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# $^{40}Ar$-$^{39}Ar$ geochronological investigations in the central Hearne domain, western Churchill Province, Nunavut: a progress report[1]

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[1] Contribution to the Western Churchill NATMAP Project

## Abstract

*The western Churchill Province of the northwest Canadian Shield was originally defined on the basis of widespread, Proterozoic K-Ar ages, but early mapping in conjunction with sparse, old K-Ar ages indicated that it contained preserved remnants of Archean supracrustal and granitoid rocks. A reconnaissance $^{40}Ar$-$^{39}Ar$ thermochronological investigation of a segment of crust lying along a north-northwest-trending transect from Kaminak Lake (central Hearne domain) in the south to Yathkyed Lake (northern Hearne domain) in the northwest, indicates that the Archean supracrustal belts preserve primary Archean igneous and metamorphic cooling ages for hornblende, but biotite ages were reset in the Proterozoic. The domain lying between the two supracrustal belts yielded Proterozoic ages for all dated minerals. The resetting of the $^{40}Ar$-$^{39}Ar$ systematics is attributed to* *large-scale thermal overprinting during Hudsonian deformation and magmatism at ca. 1830–1810 Ma and subsequent slow cooling. Local evidence for ca. 1750 Ma resetting of mica ages exists, but no unequivocal evidence for a ca. 1900 Ma tectonothermal event can be discerned in the $^{40}Ar$-$^{39}Ar$ thermochronological data.*

## *Résumé*

*La Province de Churchill occidentale, dans la partie nord-ouest du Bouclier canadien, a été à l'origine définie par la présence répandue d'unités livrant des âges K-Ar du Protérozoïque. Cependant, les travaux initiaux de cartographie géologique et l'identification ici et là d'unités affichant des âges K-Ar plus anciens indiquaient que cette partie de la province de Churchill renferme des vestiges de roches supracrustales et de granitoïdes de l'Archéen dont la signature a été conservée. Une étude thermochronologique de reconnaissance à l'aide du couple $^{40}Ar$-$^{39}Ar$ a été menée le long d'un transect s'étendant de la ceinture de roches supracrustales de Kaminak Lake (partie centrale du domaine de Hearne) en direction du nord-nord-ouest jusqu'à la ceinture de roches supracrustales de Yathkyed Lake (partie méridionale du domaine de Hearne). Dans les bandes de roches supracrustales de l'Archéen, les résultats indiquent que la hornblende a su conservé ses âges originels de cristallisation magmatique et de refroidissement métamorphique de l'Archéen, mais que dans la biotite les horloges isotopiques ont été remises à zéro au Protérozoïque. Dans le domaine compris entre les deux ceintures de roche supracrustales, par ailleurs, tous les minéraux datés ont livré des âges situés dans le Protérozoïque. La remise à zéro du système $^{40}Ar$-$^{39}Ar$ est attribuée à une surimpression thermique à grande échelle s'étant produite au cours de la déformation et du magmatisme hudsoniens, à environ 1 830-1 810 Ma, épisode qui a été suivi par un refroidissement lent. Par endroits, on a constaté une remise à zéro des horloges isotopiques du mica à environ 1 750 Ma, mais aucun indice non équivoque d'un événement tectonothermique à 1 900 Ma n'a pu être mis en évidence dans les données thermochronologiques du système $^{40}Ar$-$^{39}Ar$.*

# INTRODUCTION

The Churchill Province of the Canadian Shield was originally defined on the basis of widespread, predominantly Proterozoic (Hudsonian) K-Ar ages (Stockwell, 1961), but early mapping in conjunction with sparse, old K-Ar ages indicated that it contained preserved remnants of Archean supracrustal and granitoid rocks (Burwash et al., 1962; Wright, 1967; Wanless and Eade, 1975). The western Churchill Province, that part of the Churchill Province exposed north and west of Hudson Bay (**Fig. 1**), was subdivided by Hoffman (1988) into Rae and Hearne provinces. Extensive field and supporting laboratory studies have led to further subdivision of the Hearne Province (now termed Hearne domain) into two subdomains, the northern and central Hearne domains. These are characterized by apparently distinct, late Neoarchean and Paleoproterozoic orogenic events (Hanmer and Relf, 2000).

Recent geochronological investigations in the western Churchill Province (Hanmer et al., 1994; Berman et al., 2000: Davis et al., 2000; MacLachlan et al., 2000) have shown that the thermal history of the Churchill Craton has been complex, locally punctuated by at least seven distinct, regional tectonometamorphic intervals, including discrete accretionary/magmatic events as well as other cryptic events that have been recognized only on the basis of detailed Sensitive High Resolution Ion Microprobe (SHRIMP) U-Pb and thermobarometric studies (Berman et al., op. cit.). These include 1) ca. 2690 Ma deformation in the northern Hearne domain (Hanmer et al., 1999; Tella et al., 2000); 2) ca. 2685 Ma greenschist-grade metamorphism and deformation in the central Hearne domain (Davis et al., 2000); 3) ca. 2600 Ma granitoid plutonism across the northern Hearne and Rae domains (Davis et al., 2000); 4) ca. 2500–2550 Ma metamorphism and deformation in the northern Hearne domain (Davis et al., 2000; MacLachlan et al., 2000); 5) ca. 1900 Ma metamorphism and deformation in the northern Hearne domain

(Berman et al., 2000); 6) ca. 1830 Ma magmatism and deformation in the northern Hearne and Rae domains (Peterson and van Breemen, 1999; Tella et al., 2000) and; 7) ca. 1755 Ma plutonism in the western Hearne and eastern Rae domains (Peterson and van Breemen, 1999).

This study, initiated as part of the Western Churchill NATMAP Project, was designed to examine the field, petrographic, and $^{40}Ar$-$^{39}Ar$ thermochronological behaviour of potassium-bearing mineral phases in selected rock units exposed within a crustal segment from the Kaminak belt of the central Hearne domain to the Yathkyed belt of the northern Hearne domain. Herein, twenty $^{40}Ar$-$^{39}Ar$ laser step-heating age dates are reported for rocks from the region and these data are used to examine the regional cooling and tectonometamorphic history of the Hearne domain, western Churchill Province.

## GEOLOGICAL SETTING

The study area, lying between Yathkyed Lake in the northwest and Kaminak Lake in the southeast, is situated in the northeastern part of what was formerly termed the Ennadai–Rankin greenstone belt (**Fig. 1**) of the Churchill Province (Wright, 1967), an areally extensive series of rocks that include the Kaminak, Yathkyed, MacQuoid and Rankin supracrustal belts. The main lithological units in the study area (**Fig. 2**) comprise greenschist-grade Archean supracrustal and granitoid rocks of the Kaminak Group in the Kaminak belt (Davidson, 1970) and the Henik Group of the Yathkyed belt (Eade, 1986). Archean rocks mainly comprise mafic to felsic volcanic rocks, although locally, and on a regional scale, occurrences of banded iron-formation, siliciclastic sedimentary rocks, and voluminous debris flows associated with felsic volcanic centres are common (Hanmer et al., 1998). Intruding the Archean supracrustal units are a wide range of Neoarchean plutonic rocks, ranging in composition from gabbro to syenogranite.

