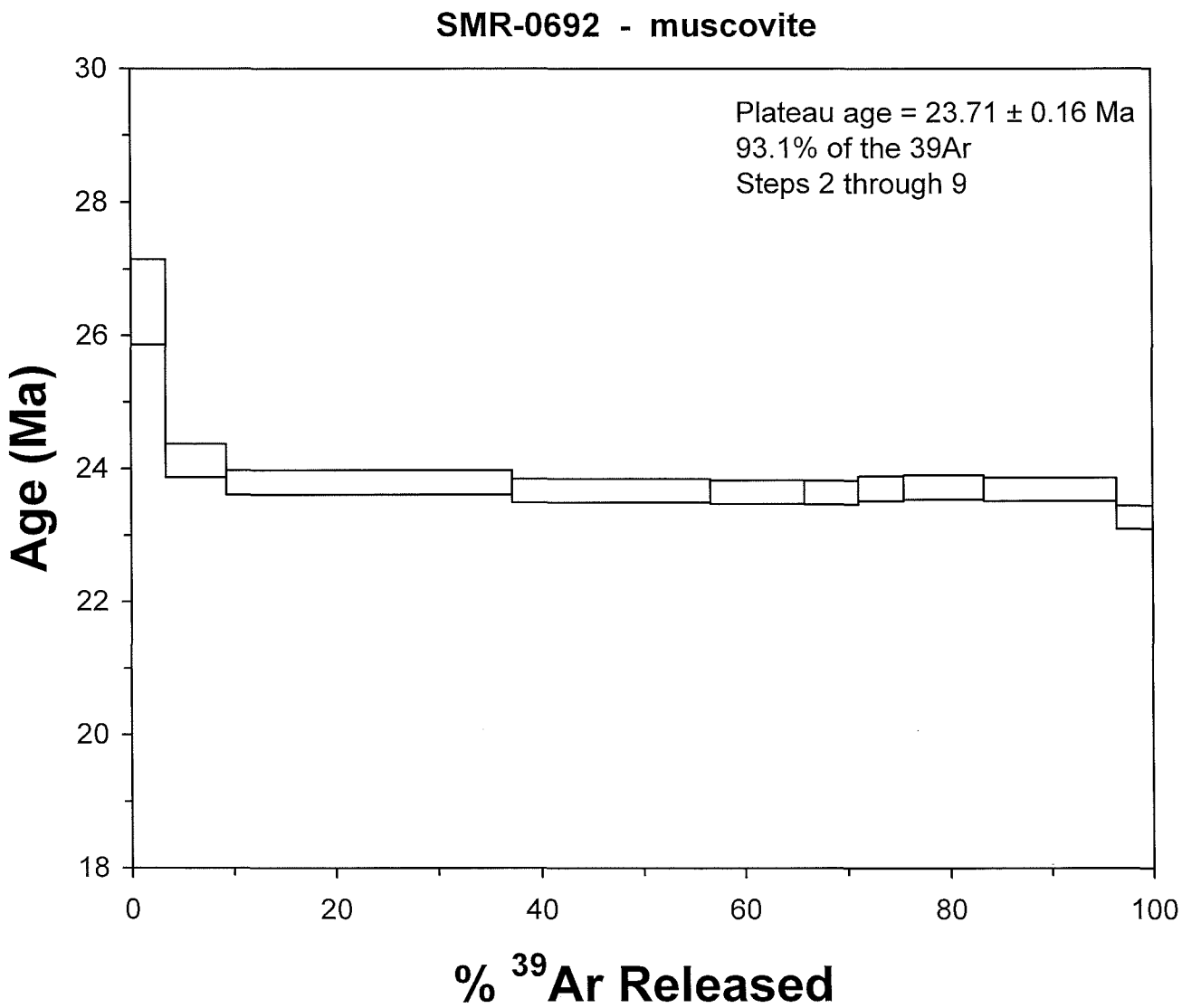

11-27-01-1 - biotite
to 115.05 ± 2.95 Ma,
45.65 ± 1.30 Ma
Plateau age = 23.57 ± 0.14 Ma
51.4% of the 39Ar
Steps 9 through 13
Age (Ma)
28
26
24
22
20
0
20
40
60
80
100
% 39Ar Released

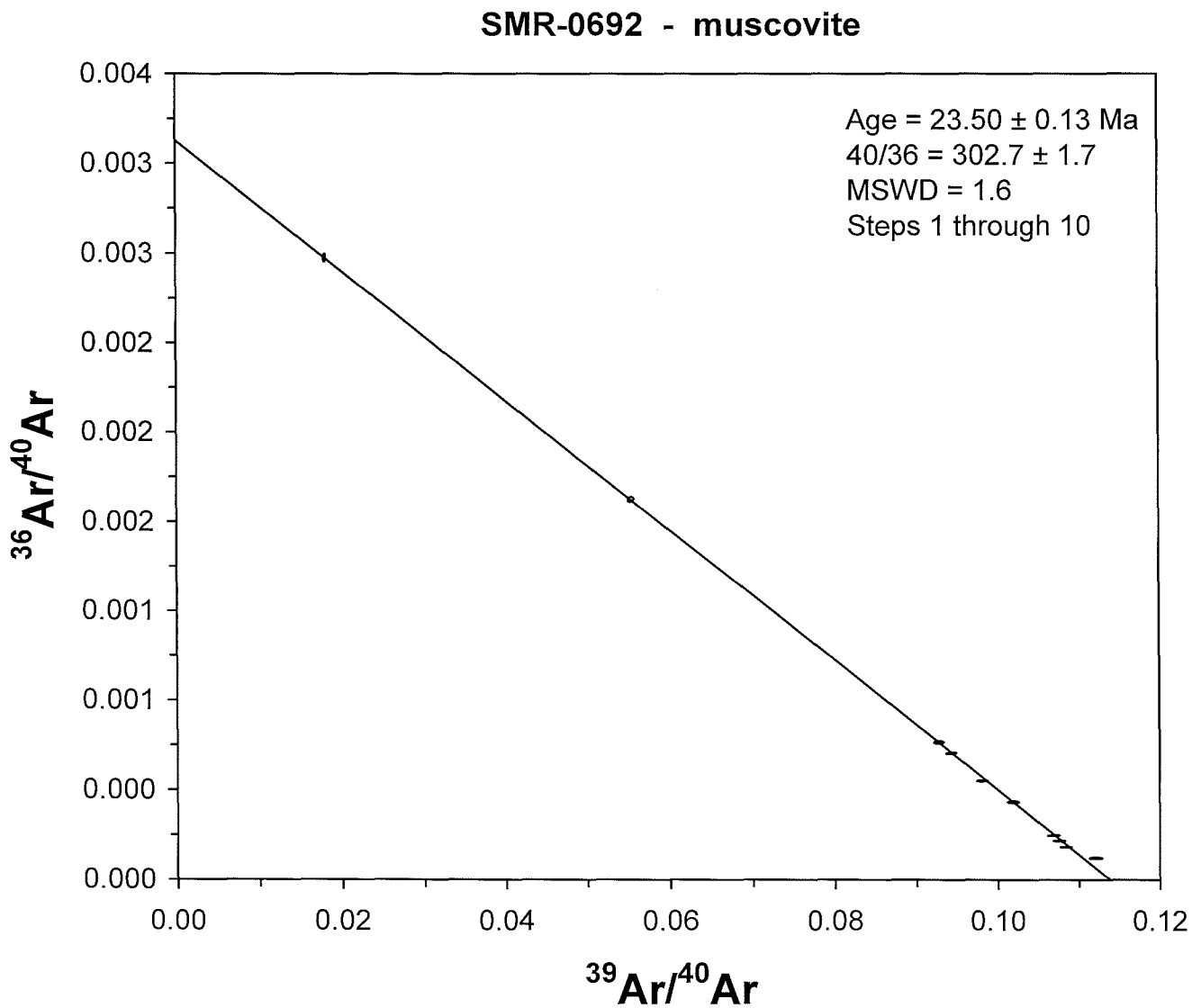

11-27-01-1 - biotite
Age = 23.41 ± 0.15 Ma
40/36 = 315.0 ± 7.5
MSWD = 2.1
Steps 6 through 12
0.0036
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00
0.02
0.04
0.06
0.08
0.10
0.12
39Ar/40Ar

Spencer-AZGS, SMR-0692, muscovite, 7.32 mg, J = 0.001493 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	750	12	6.982	0.064	1.867	44.462	2464.35	17.9	3.4	0.009401527	9.9127	26.50	0.64
2	800	12	2.435	0.057	1.443	77.426	1401.9	49.8	5.9	0.004808336	9.0143	24.12	0.25
3	850	12	1.692	0.068	5.017	365.974	3731.63	87.0	27.9	0.001213571	8.8913	23.79	0.18
4	885	12	0.438	0.06	3.323	254.109	2366.18	94.9	19.4	0.001542189	8.8461	23.67	0.18
5	910	12	0.248	0.035	1.592	120.99	1137.43	94.2	9.2	0.001889405	8.8375	23.65	0.18
6	940	12	0.255	0.032	0.904	67.858	671.711	89.8	5.2	0.003080034	8.8349	23.64	0.18
7	990	12	0.407	0.018	0.782	57.592	626.736	81.9	4.4	0.002041347	8.8567	23.70	0.19
8	1050	12	0.648	0.032	1.445	103.107	1098.81	83.3	7.9	0.002027068	8.8642	23.72	0.18
9	1120	12	0.265	0.022	2.245	171.501	1587.19	95.7	13.1	0.000837842	8.8525	23.69	0.18
10	1400	12	0.071	0.048	0.645	46.524	427.435	97.1	3.6	0.006738625	8.6953	23.27	0.17
							Cumulative %39Ar rlsd =		100.0		Total gas age =	23.82	0.15
											plateau age =	23.71	0.16
											(steps 2-9)		

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

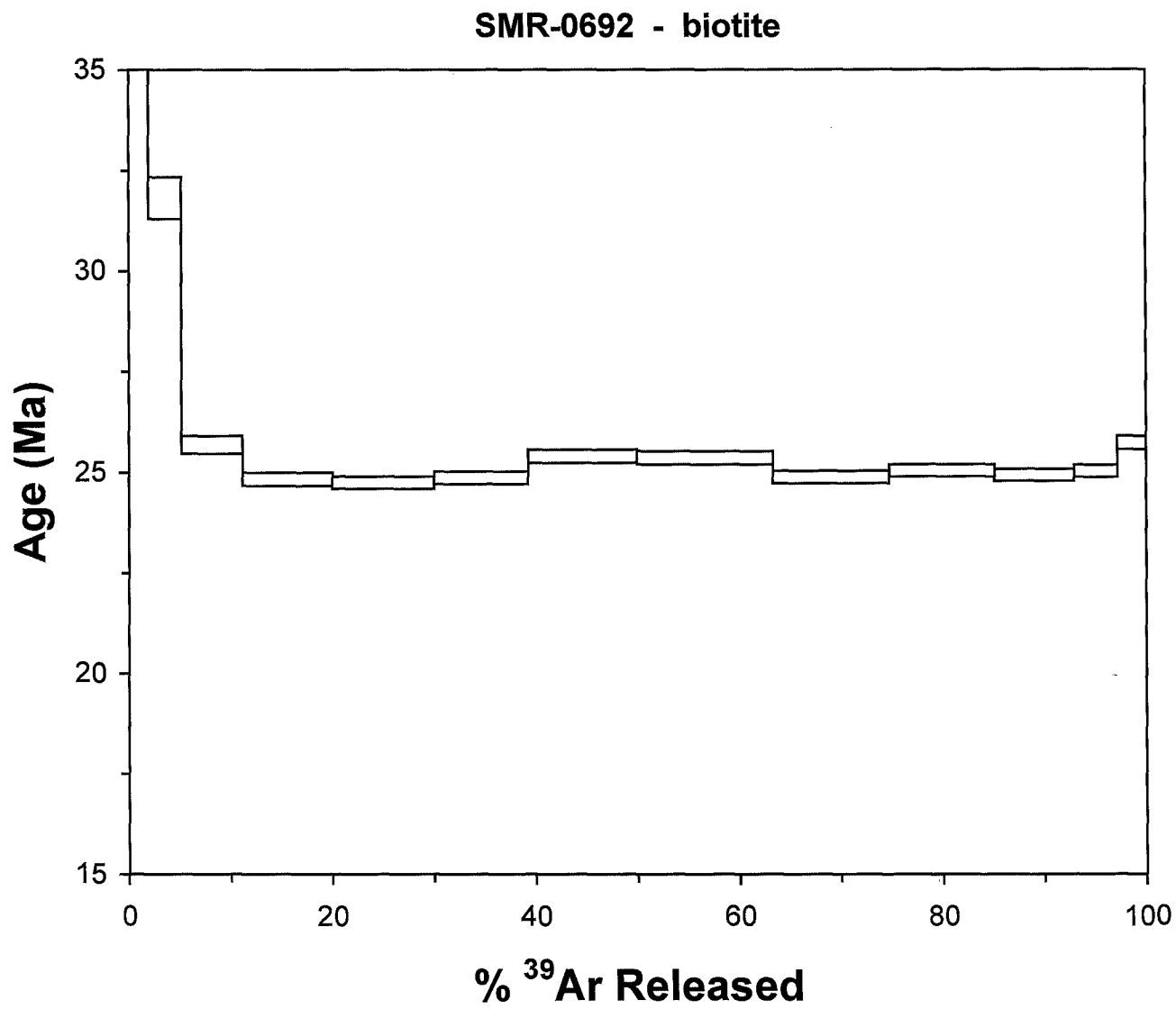

SMR-0692 - muscovite
Plateau age = 23.71 ± 0.16 Ma
93.1% of the 39Ar
Steps 2 through 9
Age (Ma)
30
28
26
24
22
20
18
0
20
40
60
80
100
% 39Ar Released

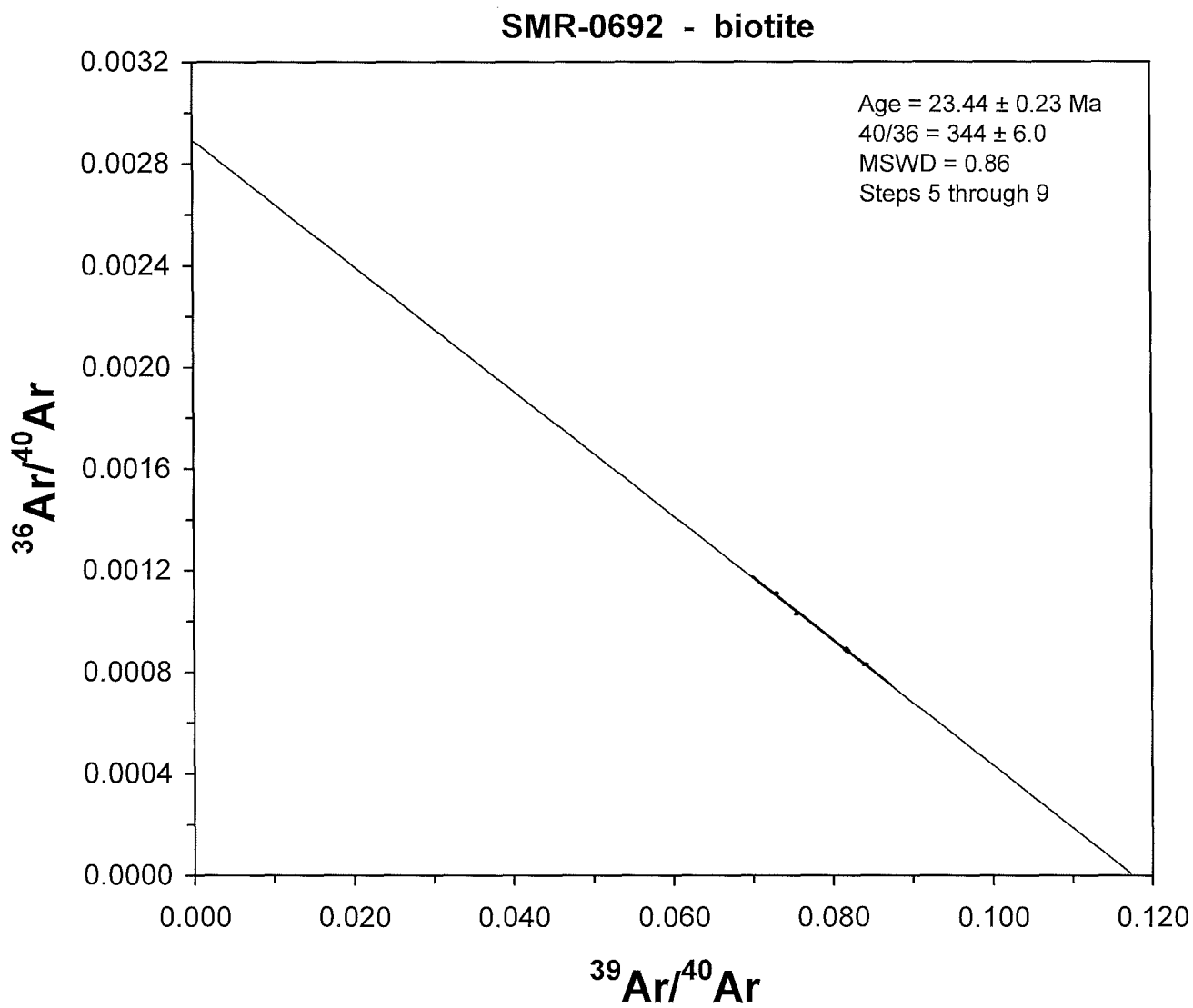

SMR-0692 - muscovite
Age = 23.50 ± 0.13 Ma
40/36 = 302.7 ± 1.7
MSWD = 1.6
Steps 1 through 10
0.004
0.003
0.003
0.002
0.002
0.002
0.001
0.001
0.000
0.000
0.00
0.02
0.04
0.06
0.08
0.10
0.12
36Ar/40Ar
39Ar/40Ar

Spencer-AZGS, SMR-0692, biotite, 7.05 mg, J = 0.001538 ± 0.5%
4 amu discrimination = 1.01757 ± 0.20%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	18.603	1.073	3.968	19.223	6080.7	11.2	1.9	0.261675414	35.5689	96.09	1.90
2	650	12	5.098	0.763	1.422	32.62	1855.84	20.3	3.2	0.109649103	11.5712	31.82	0.52
3	695	12	2.695	1.144	1.333	61.044	1349.14	42.3	6.0	0.087850593	9.3232	25.69	0.22
4	740	12	1.527	1.531	1.444	89.584	1247.06	64.9	8.9	0.080113441	9.0096	24.83	0.17
5	785	12	1.038	1.522	1.531	100.896	1203.58	75.5	10.0	0.07071314	8.9796	24.75	0.15
6	845	12	1.064	1.409	1.44	93.491	1149.05	73.7	9.2	0.070648118	9.0238	24.87	0.16
7	910	12	1.706	1.306	1.722	108.111	1485.05	67.3	10.7	0.056627954	9.2197	25.40	0.16
8	975	12	1.915	1.406	2.133	135.608	1795.88	69.6	13.4	0.048602268	9.2029	25.36	0.16
9	1025	12	1.304	1.23	1.768	115.548	1414.48	73.9	11.4	0.049899866	9.0271	24.88	0.15
10	1070	12	0.912	1.123	1.538	104.529	1207.95	78.9	10.3	0.050361623	9.0874	25.04	0.15
11	1120	12	0.578	1.215	1.161	79.53	884.716	81.9	7.9	0.071615137	9.0465	24.93	0.15
12	1180	12	0.396	1.952	0.645	43.031	504.468	78.6	4.3	0.21265536	9.0830	25.03	0.16
13	1400	12	0.268	1.431	0.435	28.351	337.508	81.4	2.8	0.236620486	9.3400	25.73	0.16
							Cumulative %39Ar rlsd =		100.0		Total gas age =	26.66	0.14
											no plateau		