The Kaminak Group is intruded by a suite of ca. 2450 Ma (Heaman, 1994), northeast-trending diabase dykes (Kaminak dykes; Christie et al., 1975), whereas in the Yathkyed belt, Kaminak dykes are apparently absent, but the Archean stratigraphy is crosscut by east-west-trending diabase dykes of the Tulemalu swarm (Eade, 1986). The Archean rocks of both the Kaminak and Yathkyed belts are overlain by the Proterozoic Hurwitz Group (Davidson, 1970), the erosional remnants of an extensive, relatively shallow, Paleoproterozoic intracratonic basin now preserved as a series of outliers across the Hearne domain (Aspler and Chiarenzelli, 1996, 1997). A maximum age of 2450 Ma for the Hurwitz Group is implied by U-Pb dating of baddeleyite in the Kaminak dykes (Heaman, 1994), whereas a 2111 ± 1 Ma U-Pb baddeleyite age from gabbroic sills in the contained Ameto Formation provides a minimum age of deposition of the lower part of the Group (Heaman and LeCheminant, 1993). Deformation of the Hurwitz Group occurred subsequent to the intrusion of the 2111 ± 1 Ma gabbro sills, but prior to the intrusion of the ca.1830 Ma lamprophyre dykes associated with the ultrapotassic lavas of the Baker Lake Basin (Tella et al., 1985; Roddick and Miller, 1994; MacRae et al. 1995).

Lying between the Kaminak and Yathkyed belts *proper* are a series of generally flat-lying, amphibolite-facies metasedimentary and metavolcanic rocks assumed to be correlative with the Kaminak and/or Henik Groups that are therefore interpreted to be Archean. These rocks are widely intruded by both schlieren-rich tonalite to monzogranite and by clean, variably foliated, biotite+magnetite±fluorite monzogranite. At least three examples of the latter are known to be Paleoproterozoic (W.J. Davis, pers. comm., 2000; K. MacLachlan, pers. comm., 2000; T.D. Peterson, pers. comm., 2000).

## FIELD AND PETROGRAPHIC OBSERVATIONS

The samples under investigation were collected from outcrops located in **Figure 2**. Brief descriptions of the samples and their UTM co-ordinates are presented in **Table 1**. The samples include a wide range of rock types including tonalitic and monzonitic intrusive units from the Kaminak belt; metasedimentary and granitoid units from north and northwest of the Kaminak belt, including probable Archean supracrustal rocks and Proterozoic granitoids; and amphibolitic metavolcanic units from the Yathkyed belt.

Geological mapping (Davidson, 1970; Eade, 1986; Aspler and Chiarenzelli, 1996; Relf et al., 1998; Hanmer et al., 1998), in conjunction with U-Pb geochronological investigations (Wanless and Eade, 1975; Mortensen and Thorpe, 1987; Davis et al., 2000; MacLachlan et al., 2000), has roughly outlined the extent of Archean crust in both the Yathkyed and Kaminak belts and has shown that the rocks between these two belts contain a high proportion of variably foliated granite, which, on the basis of field relationships, textures, and local U-Pb ages, are inferred to be predominantly Paleoproterozoic. Moreover, recent U-Pb dating of zircon grains (MacLachlan, pers. comm., 2000) has shown that the oldest rock type in the intervening domain contains a high proportion of metamorphic zircons that yielded ca. 1830 Ma thermal ionization mass spectrometry (TIMS) U-Pb ages.

Specimen PHA-97-H521 represents massive green biotite occurring in veins throughout the host rock. These veins parallel the nearby, para-authochthonous contact with the Paleoproterozoic Hurwitz Group (Fig. 2), and are interpreted to have been emplaced during a hydrothermal event accompanying deformation along this contact.

# $^{40}$AR-$^{39}$AR THERMOCHRONOLOGY

## *Analytical Methods*

All minerals were separated, processed, irradiated and analyzed following the methods outlined in Villeneuve et al. (2000), except for the use of PP-20 hornblende (identical to Hb3gr: apparent age 1072 Ma; Roddick, 1983) that was interspersed along the length of the cannister to arrive at an interpolated J-value for each sample. The two canisters (RAD-28 and RAD-33: GSC Ar geochronological database) were irradiated for approximately 80 hrs in position 5C of McMaster Reactor and these were allowed to cool for 2 months. All data are presented in **Figures 3** through **5**, and numerical data is listed in **Table 2**. All ages are quoted at the 2$\sigma$ confidence level and include the error in the J-value. Each sample was irradiated within the same 3 mm x 2 mm packet, but was split into multiple aliquots for replicate analysis. These aliquots are marked by alternately shaded portions of the gas release spectra in Figures 3 to **6**, with the width of each shaded portion representing the relative volume of $^{39}$Ar released for a single aliquot. The width of the shaded band therefore approximates the relative radiogenic argon volume of each analyzed sample.

Hornblende analyses proved somewhat problematic because of changes made to the laser sampling system during the course of the analytical schedule, and because the specimens were under-irradiated for the absolute age of the samples. Hornblende, which releases gas over a narrow temperature window, yielded an erratic and commonly catastrophic release of radiogenic argon within a few incremental increases in laser power. Hence, splitting of gas aliquots was typically difficult. This, coupled with low volumes of $^{39}Ar_K$ ($^{39}$Ar generated from $^{39}$K during irradiation) due to irradiation, resulted in larger than typical analytical errors for some specimens. Nevertheless, meaningful data were generated. Even release of gas from mica was much easier to obtain due to the broader temperature window through which the phyllosilicates release their radiogenic argon.

Herein, we report total-gas, integrated ages (equivalent to a K-Ar age: IA), plateau or pseudo-plateau ages (PA), and inverse isotope-correlation ages (CA). Plateaus, traditionally described as three contiguous steps overlapping in error and comprising greater than or equal to 50% of the $^{39}Ar$ released, were commonly not obtained during this investigation owing to the problems of attaining consistent volume release of gas from all of the minerals. Thus, many of the hornblende plateau ages in particular, as well as those for some of the micas, are referred to as 'pseudo-plateau' ages and represent only best approximations of the 'actual age' of the mineral. The gas steps used in the calculation of the plateaus or pseudo-plateau ages, as well as the inverse isotope-correlation ages, are denoted by asterisks in **Table 2** and are filled black boxes in **Figures 3** through **6**. Below, the approximate Ar closure temperatures (McDougall and Harrison, 1988; Reynolds, 1992) for hornblende (500°C), muscovite (350°C), and biotite (300°C) are used to assist in the interpretation of the cooling history of the region.

## *Step-heating results*

### Rocks from the Kaminak and Yathkyed belts (known or inferred Archean ages)

*PHA-97-H506*

Two aliquots of hornblende from this tonalite pluton yielded a reasonably simple compound spectrum (**Fig. 3A**) with a total-gas, integrated age of 2669 ± 15 Ma. The plateau age of 2652 ± 15 Ma, representing 91% of the total $^{39}Ar$ released, overlaps, within error, the integrated age. The corresponding inverse-correlation age ($^{36}Ar/^{40}Ar$ versus $^{39}Ar/^{40}Ar$) of 2654 ± 14 Ma (Mean square of the weighted deviates (MSWD) = 7.5) overlaps, within error, the plateau age, thereby indicating that an age of 2652 ± 15 Ma may be interpreted as a robust cooling age through approximately 500°C for this specimen.

*PHA-97-H161*

Two aliquots of hornblende from this tonalite pluton yielded only moderately reproducible gas-release patterns (**Fig. 3B**). The second aliquot, however, gave an internally consistent gas-release spectrum. The combined total-gas, integrated age of 2681 ± 14 Ma is almost identical to the known crystallization age of the rock (**Table 1**), and suggests the presence of minor excess argon as shown in the initial steps of both aliquots (Fig. 3B). Excess argon is also readily observed in the inverse-isochron plot. Nevertheless, four large gas steps from aliquot 2, all overlapping in error, representing 78% of the $^{39}Ar$ released from that aliquot, yield a plateau age of 2623 ± 15 Ma. The corresponding correlation age of 2622 ± 14 Ma (MSWD = 0.6) is in agreement (within error), indicating that the plateau age is a robust estimate of the cooling age of the rock.