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

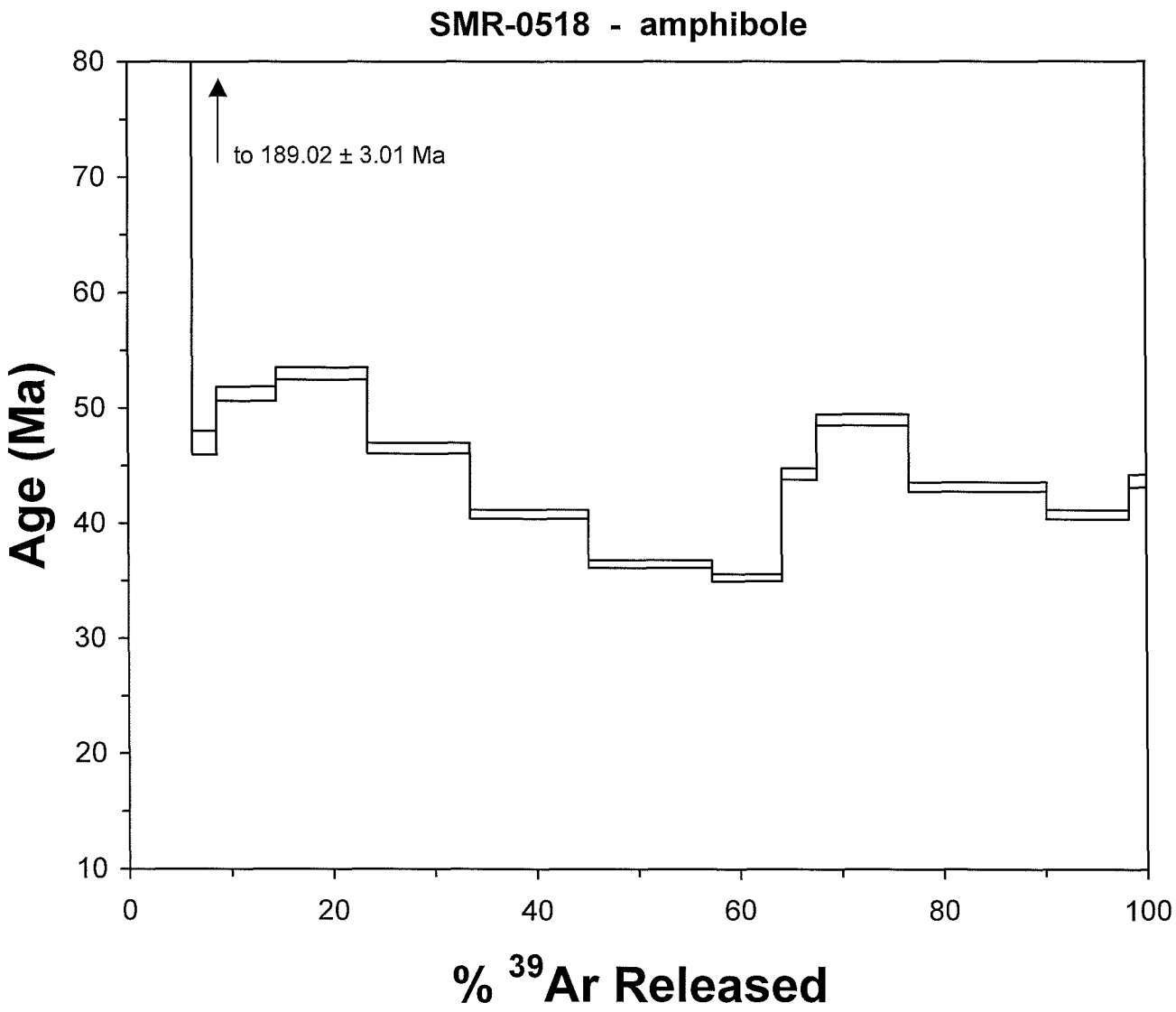

SMR-0692 - biotite
Age (Ma)
35
30
25
20
15
0
20
40
60
80
100
% 39Ar Released


SMR-0692 - biotite
Age = 23.44 ± 0.23 Ma
40/36 = 344 ± 6.0
MSWD = 0.86
Steps 5 through 9
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.000
0.020
0.040
0.060
0.080
0.100
0.120
39Ar/40Ar

Spencer-AZGS, SMR-0518, amphibole, 13.38 mg, J = 0.0015135 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	800	12	9.214	3.010	1.992	13.759	3671.01	27.3	6.3	1.245911285	72.9823	189.02	3.01
2	900	12	1.198	1.799	0.289	5.149	437.082	20.7	2.3	1.990274449	17.4326	46.98	1.02
3	1000	12	1.133	26.379	0.408	12.927	567.916	43.5	5.9	11.65804574	19.0264	51.22	0.61
4	1040	12	1.185	58.004	0.515	19.792	718.641	54.2	9.0	16.768657	19.7000	53.00	0.54
5	1060	12	0.982	59.83	0.521	22.11	651.11	58.6	10.1	15.47719909	17.2488	46.49	0.45
6	1080	12	0.952	66.504	0.542	25.581	646.06	59.9	11.6	14.86664441	15.1030	40.77	0.39
7	1100	12	0.787	67.476	0.555	26.661	571.368	63.1	12.1	14.47118716	13.4810	36.44	0.34
8	1120	12	0.387	37.799	0.297	15.131	298.461	67.1	6.9	14.28300094	13.0342	35.24	0.31
9	1150	12	0.418	20.865	0.193	7.618	239.251	53.3	3.5	15.66621596	16.4083	44.26	0.48
10	1180	12	1.029	56.213	0.537	19.819	642.132	56.2	9.0	16.22611366	18.1746	48.96	0.49
11	1220	12	1.147	81.028	0.662	29.788	785.987	60.5	13.5	15.55845434	15.9768	43.11	0.42
12	1260	12	0.683	52.408	0.36	17.825	451.954	59.8	8.1	16.82306567	15.0771	40.71	0.39
13	1400	12	0.246	25.548	0.096	3.716	129.099	50.6	1.7	39.60681173	16.1767	43.64	0.56
							Cumulative %39Ar rlsd =		100.0		Total gas age =	52.80	0.30
											no plateau		

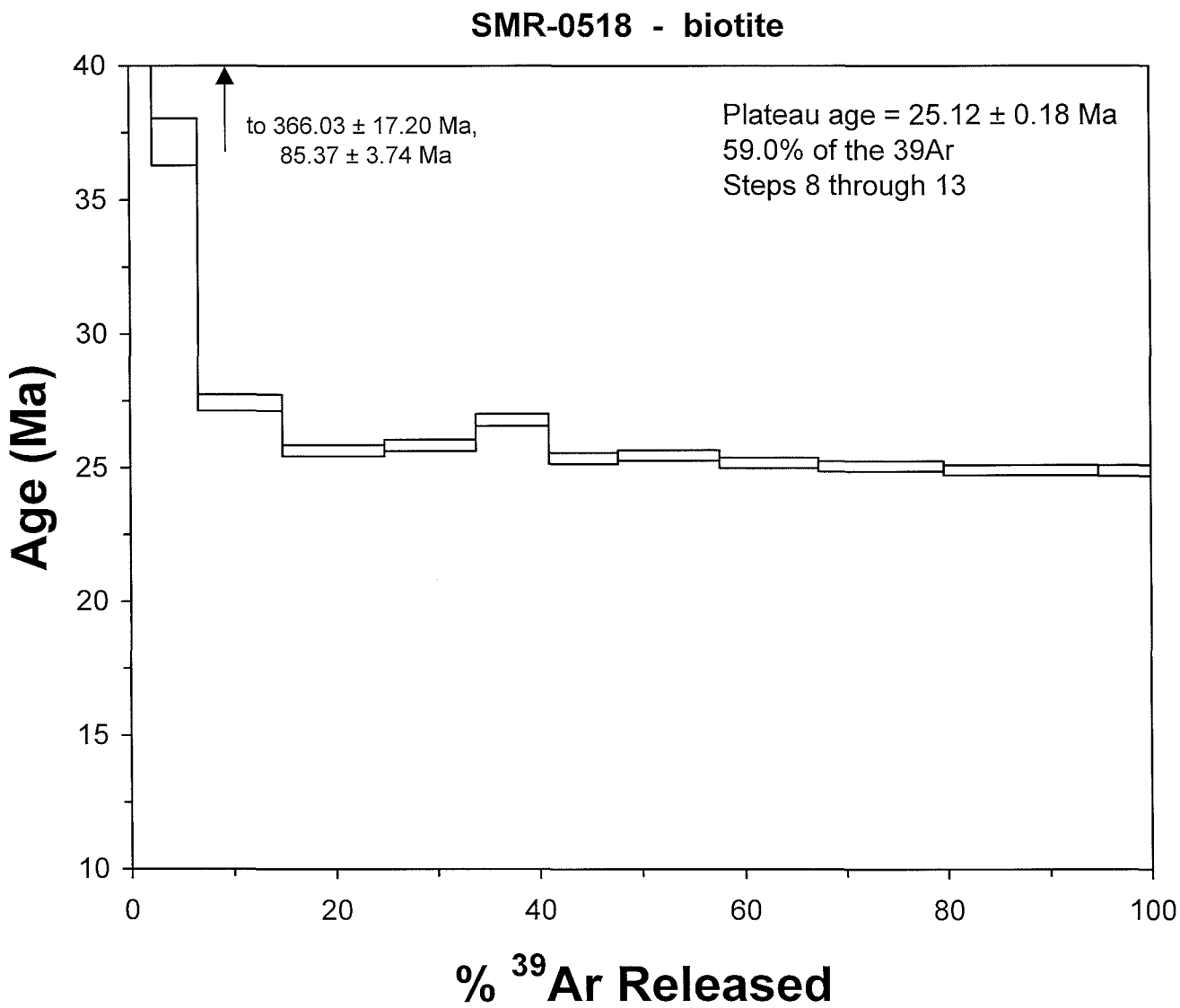
note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

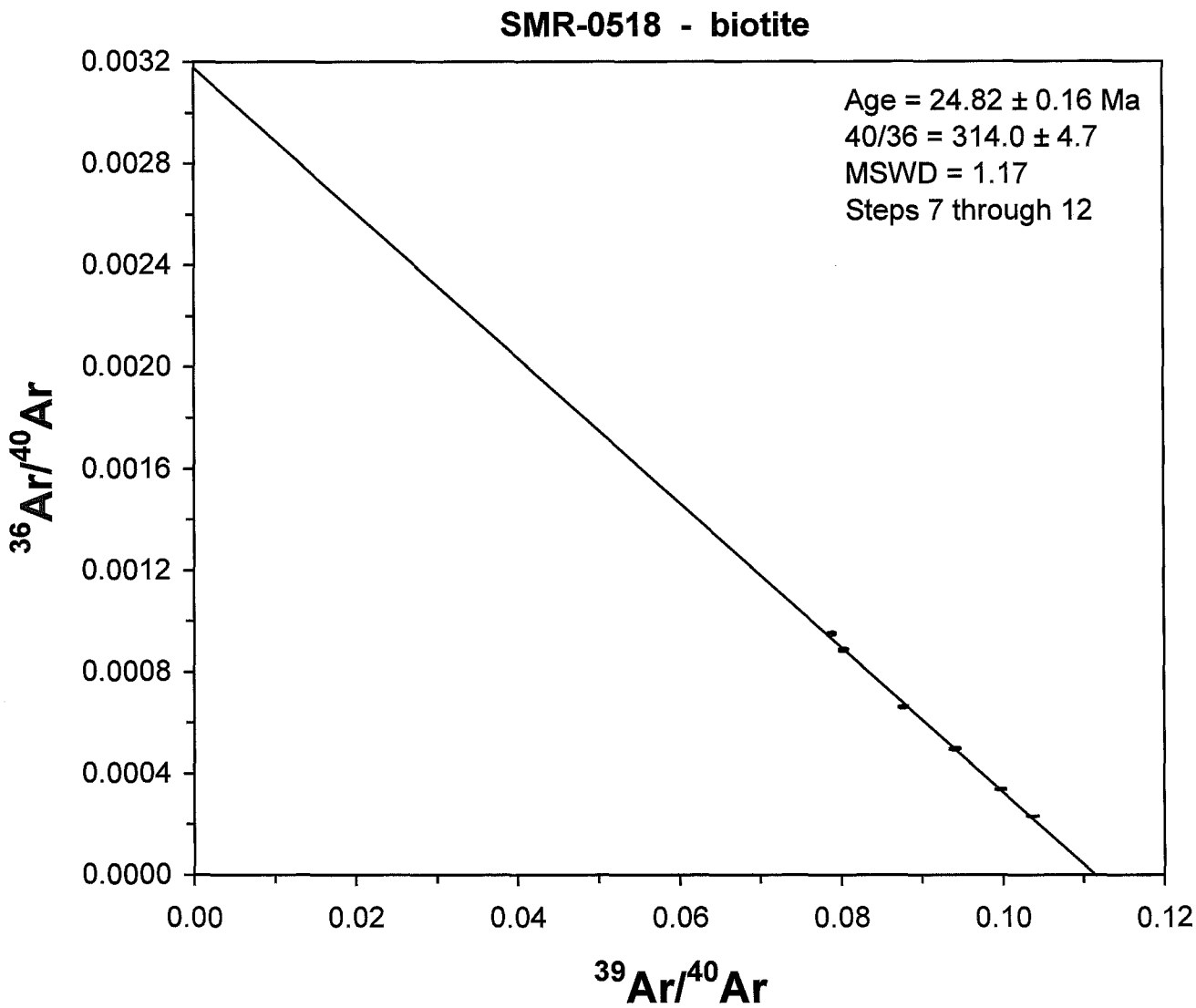

SMR-0518 - amphibole
to 189.02 ± 3.01 Ma
Age (Ma)
80
70
60
50
40
30
20
10
0
20
40
60
80
100
% 39Ar Released

Spencer-AZGS, SMR-0518, biotite, 10.77 mg, J = 0.001544 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	63.701	0.275	12.368	11.565	20149.6	8.3	0.6	0.136245241	145.6841	366.03	17.20
2	650	12	32.118	0.27	6.728	31.788	10308.1	9.6	1.6	0.048665748	31.3851	85.37	3.74
3	695	12	17.27	0.311	4.504	86.996	6176.39	18.9	4.4	0.020482373	13.4789	37.16	0.87
4	740	12	6.513	0.418	3.41	162.345	3493.74	46.0	8.2	0.014752165	9.9249	27.44	0.31
5	785	12	2.193	0.414	2.996	198.029	2464.6	74.4	10.0	0.011978146	9.2705	25.64	0.21
6	845	12	1.647	0.42	2.572	177.058	2069.73	77.1	9.0	0.013591018	9.3434	25.84	0.21
7	910	12	1.608	0.433	2.197	141.309	1765.33	73.1	7.2	0.017556456	9.6898	26.79	0.22
8	975	12	1.654	0.689	2.042	133.233	1695.76	72.0	6.7	0.029629735	9.1620	25.34	0.21
9	1025	12	1.514	1.217	2.831	194.577	2222.9	80.5	9.9	0.035836059	9.2046	25.46	0.20
10	1070	12	1.051	2.13	2.689	191.232	2038.36	85.3	9.7	0.063818098	9.1027	25.18	0.20
11	1120	12	0.873	2.94	3.37	244.175	2452.88	90.0	12.4	0.068987694	9.0561	25.05	0.19
12	1170	12	0.713	4.205	4.105	299.16	2890.66	93.0	15.2	0.080535893	9.0019	24.90	0.19
13	1400	12	0.373	7.542	1.442	102.489	1028.54	90.4	5.2	0.421677903	8.9960	24.89	0.20
							Cumulative %39Ar rlsd =		100.0		Total gas age =	29.05	0.16
											plateau age =	25.12	0.18
											(steps 8-13)		

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

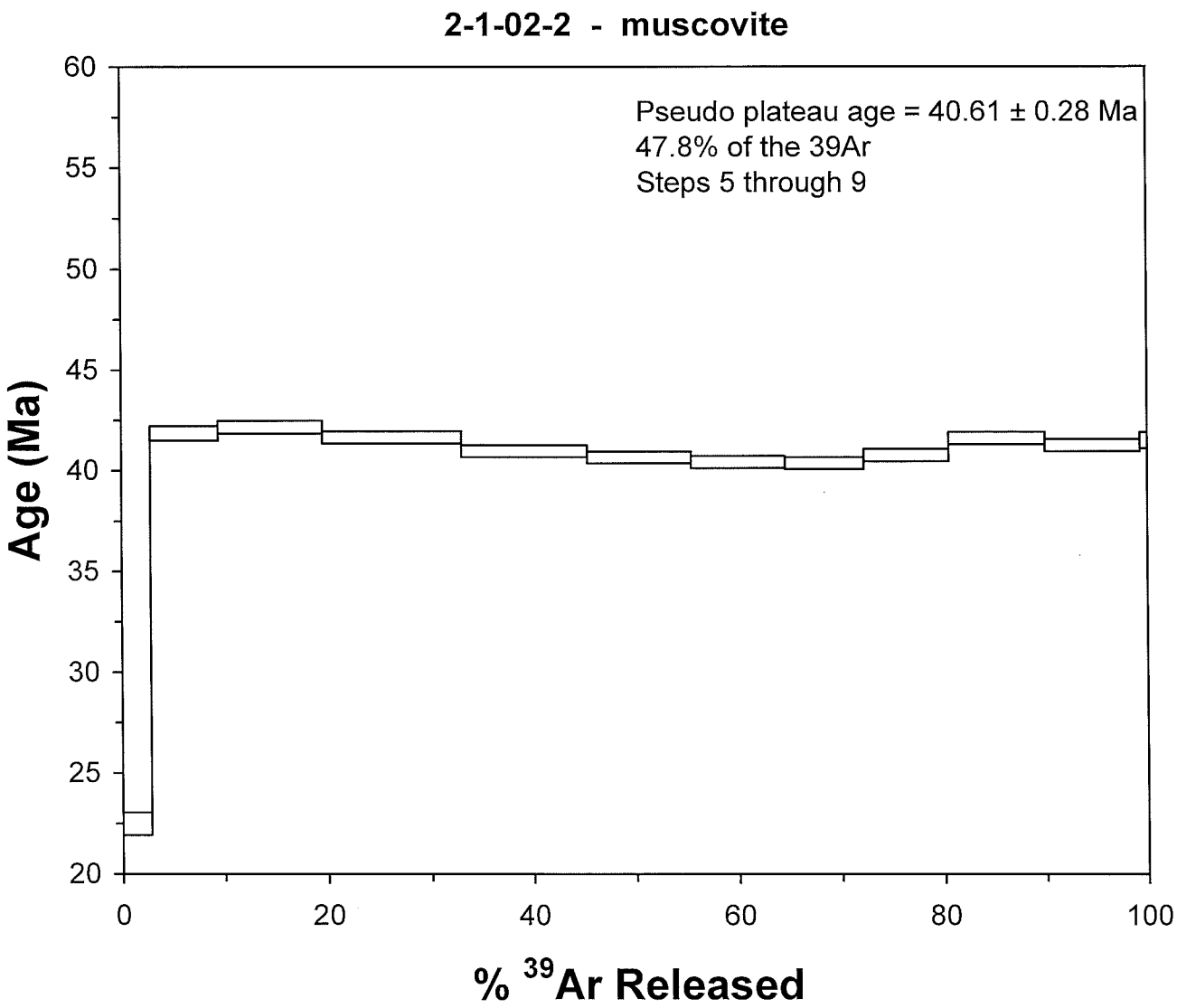

SMR-0518 - biotite
to 366.03 ± 17.20 Ma,
85.37 ± 3.74 Ma
Plateau age = 25.12 ± 0.18 Ma
59.0% of the 39Ar
Steps 8 through 13
Age (Ma)
40
35
30
25
20
15
10
0
20
40
60
80
100
% 39Ar Released


SMR-0518 - biotite
Age = 24.82 ± 0.16 Ma
40/36 = 314.0 ± 4.7
MSWD = 1.17
Steps 7 through 12
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.00
0.02
0.04
0.06
0.08
0.10
0.12
39Ar/40Ar