### *PHA-97-H418*

Two aliquots of hornblende from this monzonite intrusion yielded a complex, irregular spectrum (**Fig. 3C**) having an integrated, total-gas age of 2743 ± 15 Ma and a broad scatter about an average age (pseudo-plateau) of 2660 ± 15 Ma for the mid- to high-temperature steps (representing 66% of the total $^{39}Ar$ released). The correlation plot for this specimen yields no geologically sensible age. Because this hornblende age overlaps (within error) with that determined for PHA-97-H506 (*see* above), it is interpreted as a maximum age for the specimen.

Two aliquots of biotite yielded spectra having comparable shapes with high-power steps indicating the presence of alteration phases in the mineral (**Fig. 4A**). Furthermore, the plateau age for each aliquot is distinct by ca. 30 Ma. The plateau age of 1914 ± 12 Ma for aliquot 1, representing 38% of the total $^{39}Ar$ released, is 29 Ma younger than the corresponding plateau age for aliquot 2 of 1943 ± 13 Ma (representing 35% of the $^{39}Ar$ released). These do not overlap within error, but the minimum cooling age for this biotite is interpreted to be Proterozoic, between ca. 1914 and 1943 Ma.

*CS-96-1302.*

Two aliquots of hornblende from this fine-grained amphibolite from the Yathkyed belt gave an old, total-gas, integrated age of 2901 ± 16 Ma, significantly older than crystallization ages for igneous rocks from the region (Eade, 1986; Loveridge et al., 1988; MacLachlan et al., 2000). The two aliquots yielded comparable spectra (**Fig. 3D**) characterized by small saddles near the high-power end of the patterns. The saddles are interpreted as representing the 'true' cooling age, whereas the remainder of the steps represent gas contaminated by excess argon. The plateau steps, representing 12% of the total $^{39}Ar$ released, yield an age of 2670 ± 16 Ma. The inverse isotope-correlation age for all of the gas steps yields an age of 2630 ± 78 Ma (MSWD = 73.5). Because the specimen contains a large amount of excess argon, and the plateau and correlation ages do not overlap within error, we interpret the correlation age as a best estimate of the cooling age of the hornblende.

*YD97-7116a*

Two aliquots of hornblende from this specimen of amphibolitic metavolcanic rock gave an integrated, total-gas age of 2662 ± 15 Ma. Gas from this specimen was released over a very narrow power interval (for both aliquots: **Fig. 3E**) but yielded five roughly concordant steps (especially on the bulk of the gas released in aliquots 1 and 2), representing 80% of the $^{39}Ar$ released, and a pseudo-plateau age of 2513 ± 14 Ma. The corresponding argon-correlation age of 2485 ± 14 Ma (MSWD =72.2) is similar, implying that the plateau age represents a reasonable estimate of the cooling age of the hornblende.

### *YD97-9059*

Three aliquots of hornblende from this specimen of amphibolite-facies metavolcanic rock from the Yathkyed belt yielded irregular gas-release patterns and a total-gas, integrated age of 2493 ± 14 Ma. Three steps, one from each aliquot, represent the bulk of the gas release and give similar ages (**Fig. 3F**). These yield a plateau age of 2460 ± 14 Ma (representing 78% of the $^{39}Ar$ released). The inverse isotope-correlation age of 2459 ± 14 Ma (MSWD =0.7) for this specimen is essentially identical, suggesting that this represents a robust metamorphic cooling age of the hornblende.

Two aliquots of biotite yielded roughly comparable age spectra (**Fig. 4B**), exhibiting gradual increases in apparent age with laser power, and giving a total-gas, integrated age of 1768 ± 11 Ma. The high-power steps of both aliquots, excluding the final step of aliquot 1, yielded a pseudo-plateau age of 1785 ± 11 Ma, representing 63% of the gas released. Given the continually climbing ages with increasing laser power, this plateau age should be considered as a minimum and likely implies that the biotite has undergone a secondary thermal event that has partially reset the $^{40}Ar$-$^{39}Ar$ systematics. The corresponding argon isotope-correlation age of 1785 ± 11 Ma (MSWD = 9.8) is identical, and is interpreted as the metamorphic cooling age of the biotite when it last cooled through approximately 300°C.

### *PHA-97-H524A*

Two aliquots of biotite from this tonalite pluton from the Kaminak belt yielded comparable, saddle-shaped, convex-upwards release patterns (**Fig. 4C**) and a total-gas integrated age of 1980 ± 12 Ma. Saddle-shaped spectra are commonly attributed to the release of $^{39}Ar$ that underwent recoil during irradiation (McDougall and Harrison, 1988). Therefore the age maxima for the saddles may be an overestimation of the cooling age of the biotite, but nevertheless suggests a maximum, ca. 2000 to 2100 Ma cooling age for this biotite.

### *PHA-97-H521*

Two aliquots of vein biotite from this specimen of tonalite yielded generally concordant age spectra with the exception of one step (**Fig. 4D**). The resultant plateau age of 1722 ± 11 Ma, representing 92.6% of the $^{39}Ar$ released, is interpreted as the age of tectonic hydrothermal activity that resulted in the emplacement of the vein network. The corresponding inverse-correlation age is 1721 ± 11 Ma (MSWD = 4.1).

## Rocks exposed in the transect between the supracrustal belts (Proterozoic or Archean)

### *PHA-97-H487*

Two aliquots of hornblende from this psammitic gneiss gave irregular argon release patterns (**Fig. 5A**) wherein the majority of the radiogenic argon was released in two large steps. Both aliquots gave spectra characterized by young apparent ages in both low and high laser-power steps, but roughly concordant, large gas steps at intermediate laser power. The analyses did not yield a sensible plateau, *sensu stricto*, but gave a total-gas integrated age of 1797 ± 12 Ma. The two large steps gave overlapping (within error) ages, the integrated age for these two steps being 1795 ± 12 Ma, representing 86% of the $^{39}Ar$ released. This is interpreted as a reasonable estimate of the cooling age of the hornblende.

Two aliquots of biotite from this sample yielded generally concordant spectra wherein young ages were recorded in the low- and higher-power gas steps (**Fig. 5B**). The analysis yielded a total-gas integrated age of 1720 ± 11 Ma and a plateau age of 1725 ± 11 Ma (represented by 87% of the $^{39}Ar$ released). This sample yielded an isotope-correlation age of 1722 ± 11 Ma (MSWD=6.0), similar to the plateau age.

## *PHA-97-N48*

Two aliquots of biotite gave similar, convex-down argon-release patterns (**Fig. 5C**) typically associated with $^{39}Ar$ recoil. The major difference between the two was the volume of $^{39}Ar$ released: the second aliquot yielded four times that of aliquot one and moreover, yielded a good plateau. The first aliquot clearly comprised a significantly altered biotite, whereas the second yielded a gas-release spectrum characteristic of a relatively fresh mica. We therefore only used aliquot 2 in our age calculations. The resultant total-gas, integrated age of aliquot 2 is 1732 ± 12 Ma, which is slightly younger than the plateau age of 1743 ± 12 Ma (78% of the total $^{39}Ar$ released) and identical to the inverse correlation age of 1742 ± 12 Ma (MSWD = 2.6).

Two aliquots of muscovite from this sample yielded roughly concordant spectra (**Fig. 5D**) having a combined integrated and plateau age of 1736 ± 11 Ma. The corresponding isotope-correlation age is 1737 ± 11 Ma (MSWD = 4.0). This is interpreted as the time of closure of the muscovite lattice to argon diffusion (T = 350°C), presumably during a Paleoproterozoic tectonothermal event.