Spencer-AZGS, 2-1-02-2, muscovite, 6.05 mg, J = 0.001503 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	750	12	2.972	0.030	0.882	35.487	1157.46	25.6	2.8	0.00473287	8.3431	22.48	0.56
2	825	12	2.408	0.017	1.516	84.923	2019.41	65.6	6.7	0.001120716	15.2302	41.85	0.37
3	845	12	0.862	0.011	1.791	128.285	2260.14	89.2	10.1	0.000480053	15.3436	42.16	0.32
4	865	12	0.534	0.03	2.322	171.569	2809.75	94.7	13.5	0.000978937	15.1536	41.64	0.31
5	885	12	0.319	0.023	2.106	156.87	2479.29	96.5	12.3	0.000820843	14.8993	40.95	0.30
6	905	12	0.233	0.018	1.72	128.658	2010.12	96.9	10.1	0.000783263	14.7842	40.64	0.30
7	935	12	0.245	0.023	1.527	116.013	1812.5	96.4	9.1	0.001109924	14.6977	40.41	0.30
8	975	12	0.298	0.027	1.318	97.606	1549.45	94.8	7.7	0.001548672	14.6753	40.34	0.30
9	1040	12	0.492	0.028	1.407	105.234	1735.65	92.1	8.3	0.001489615	14.8210	40.74	0.31
10	1100	12	0.411	0.027	1.649	120.292	1978.31	94.2	9.4	0.001256606	15.1330	41.59	0.31
11	1170	12	0.167	0.032	1.578	119.109	1870.82	97.9	9.4	0.001504103	14.9998	41.23	0.30
12	1400	12	0.111	0.031	0.14	8.955	174.029	85.4	0.7	0.019380753	15.0907	41.47	0.40
							Cumulative %39Ar rlsd =		100.0		Total gas age =	40.66	0.25
											pseudo plateau age =	40.61	0.28
											(steps 5-9)		

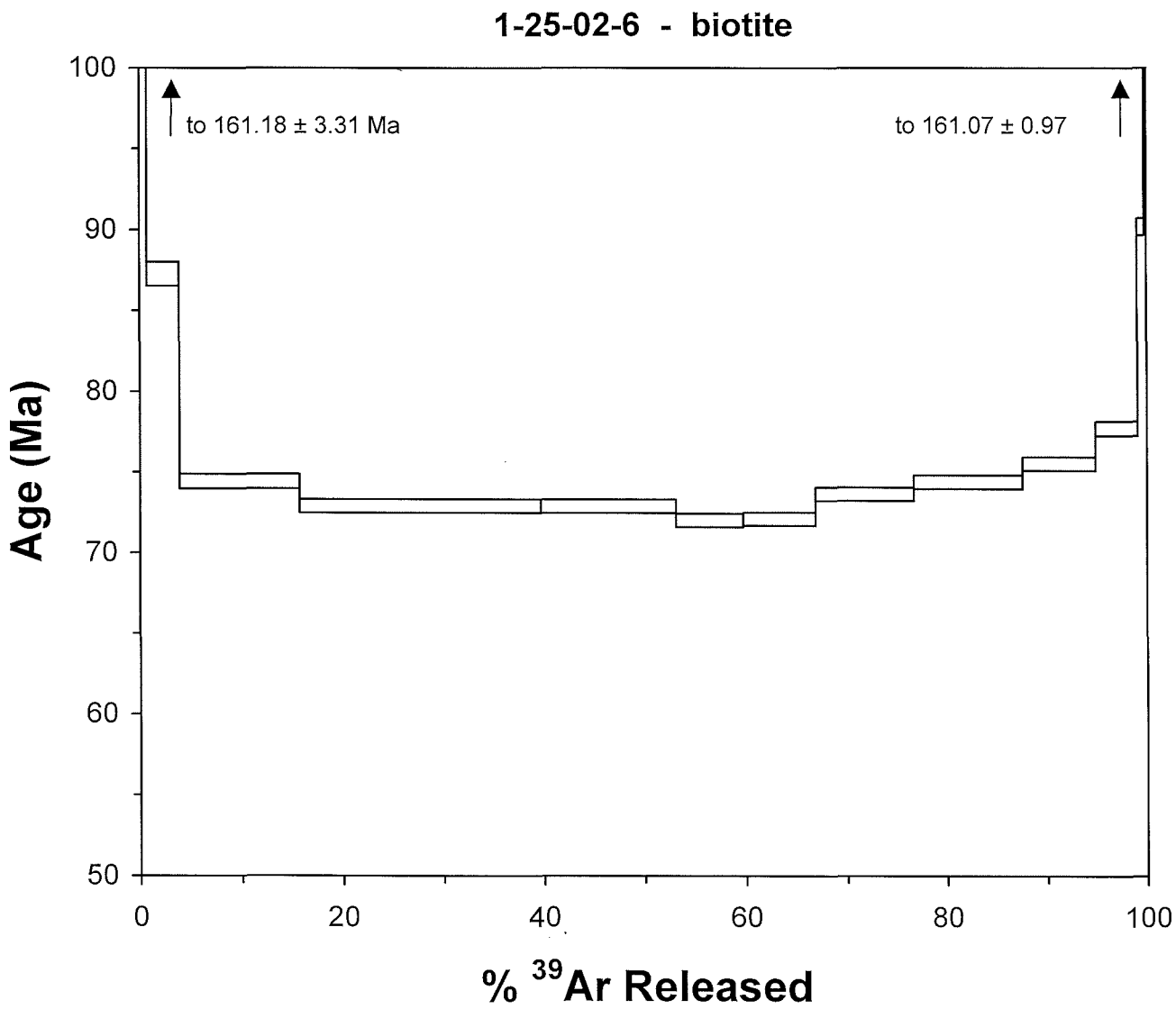
note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

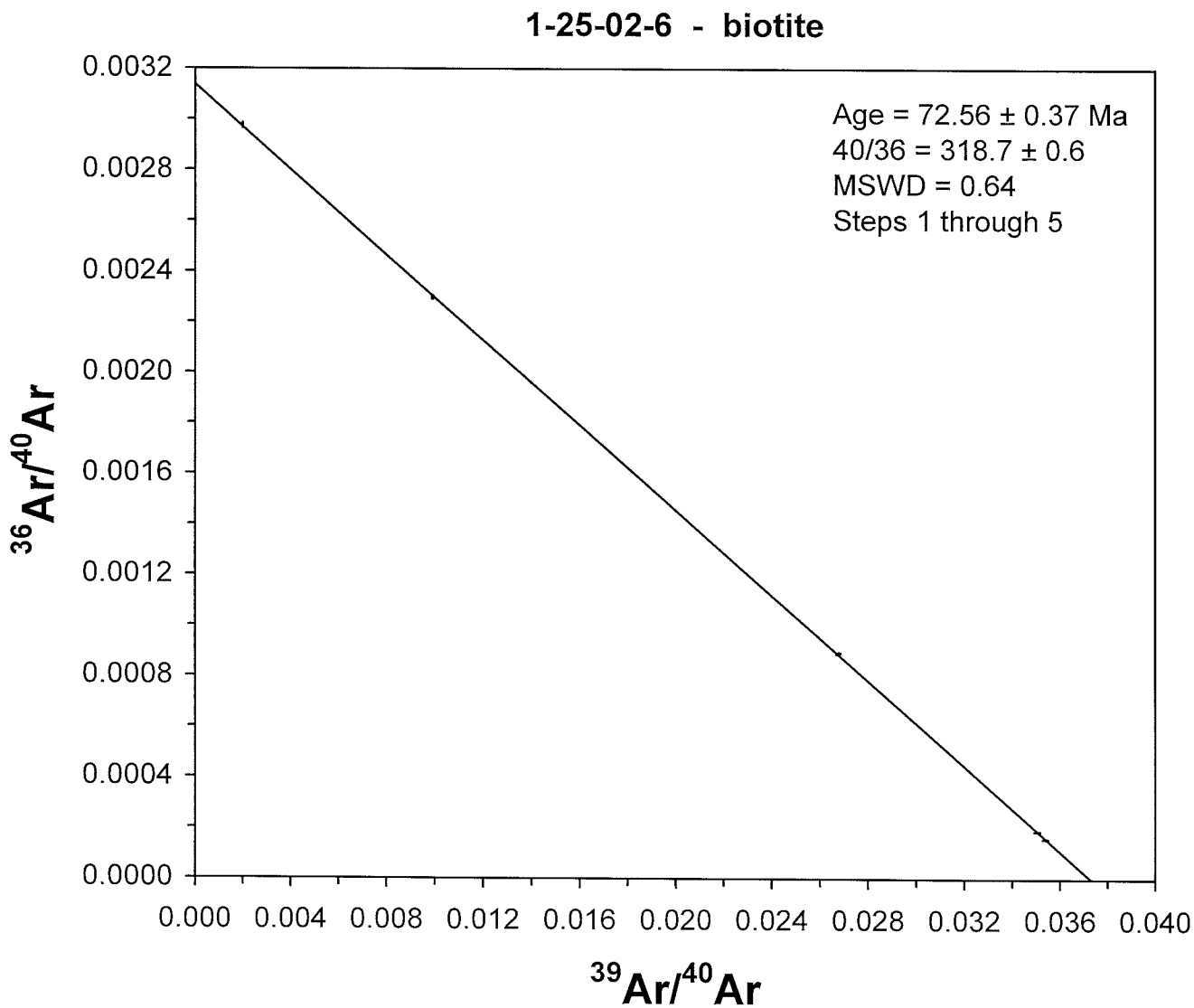

2-1-02-2 - muscovite
Pseudo plateau age = 40.61 ± 0.28 Ma
47.8% of the 39Ar
Steps 5 through 9
Age (Ma)
60
55
50
45
40
35
30
25
20
0
20
40
60
80
100
% 39Ar Released

Spencer-AZGS, 1-25-02-6, biotite, 12.35 mg, J = 0.001531 ± 0.5%
4 amu discrimination = 1.01757 ± 0.20%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	25.73	0.207	5.280	16.983	8500.9	12.2	0.7	0.060846542	61.0404	161.18	3.31
2	650	12	17.51	0.235	4.274	74.514	7485.36	32.1	3.2	0.0157436	32.3771	87.28	0.75
3	710	12	9.434	0.525	5.538	278.939	10380.6	73.7	11.8	0.009395574	27.5099	74.43	0.45
4	780	12	3.124	0.758	7.853	565.092	16064.3	94.4	24.0	0.006696116	26.9337	72.90	0.42
5	850	12	1.473	0.708	4.343	316.011	8901.31	95.3	13.4	0.01118419	26.9250	72.88	0.42
6	915	12	1.215	0.76	2.215	156.371	4491.89	92.4	6.6	0.024262333	26.5982	72.01	0.42
7	975	12	1.36	1.247	2.40	167.701	4838.70	92.1	7.1	0.037119974	26.6265	72.08	0.42
8	1025	12	1.067	0.656	3.204	230.892	6562.98	95.5	9.8	0.014183024	27.2070	73.62	0.42
9	1075	12	0.929	0.706	3.439	257.461	7315.24	96.5	10.9	0.013688853	27.4895	74.37	0.43
10	1120	12	0.621	1.362	2.327	170.95	4923.61	96.5	7.3	0.039772713	27.9130	75.50	0.43
11	1170	12	0.378	6.216	1.357	100.215	2977.25	96.6	4.3	0.30966402	28.7407	77.69	0.44
12	1225	12	0.127	5.774	0.255	16.196	576.007	95.2	0.7	1.780629648	33.4822	90.19	0.53
13	1400	12	0.101	1.227	0.084	5.296	345.448	96.5	0.2	1.156963695	60.9980	161.07	0.97
							Cumulative %39Ar rlsd =		100.0		Total gas age =	74.99	0.40
											no plateau		

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)


1-25-02-6 - biotite
to 161.18 ± 3.31 Ma
to 161.07 ± 0.97
Age (Ma)
100
90
80
70
60
50
0
20
40
60
80
100
% 39Ar Released

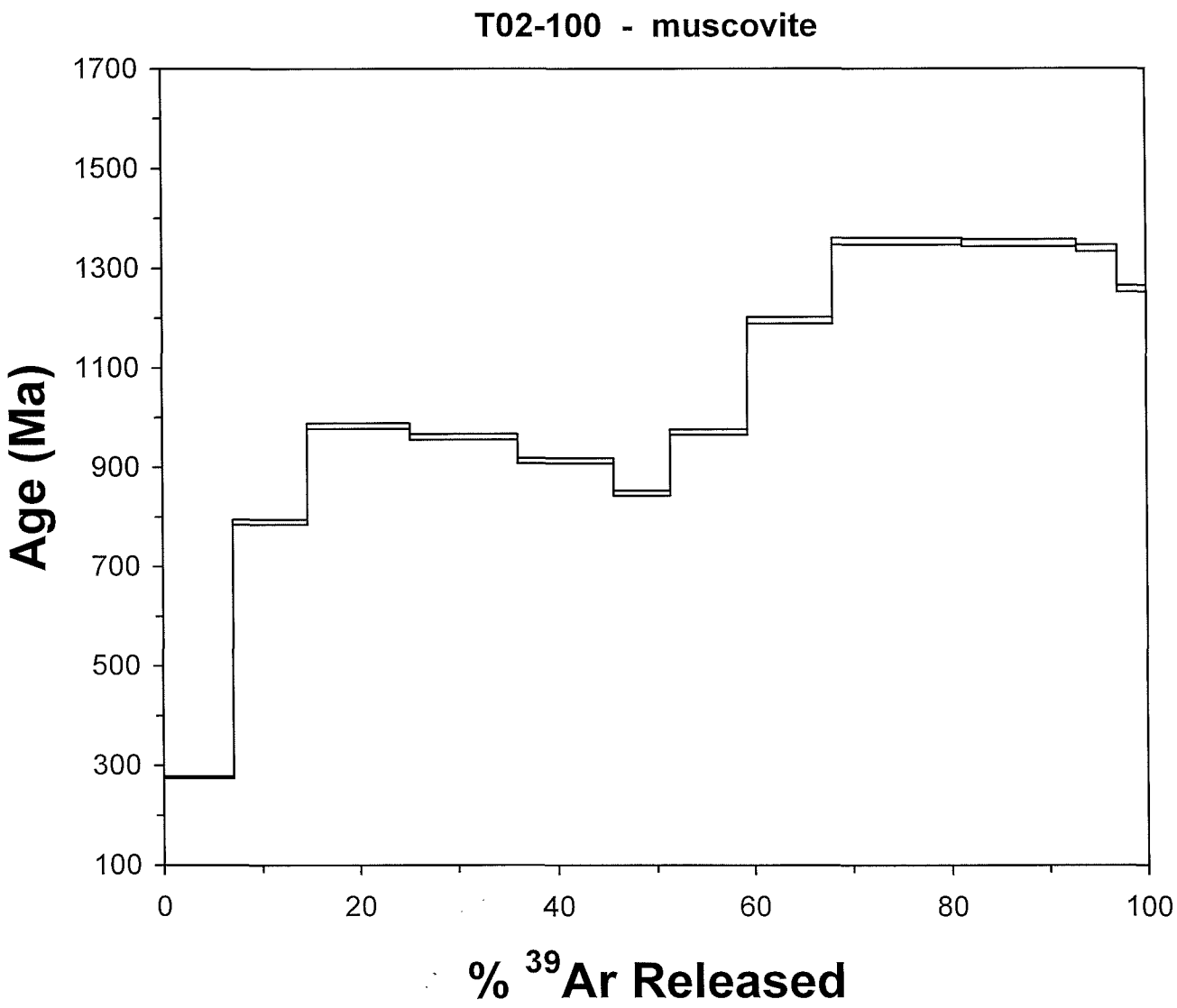

1-25-02-6 - biotite
Age = 72.56 ± 0.37 Ma
40/36 = 318.7 ± 0.6
MSWD = 0.64
Steps 1 through 5
0.0032
0.0028
0.0024
0.0020
0.0016
0.0012
0.0008
0.0004
0.0000
36Ar/40Ar
0.000
0.004
0.008
0.012
0.016
0.020
0.024
0.028
0.032
0.036
0.040
39Ar/40Ar

Spencer-AZGS, T02-100, muscovite, 7.94 mg, J = 0.001477 ± 0.5%
4 amu discrimination = 1.01920 ± 0.42%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	750	12	1.843	0.211	0.802	35.414	4490.35	88.2	7.1	0.03817539	112.1898	276.61	1.96
2	825	12	0.61	0.214	0.622	38.209	14325.1	98.8	7.6	0.035885898	371.9410	789.90	4.84
3	845	12	0.363	0.082	0.795	52.699	25832.4	99.6	10.5	0.009969739	490.3461	982.84	5.78
4	865	12	0.305	0.144	0.791	54.302	25274.2	99.7	10.8	0.016991038	476.1807	960.81	5.51
5	885	12	0.177	0.099	0.639	48.20	21441.9	99.8	9.6	0.013160152	445.7533	912.57	5.38
6	905	12	0.148	0.132	0.383	28.828	11699.4	99.7	5.8	0.029338255	406.1815	847.84	4.97
7	950	12	0.165	0.082	0.494	39.61	19064.9	99.8	7.9	0.013264222	482.2521	970.29	5.59
8	1000	12	0.202	0.346	0.474	43.515	27620.8	99.8	8.7	0.050946551	636.2262	1195.27	6.46
9	1080	12	0.119	0.131	0.896	65.914	49698.6	99.9	13.2	0.012734043	756.7745	1353.70	6.97
10	1160	12	0.035	0.191	0.71	58.255	43738.8	100.0	11.6	0.021007479	753.9773	1350.18	7.06
11	1240	12	0.037	0.161	0.243	20.654	15335.4	100.0	4.1	0.049945832	745.5631	1339.54	7.03
12	1400	12	0.062	0.185	0.173	14.904	10144.7	99.9	3.0	0.079533538	683.0019	1258.41	6.64
							Cumulative %39Ar rlsd =		100.0		Total gas age =	1033.21	5.02

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

no plateau

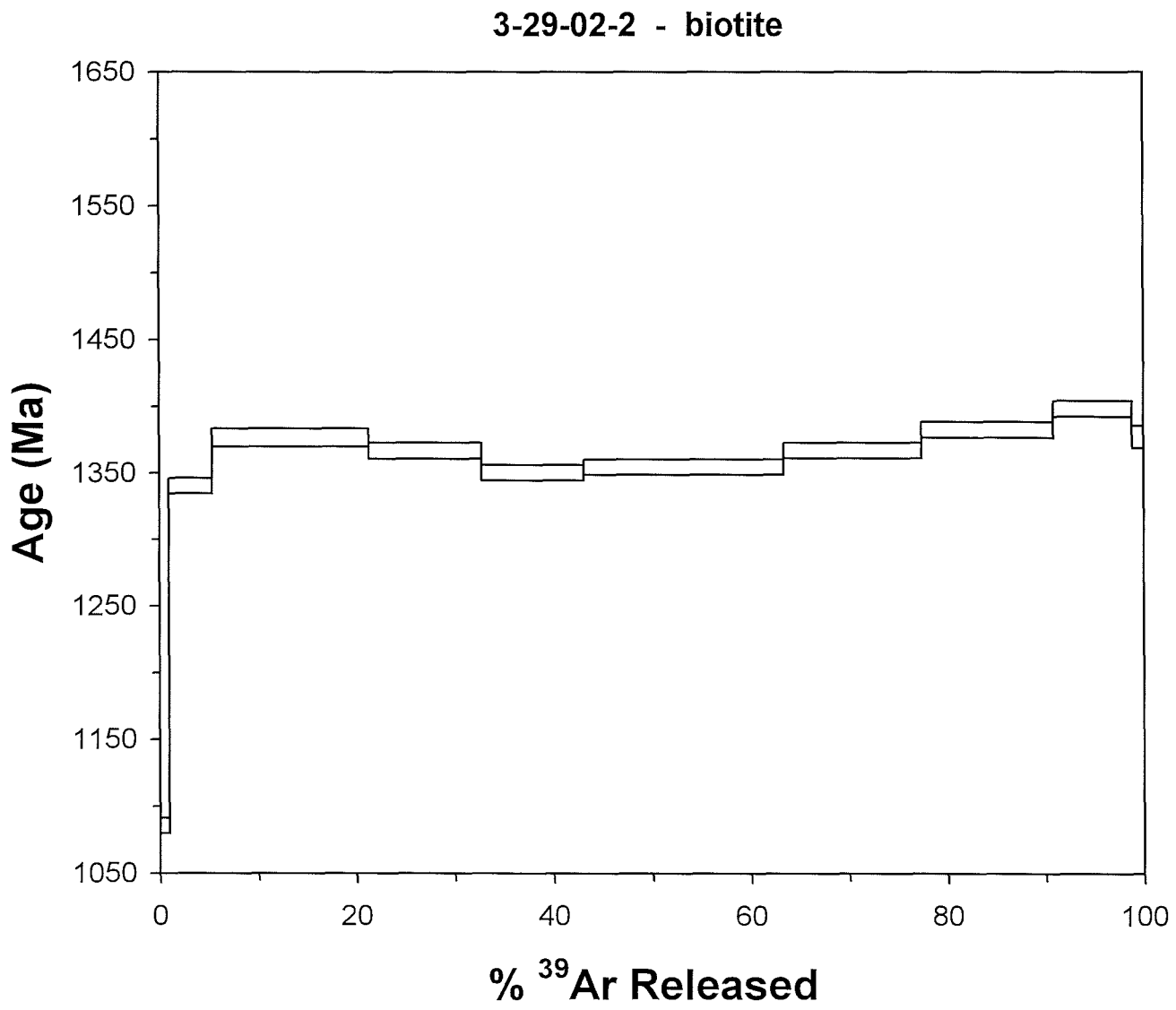

T02-100 - muscovite
Age (Ma)
1700
1500
1300
1100
900
700
500
300
100
0
20
40
60
80
100
% 39Ar Released