## *PHA-97-J249*

Two aliquots of biotite from this specimen of semipelitic schist yielded roughly concordant spectra, although the second aliquot yielded a larger volume of gas and a better defined plateau (*sensu stricto*). We therefore use only the second aliquot in our calculations. The sample gave a total-gas, integrated age of 1711 ± 11 Ma (**Fig. 5E**). Eleven of 16 steps form a rough plateau yielding an age of 1718 ± 11 Ma and representing 94% of the total $^{39}Ar$ released. The corresponding inverse isotope-correlation age of 1719 ± 11 Ma (MSWD = 0.3) is identical, within error, implying that the mineral's argon systematics have remained closed to the addition or removal of argon since recrystallization.

## *PHA-97-H348*

One aliquot of biotite from this specimen of well lineated tonalite yielded a spectrum characterized by progressively older steps with laser power (**Fig. 5F**). The total-gas integrated age of 1707 ± 11 Ma is essentially identical to the plateau age (91% of the $^{39}Ar$ released) of 1718 ± 11 Ma. This is also identical (within error) to the isotope-correlation age yielded by the same gas steps of 1722 ± 11 Ma (MSWD = 2.8).

## *PHA-97-H479*

Two aliquots of hornblende from this schlieren-laden monzogranite gave very irregular argon-release patterns (**Fig. 6A**). Both aliquots exhibited saddle-shaped spectra having gas steps with large individual errors, and declining to ca. 1745 Ma minima in their high-power gas steps. The analyses did not yield a sensible plateau, but gave a total-gas integrated age of 1772 ± 12 Ma. Because the majority of the steps gave ages between 1780 and 1740 Ma, the integrated age for all steps in this interval, i.e. a pseudo-plateau, yielded an age of 1754 ± 12 Ma (59% of the $^{39}Ar$ released). A corresponding isotope-correlation age is 1748 ± 11 (MSWD=5.9), overlapping, within error, the plateau age. The plateau age is therefore interpreted as a reasonable estimate of the cooling age of the hornblende.

Two aliquots of biotite from this specimen gave generally concordant spectra wherein young ages were recorded in the first gas steps but the remainder formed a rough plateau (**Fig. 6B**). The analysis yielded a total-gas integrated age of 1721 ± 11 Ma and a plateau age of 1727 ± 11 Ma (represented by 90% of the $^{39}Ar$ released). This corresponds well with the correlation age of 1727 ± 11 Ma (MSWD=10.0).

### *PHA-97-H319*

Two aliquots of biotite from this clean, unfoliated Paleoproterozoic monzogranite (**Table 1**) gave generally concordant spectra wherein young ages were recorded in the first gas steps, but the remainder formed a rough plateau (**Fig. 6C**). The analyses yielded a total-gas integrated age of 1728 ± 11 Ma. and a plateau age of 1739 ± 11 Ma (represented by 72% of the $^{39}Ar$ released). The correlation age is identical, yielding an age of 1738 ± 11 Ma (MSWD=3.1).

*PHA-97-N50a*

Two aliquots of biotite from this clean, well foliated Paleoproterozoic monzogranite (Table 1) gave generally concordant spectra wherein young ages were recorded in the first gas steps but the remainder formed a rough plateau (Fig. 6D). The analysis yielded a total-gas integrated age of 1705 ± 11 Ma, a plateau age of 1713 ± 11 Ma (represented by 88% of the $^{39}Ar$ released), and an identical correlation age of 1713 ± 11 Ma (MSWD=2.3).

## DISCUSSION

Herein we discuss the $^{40}Ar$-$^{39}Ar$ thermochronological data in light of the results presented above. All of the results, along with other geochronological determinations for rocks of the region, are presented schematically in Figure 7 and tabulated in Table 3.

Intrusive rocks from the Kaminak supracrustal belt preserve primary igneous textures including interlocking quartz and plagioclase that are intergrown with platy biotite and stubby, euhedral grains of prismatic titanite and hornblende. Although these units yield variable argon-release plateaus, they are typically characterized by Archean cooling ages for hornblende. This implies that the interior parts of the Kaminak supracrustal belt, although having undergone Archean, greenschist-grade tectonometamorphism, record primary Archean hornblende cooling ages. Biotite from these specimens, however, typically yielded convex-down argon-release patterns typical of specimens that have experienced $^{39}Ar$ recoil, a feature compatible with observed petrographic evidence for minor chloritization or alteration of the biotite. The biotite yields Paleoproterozoic ages ranging from ca. 2084 to 1914 Ma, indicating that the primary Archean argon systematics have been reset, probably during a Paleoproterozoic tectonothermal event.

One specimen of biotite (PHA-97-H521) from an intrusive unit in the Kaminak belt was obtained from a biotite-rich vein, exposed as a series of veins crosscutting the pluton and paralleling the adjacent contact with the Paleoproterozoic Hurwitz Group (Fig. 2). This specimen yielded a well defined argon-release pattern having a plateau age of 1722 ± 11 Ma and interpreted as representing crystallization during a Paleoproterozoic tectonothermal event.

Amphibolitic metamorphic rocks from the Yathkyed supracrustal belt yield a range of hornblende cooling ages from ≤2630 to 2460 Ma. These are interpreted to reflect regional cooling after a late Archean regional metamorphic event. This suggestion is corroborated by U-Pb ages for metamorphic monazite, zircon, and titanite from supracrustal and intrusive rocks of the Yathkyed belt that range in age from ca. 2491 to 2568 Ma (MacLachlan et al., 2000). Biotite from one of the rocks yielded a reasonable plateau having an age of 1785 ± 11 Ma. This determination is interpreted to reflect Paleoproterozoic resetting of the biotite argon systematics.

Rocks exposed in a north-south corridor between the northern edge of the Kaminak belt and the southern edge of the Yathkyed belt yield roughly comparable Paleoproterozoic cooling ages ranging from 1713 to 1795 Ma. These data include analyses of hornblende, muscovite, and biotite from rocks that are known to be Paleoproterozoic, as well as metasedimentary and gneissic units interpreted to be correlative with rocks of the Kaminak and Henik groups (Davidson, 1970; Hanmer et al., 1998). In general, hornblende cooling ages are older than those for the micas. Ages for biotite and muscovite from a single specimen (PHA-97-N48) overlap, within error, are essentially identical, and therefore indicate rapid cooling through the muscovite and biotite closure temperatures (approximately 350–300°C). These data are imply that the region lying between the two supracrustal belts has been extensively affected by Paleoproterozoic tectonothermal activity at temperatures above 500°C, the closure temperature of hornblende (McDougall and Harrison, 1988). This tectonothermal event probably accompanied and was followed by intrusion of the voluminous, ca. 1830 Ma Hudsonian granitoid rocks exposed therein, but may have been associated with intrusion of the ca. 1755 Ma Nueltin granitoid suite (Peterson and van Breemen, 1999). The latter suite, however, is not know to occur in the study area. Significantly, no unequivocal evidence for a cryptic, ca. 1900 Ma thermal event (*see* Berman et al., 2000) can be discerned from the thermochronological data. Many of these data are comparable to a hornblende plateau age of 1780 ± 20 Ma (Miller et al., 1995) the only other reported $^{40}Ar$-$^{39}Ar$ step-heating age from the region.

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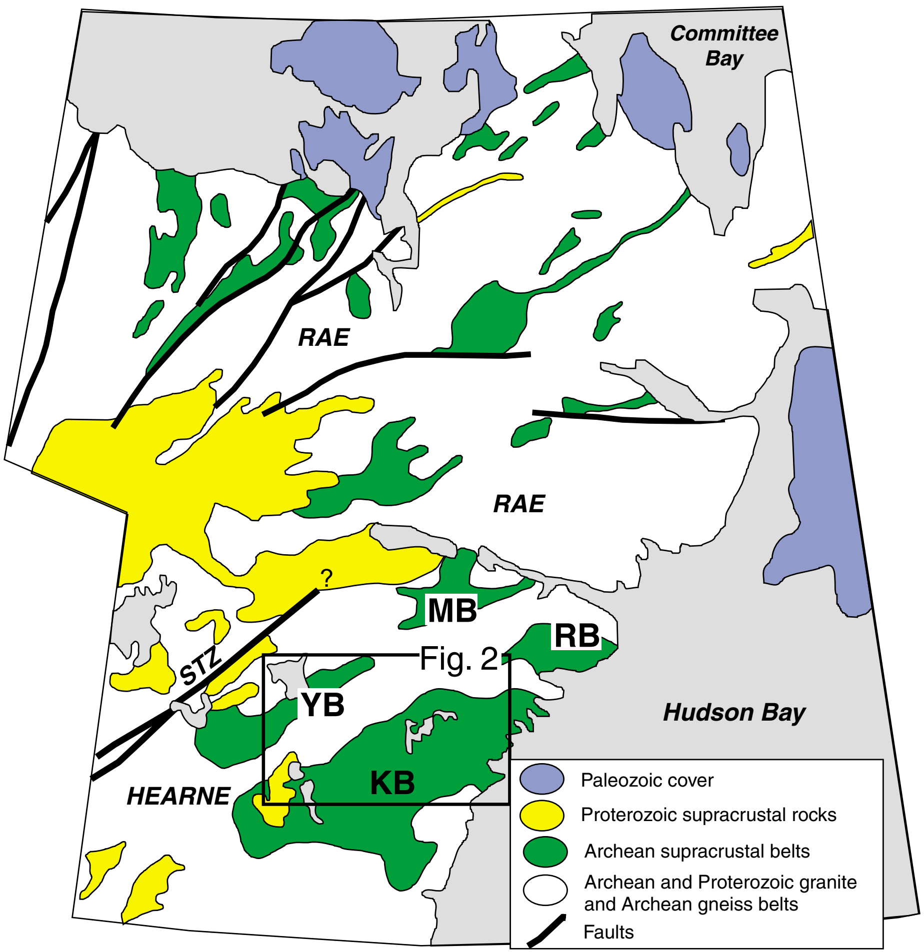


**Figure 1.** Simplified geological map of north-central Canadian Shield showing the location of the study area in the western Churchill Province (*modified after* Hoffman, 1988). Key: KB – Kaminak belt; YB – Yathkyed belt; MB – MacQuoid belt; RB – Rankin Inlet belt; STZ – Snowbird tectonic zone.

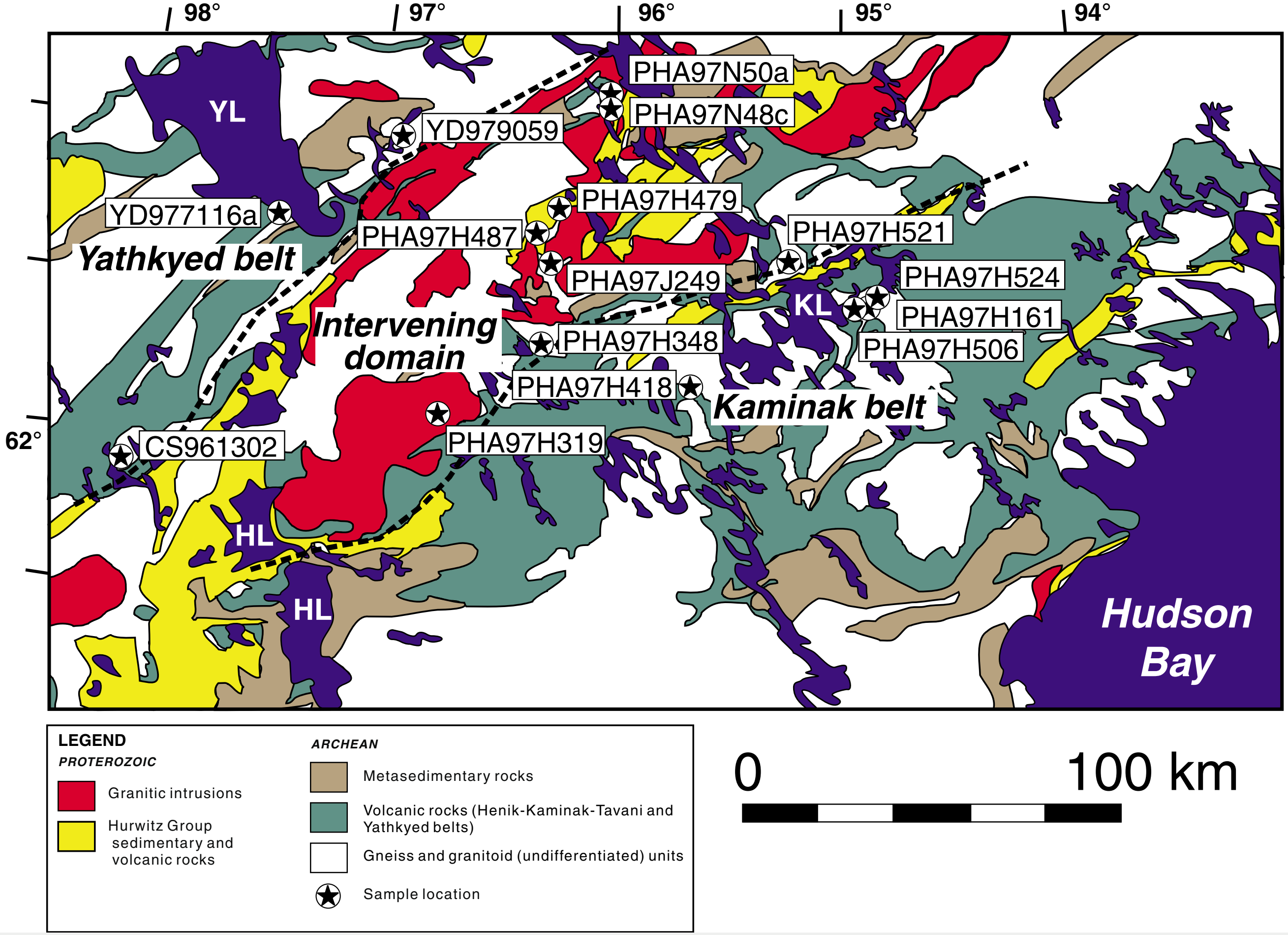


**Figure 2.** Simplified geological map of the central Hearne domain showing the locations of the analyzed specimens in relation to the approximate domain boundaries discussed in the text. Key: YL – Yathkyed Lake; HL – Henik Lakes; KL – Kaminak Lake.