Spencer-AZGS, 3-29-02-2, biotite, 0.48 mg, J = 0.001555 ± 0.5%
4 amu discrimination = 1.01685 ± 0.19%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	625	12	0.392	0.038	0.085	0.837	550.826	80.2	0.9	0.376334735	530.8806	1085.81	5.72
2	710	12	0.239	0.036	0.081	3.938	2841.31	97.8	4.4	0.075771117	708.6572	1340.20	5.80
3	790	12	0.08	0.068	0.165	14.209	10428.8	99.8	15.9	0.039665925	735.8981	1376.19	6.87
4	860	12	0.046	0.039	0.13	10.243	7436.8	99.9	11.5	0.031557934	728.4679	1366.45	5.92
5	935	12	0.046	0.037	0.127	9.227	6586.84	99.9	10.3	0.033236291	716.1670	1350.19	5.78
6	1010	12	0.048	0.133	0.219	18.133	12993.7	99.9	20.3	0.060793469	719.1984	1354.21	5.84
7	1060	12	0.054	0.088	0.17	12.51	9084.79	99.9	14.0	0.058304219	728.5622	1366.57	5.83
8	1110	12	0.026	0.131	0.162	12.002	8851.00	100.0	13.4	0.090468314	740.5357	1382.25	5.98
9	1170	12	0.03	0.24	0.099	7.153	5363.55	99.9	8.0	0.278116242	752.8459	1398.23	5.90
10	1400	12	0.05	0.239	0.022	1.05	777.379	99.3	1.2	1.887652946	736.4203	1376.88	8.20
							Cumulative %39Ar rlsd =		100.0		Total gas age =	1364.89	6.70

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

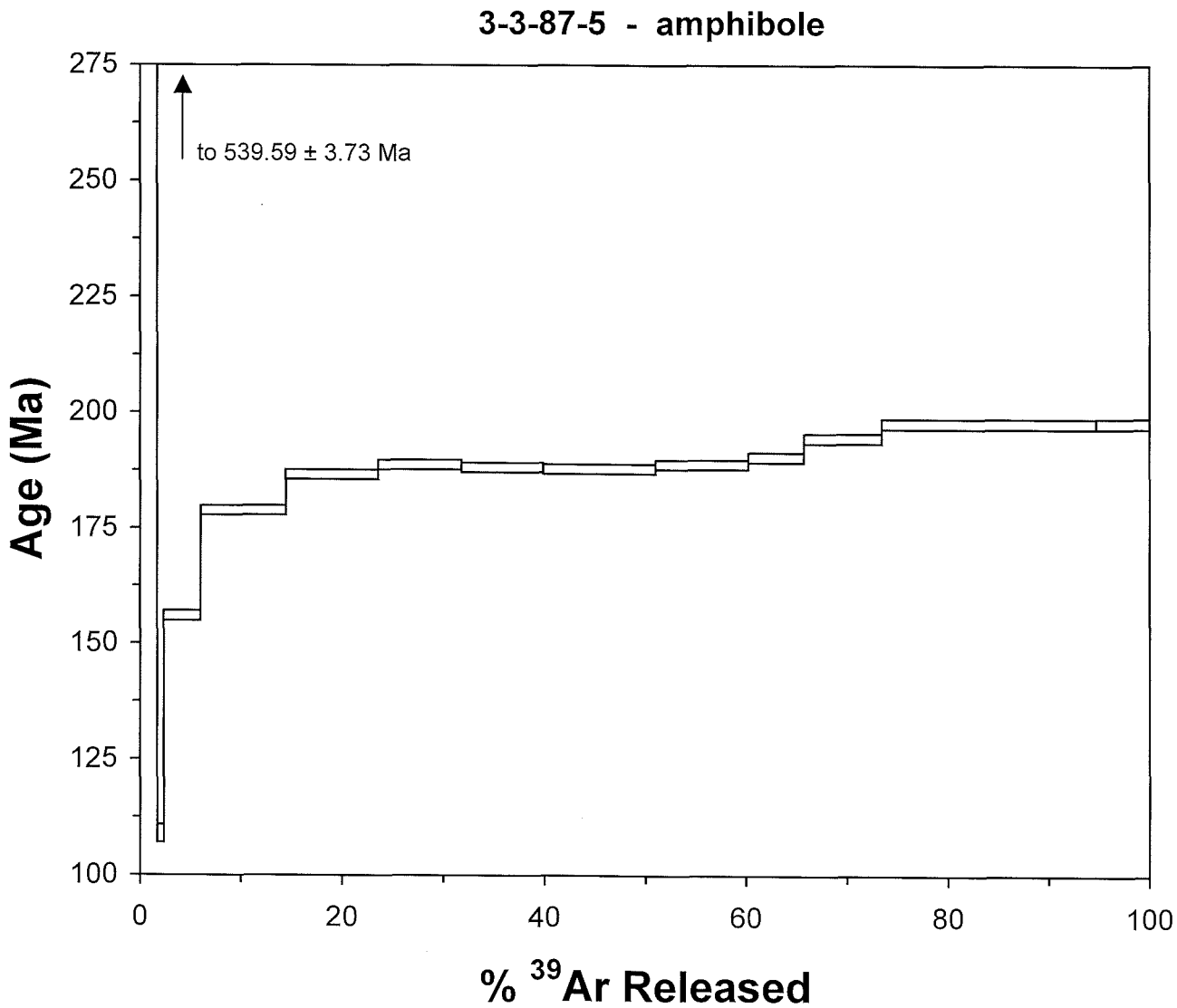
no plateau


3-29-02-2 - biotite
Age (Ma)
1650
1550
1450
1350
1250
1150
1050
0
20
40
60
80
100
% 39Ar Released

Richard-AZGS, 3-3-87-5, amphibole, 15.65 mg, J = 0.001522 ± 0.5%
4 amu discrimination = 1.01757 ± 0.20%, 40/39K = 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	800	12	5.556	4.239	1.150	4.598	2657.7	39.5	1.7	4.505312882	229.0668	539.59	3.73
2	900	12	0.678	2.488	0.155	1.784	268.872	27.8	0.7	6.820055887	40.9071	108.97	1.95
3	1000	12	0.86	29.286	0.304	10.068	833.927	71.8	3.7	14.25665892	59.3419	156.00	1.10
4	1050	12	0.76	67.691	0.462	22.937	1763.11	88.8	8.4	14.46513005	68.4766	178.86	1.02
5	1080	12	0.558	71.334	0.447	24.791	1906.51	92.7	9.1	14.10208511	71.5935	186.59	1.05
6	1100	12	0.43	64.109	0.372	22.492	1726.92	94.1	8.3	13.9686478	72.4672	188.75	1.07
7	1120	12	0.391	62.91	0.369	22.052	1681.99	94.4	8.1	13.9809519	72.2189	188.14	1.04
8	1150	12	0.495	87.976	0.513	30.276	2292.99	94.8	11.1	14.24179368	72.0965	187.84	1.03
9	1175	12	0.452	80.443	0.403	25.037	1915.74	94.3	9.2	15.75439292	72.4716	188.76	1.05
10	1200	12	0.312	47.414	0.256	15.071	1174.46	93.7	5.5	15.4247225	73.1015	190.32	1.09
11	1230	12	0.391	58.921	0.326	20.856	1650.00	94.2	7.7	13.84479139	74.7793	194.46	1.08
12	1270	12	0.962	161.108	0.949	58.054	4631.05	94.8	21.3	13.59879027	76.0655	197.63	1.09
13	1400	12	0.311	39.688	0.255	14.401	1164.71	94.3	5.3	13.50422225	76.1041	197.73	1.13
							Cumulative %39Ar rlsd =		100.0		Total gas age =	194.65	0.99
											no plateau		