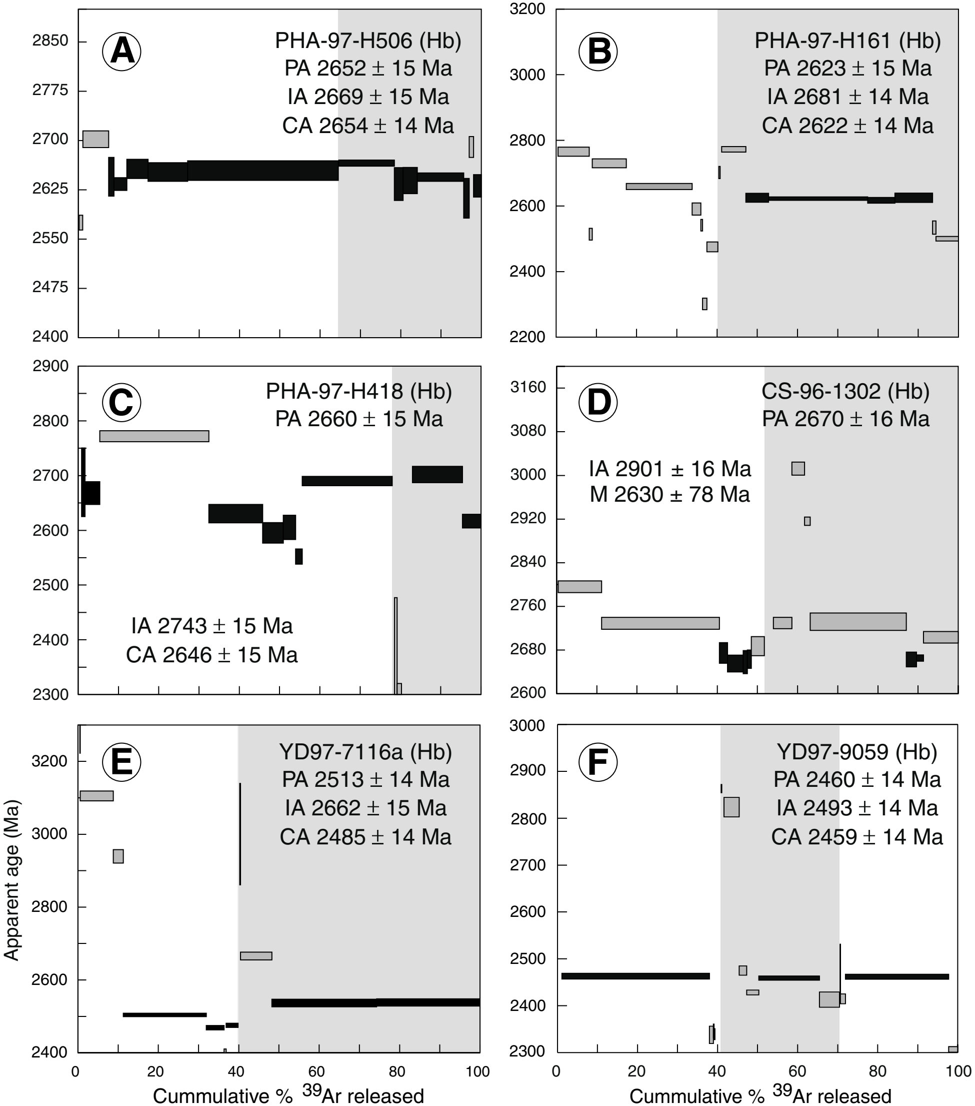


**Figure 3.** $^{40}Ar$-$^{39}Ar$ release spectra for hornblende grains from known Archean units exposed in the Kaminak and Yathkyed supracrustal belts. Gas steps used in the calculation of plateaus and inverse isotope-correlation ages are black, those not used in the calculations are grey. Key: PA – plateau age; IA – total-gas, integrated age; CA – inverse isotope-correlation age; M – maximum age (best estimate).

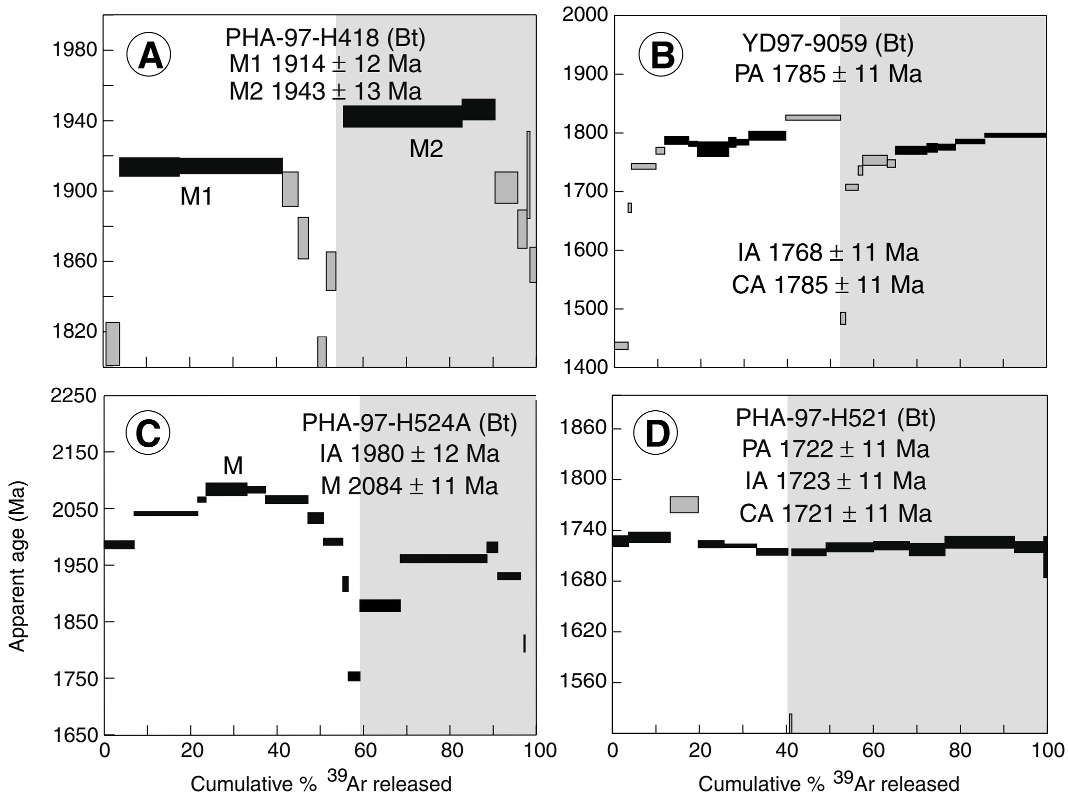


**Figure 4.** $^{40}Ar$-$^{39}Ar$ release spectra for biotite grains from known Archean units exposed in the Kaminak and Yathkyed supracrustal belts. Gas steps used in the calculation of plateaus and inverse isotope-correlation ages are black, those not used in the calculations are grey. Key: PA – plateau age; IA – total-gas, integrated age; CA – inverse isotope-correlation age; M - maximum age (best estimate).

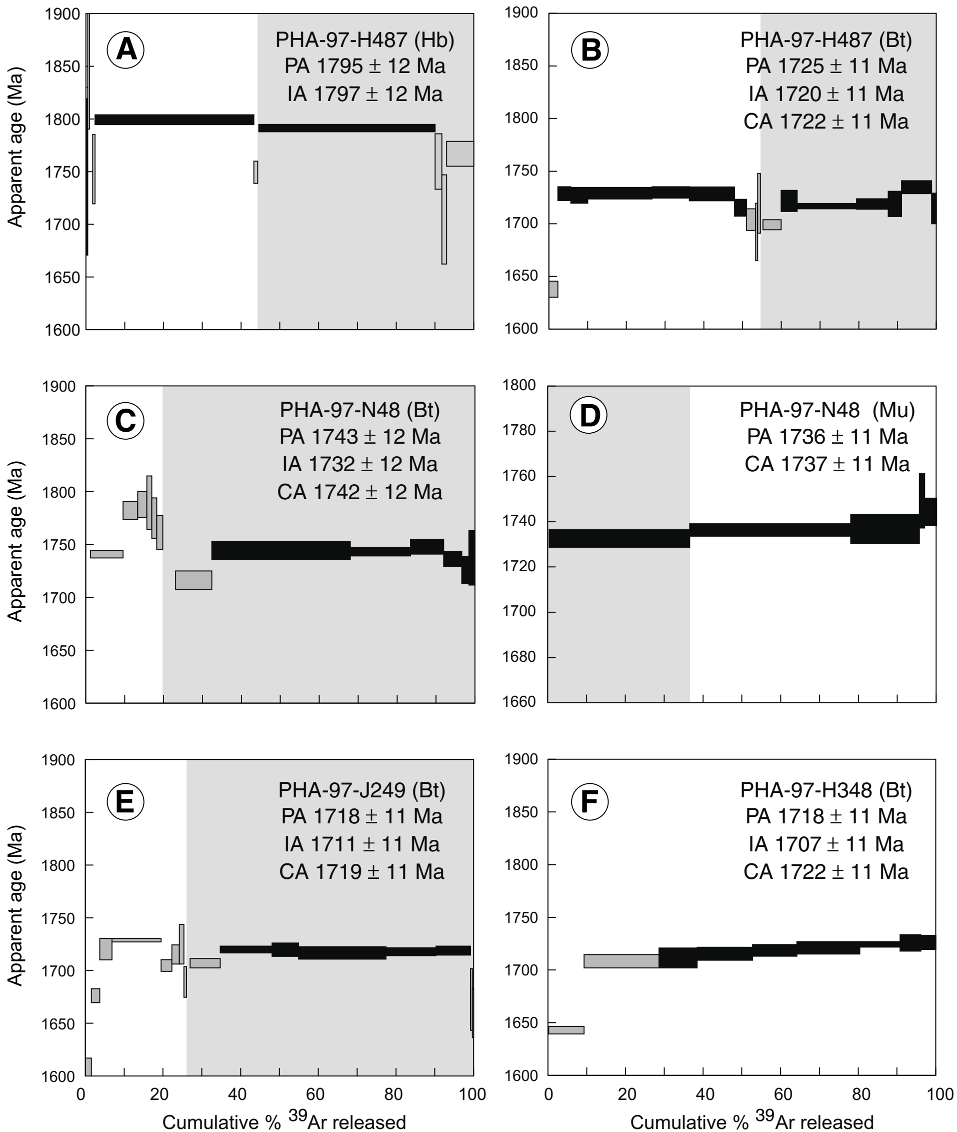


**Figure 5.** $^{40}Ar$-$^{39}Ar$ release spectra for hornblende, muscovite, and biotite from a north-south transect between the Kaminak and Yathkyed supracrustal belts. These units are interpreted to be Archean (Table 1). Gas steps used in the calculation of plateaus and inverse isotope-correlation ages are black, those not used in the calculations are grey. Key: PA – plateau age; IA – total-gas, integrated age; CA – inverse isotope-correlation age.

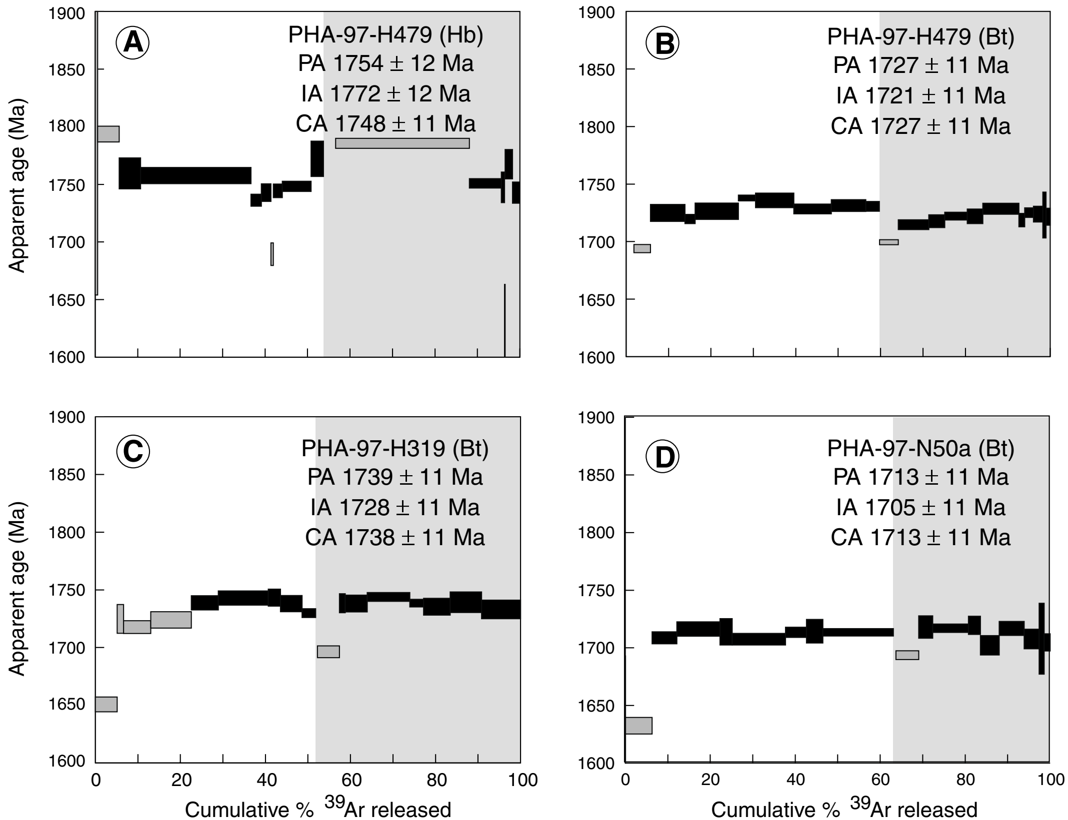


**Figure 6.** $^{40}Ar$-$^{39}Ar$ release spectra for hornblende and biotite from a north-south transect between the Kaminak and Yathkyed supracrustal belts. These units are known or inferred to be Proterozic (Table 1). Gas steps used in the calculation of plateaus and inverse isotope-correlation ages are black, those not used in the calculations are grey. Key: PA – plateau age; IA – total-gas, integrated age; CA – inverse isotope-correlation age.