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

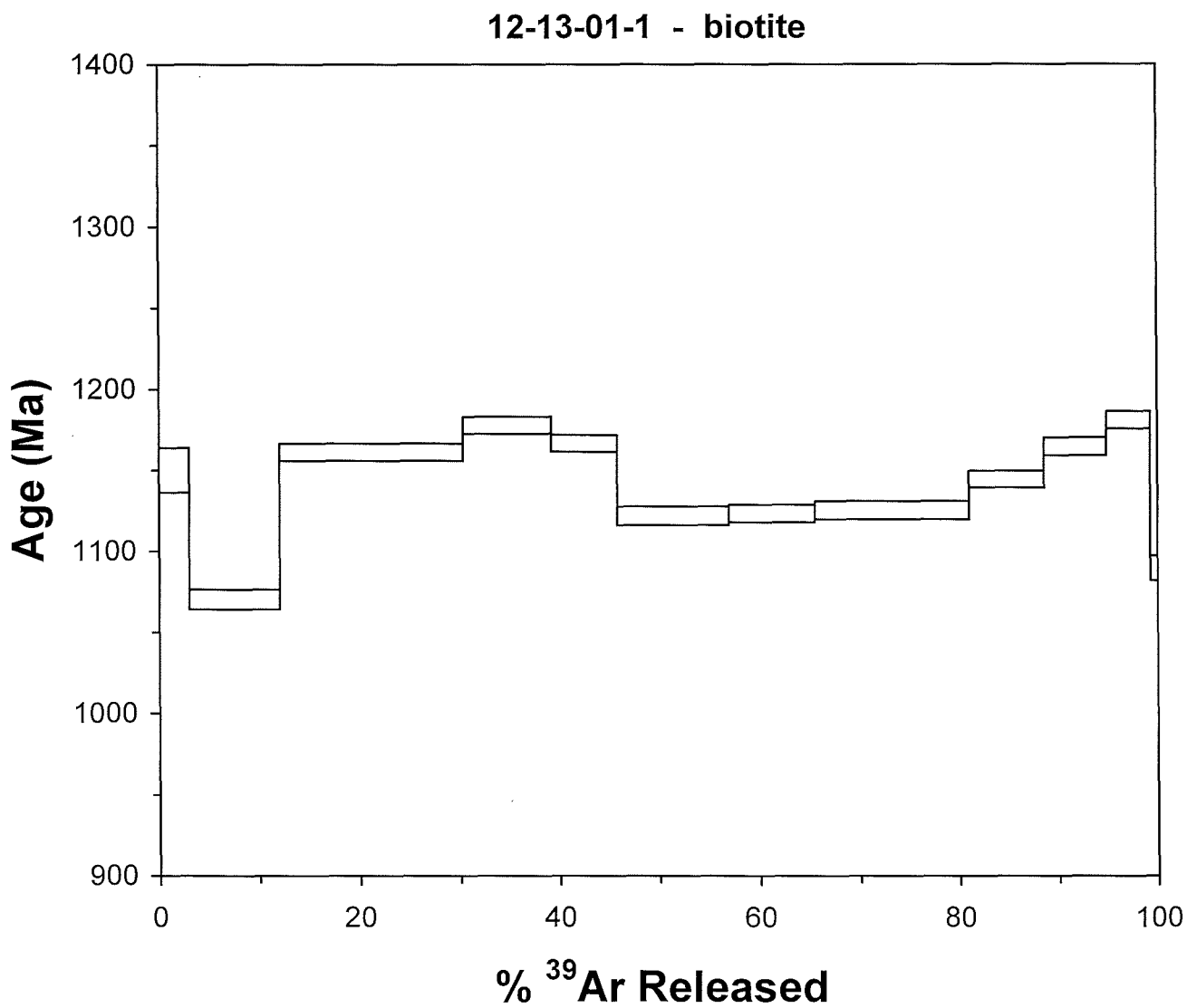

3-3-87-5 - amphibole
to 539.59 ± 3.73 Ma
Age (Ma)
275
250
225
200
175
150
125
100
0
20
40
60
80
100
% 39Ar Released

Spencer-AZGS, 12-13-01-1, biotite, 12.84 mg, J = 0.001550 ± 0.5%

4 amu discrimination = 1.01932 ± 0.26%, 40/39K = ~~0.00~~ 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	110.025	0.260	21.702	12.869	39257.5	18.7	3.0	0.145924446	575.3527	1150.15	13.78
2	675	12	59.927	0.398	12.185	39.039	37671.5	53.9	9.1	0.073633331	522.5215	1070.32	6.07
3	740	12	11.734	0.329	3.473	78.26	48800.4	93.0	18.2	0.030362705	582.8160	1161.15	5.33
4	790	12	1.282	0.26	0.675	38.156	22927.0	98.4	8.9	0.049214988	594.2160	1177.82	5.25
5	850	12	0.987	0.303	0.476	28.448	16878.9	98.3	6.6	0.076927458	586.5087	1166.56	5.24
6	910	12	2.114	0.418	1.117	47.798	27080.0	97.8	11.1	0.06316191	556.3263	1121.80	5.82
7	975	12	1.332	0.275	0.681	36.74	20762.2	98.2	8.6	0.054060623	557.2784	1123.23	5.42
8	1025	12	2.03	0.466	1.093	66.38	37499.6	98.4	15.5	0.050703243	558.5915	1125.20	5.57
9	1075	12	0.884	0.263	0.531	32.488	18731.0	98.7	7.6	0.058468352	571.4534	1144.38	5.13
10	1120	12	0.711	0.418	0.394	27.037	15945.0	98.8	6.3	0.111663905	585.1392	1164.56	5.50
11	1170	12	0.466	1.372	0.363	18.981	11389.0	98.9	4.4	0.522136045	596.2945	1180.84	5.33
12	1400	12	0.1	0.096	0.005	3.069	1662.29	98.2	0.7	0.225935411	534.9842	1089.47	7.64
							Cumulative %39Ar rlsd =		100.0		Total gas age =	1140.50	5.93
											no plateau		

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)

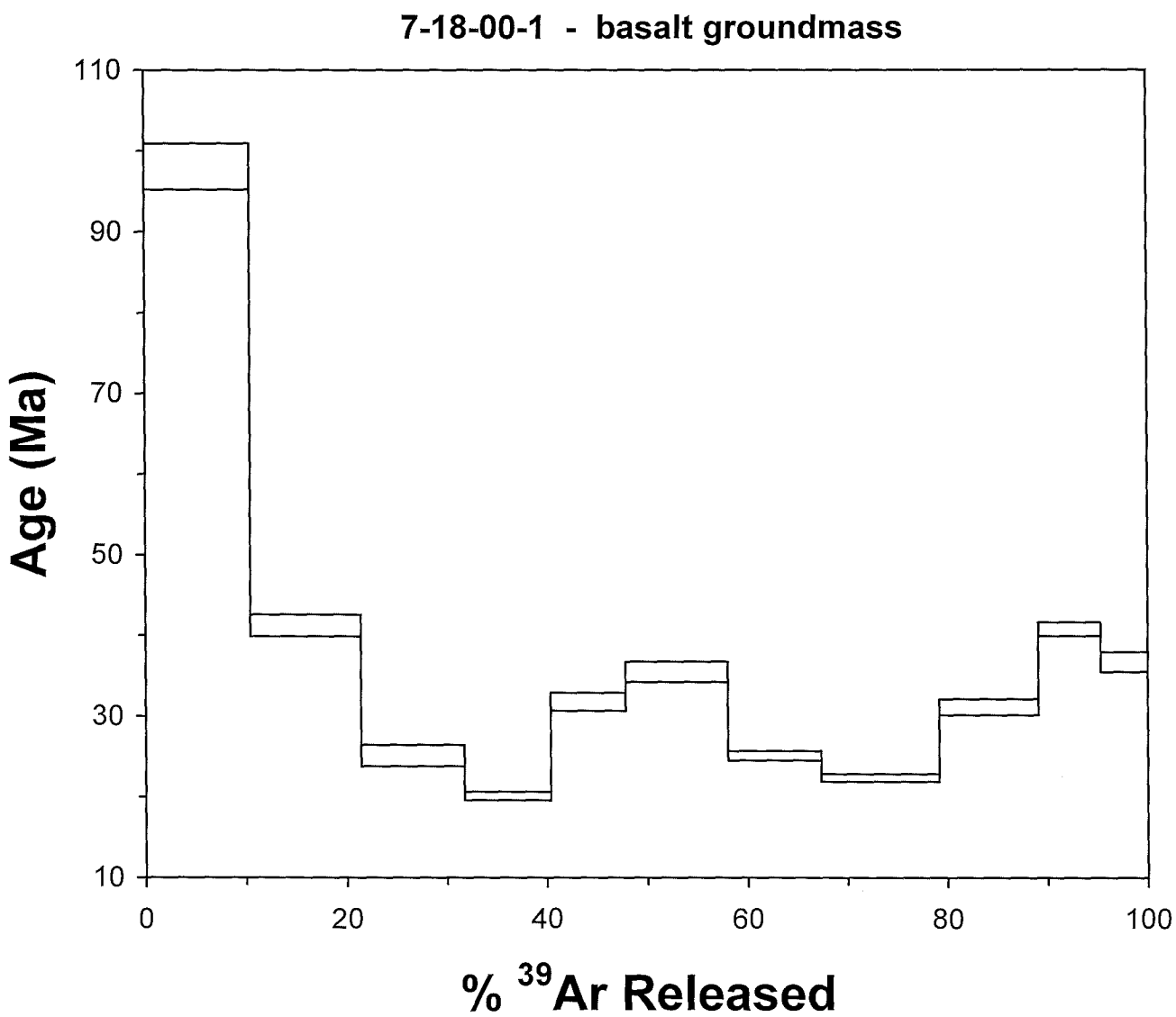

12-13-01-1 - biotite
1400
1300
1200
1100
1000
900
Age (Ma)
0
20
40
60
80
100
% 39Ar Released

Spencer-AZGS, 7-18-00-1, basalt groundmass, 8.77 mg, J = 0.0015553 ± 0.5%

4 amu discrimination = 1.01932 ± 0.26%, 40/39K = ~~0.00~~ 0.0002 ± 0.0002%, 36/37Ca = 0.000282 ± 1.51%, 39/37Ca = 0.000677 ± 0.81%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	15.401	5.624	3.209	13.033	4930.45	9.4	10.4	3.24115976	35.9258	98.09	2.85
2	650	12	6.709	5.214	1.509	13.702	2147.39	9.4	11.0	2.85783105	14.8433	41.18	1.35
3	700	12	6.487	4.821	1.39	12.922	1996.7	5.8	10.3	2.801880302	9.0008	25.08	1.31
4	750	12	2.039	4.03	0.529	10.824	668.902	11.6	8.7	2.796138609	7.1996	20.09	0.51
5	800	12	3.376	4.325	0.798	9.311	1084.59	9.7	7.4	3.48916635	11.4160	31.75	1.12
6	900	12	6.391	7.208	1.392	12.713	2013.67	8.0	10.2	4.259897975	12.7591	35.45	1.26
7	1000	12	2.565	10.443	0.617	11.65	843.842	12.4	9.3	6.739928559	8.9950	25.06	0.60
8	1100	12	2.629	36.039	0.712	14.794	868.587	13.6	11.8	18.38053492	8.0016	22.31	0.49
9	1170	12	3.064	72.884	0.754	12.413	1001.88	13.7	9.9	44.65050269	11.1723	31.08	0.99
10	1250	12	2.501	81.102	0.595	7.756	810.734	13.7	6.2	80.36076278	14.6774	40.72	0.86
11	1400	12	2.37	65.823	0.532	5.898	745.565	10.2	4.7	85.90731619	13.1962	36.65	1.21
							Cumulative %39Ar rlsd =		100.0		Total gas age =	37.36	0.50
											no plateau		

note: isotope beams in mV, rlsd = released, error in age includes 0.5% J error, all errors 1 sigma
(Not corrected for decay)


7-18-00-1 - basalt groundmass
Age (Ma)
110
90
70
50
30
10
0
20
40
60
80
100
% 39Ar Released