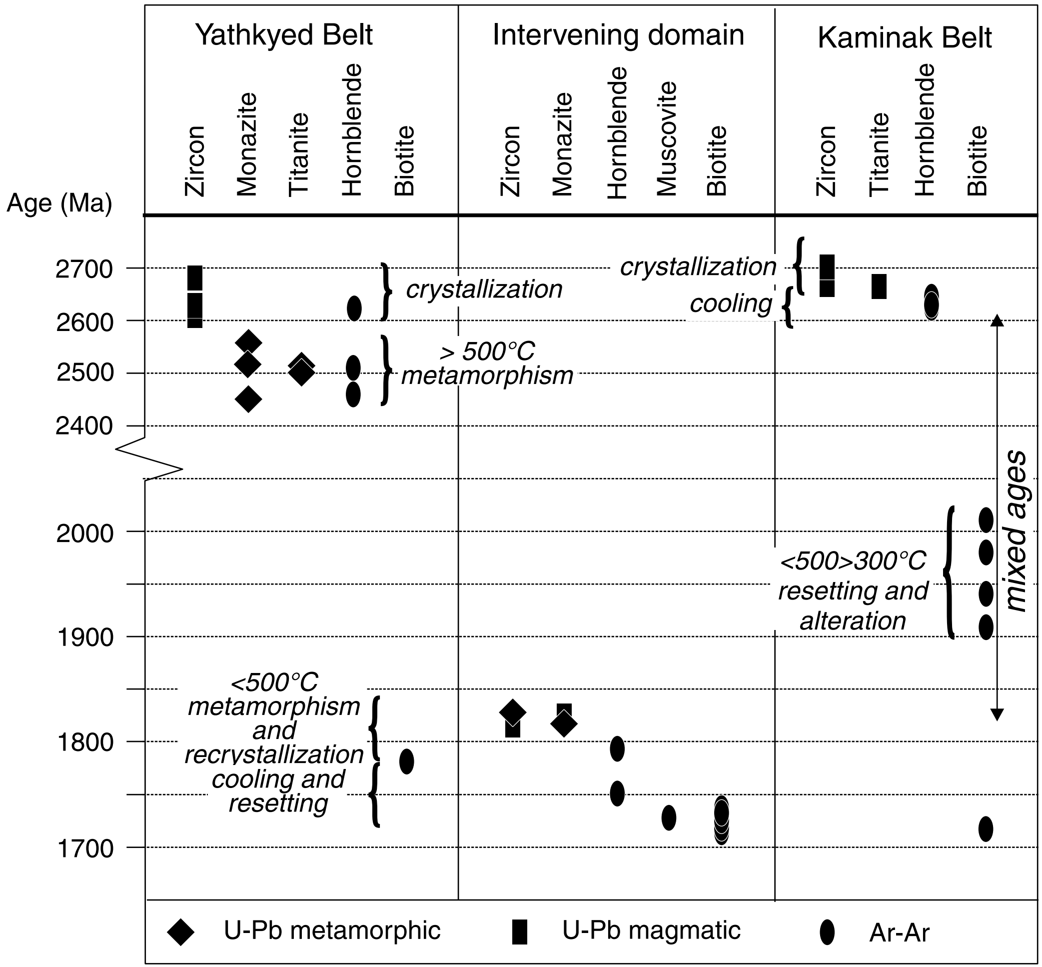


**Figure 7.** Graphical compilation of geochronological data for the study area. This includes data for rocks exposed within the three domains discussed in the paper. Published data for rocks in or adjacent to the domain boundaries are not incorporated. Zircon, monazite, and titanite ages for the Yathkyed belt are from MacLachlan et al. (2000), whereas the metamorphic zircon age from the intervening domain is from MacLachlan (pers. comm.). Zircon, monazite, and titanite ages for the Intervening domain and the Kaminak belt are from Davis et al. (2000), Peterson and van Breemen (1999), and Davis (pers. comm.).

**Table 1.** Rock type, location (UTM zone, eastings and northings) and brief descriptions of the analyzed specimens. UTM coordinates are given in the NAD 1927 projection.

| Sample | UTM co-ordinates[a] | | | Unit | Description[b] | U-Pb age[c] (Ma) |
|---|---|---|---|---|---|---|
| | Zone | Easting | Northing | | | |
| PHA-97-H161 | 15 | 413687 | 6907424 | Kaminak pluton | Medium-grained hornblende+biotite+titanite tonalite | 2679±2 Ma |
| PHA-97-H319 | 14 | 615474 | 6879582 | Kogtok pluton | Medium-grained biotite+titanite monzogranite | ca .1830 Ma |
| PHA-97-H348 | 14 | 642664 | 6895264 | unnamed | Strongly foliated and lineated biotite tonalite | ca . 2680 Ma |
| PHA-97-H418 | 15 | 364369 | 6887892 | Carr Lake monzonite | Medium-grained hornblende+biotite monzxonite | 2679±2 Ma |
| PHA-97-H479 | 15 | 642344 | 6933737 | McKenzie Lake monzogranite | Medium-grained, schlieren-rich, biotite+titanite monzogranite | ca . 1830 Ma |
| PHA-97-H487 | 14 | 645782 | 6930447 | McKenzie lake metasediments | Hornblende+biotite psammitic gneiss | ca. 2680 Ma |
| PHA-97-H506 | 15 | 412816 | 6906390 | Kaminak pluton | Medium-grained hornblende+biotite+titanite tonalite | 2679±2 Ma |
| PHA-97-H524 | 15 | 415775 | 6906951 | Kaminak pluton | Medium-grained hornblende+biotite+titanite tonalite | 2679±2 Ma |
| PHA-97-H521 | 15 | 398890 | 6918747 | Ferguson pluton | Medium-grained biotite+titanite tonalite | ca. 2679 Ma |
| PHA-97-N48c | 15 | 349736 | 6959203 | McKenzie Lake metasediments | Muscovite+biotite semipelitic schist | ca. 2680 Ma |
| PHA-97-N50a | 15 | 350226 | 6959831 | McKenzie Lake monzogranite | Strongly foliated biotite+monazite monzogranite | 1827± 3 Ma |
| PHA-97-J249 | 14 | 643760 | 6917985 | McKenzie Lake metasediments | Muscovite+biotite semipelitic schist | ca. 2680 Ma |
| CS96-1302 | 14 | 529870 | 6855283 | Yathkyed greenstone belt | Fine-grained hornblende+plagioclase amphibolite | ca. 2692 Ma |
| YD97-7116a | 14 | 578225 | 6922425 | Yathkyed greenstone belt | Banded, medium-grained, hornblende±garnet amphibolite | ca. 2692 Ma |
| YD97-9059 | 14 | 600900 | 6949500 | Yathkyed greenstone belt | Medium-grained, hornblende±garnet amphibolite | ca. 2692 Ma |

[a] - UTM co-ordinates given in NAD 1927 projection.

[b] - Field description supplemented by petrography.

[c] - U-Pb TIMS zircon or monazite age (Davis et al., 2000)

**Table 2.** $^{40}Ar$-$^{39}Ar$ analytical data. Asterisks denote steps excluded from plateau and inverse-correlation age calculations. J-values were determined through interpolation.

| Power[a] | Volume $^{39}Ar$ x$10^{-11}$ cc | $^{36}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{38}Ar/^{39}Ar$ | $^{40}Ar/^{39}Ar$ | % $^{40}Ar$ ATM | *$^{40}Ar/^{39}Ar$ | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **PHA-97-H479 Biotite; J[d]=0.01823610 (Z5435)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *1.5 | 3.7615 | 0.0070 ± 0.0002 | 0.007 ± 136.812 | 0.050 ± 0.001 | 80.022 ± 0.207 | 2.6 | 77.958 ± 0.205 | 1.8 | 1595.64 ± 2.79 |
| *2.0 | 7.9498 | 0.0018 ± 0.0002 | 0.003 ± 224.576 | 0.045 ± 0.001 | 85.927 ± 0.264 | 0.6 | 85.394 ± 0.270 | 3.9 | 1693.93 ± 3.47 |
| 2.2 | 16.6263 | 0.0019 ± 0.0003 | 0.004 ± 271.344 | 0.046 ± 0.001 | 88.374 ± 0.575 | 0.6 | 87.819 ± 0.581 | 8.1 | 1724.86 ± 7.35 |
| 2.4 | 4.9079 | 0.0018 ± 0.0002 | 0.004 ± 159.278 | 0.045 ± 0.001 | 87.947 ± 0.312 | 0.6 | 87.409 ± 0.315 | 2.4 | 1719.67 ± 3.99 |
| 2.6 | 20.9021 | 0.0018 ± 0.0002 | 0.004 ± 46.887 | 0.047 ± 0.002 | 88.477 ± 0.558 | 0.6 | 87.937 ± 0.562 | 10.2 | 1726.35 ± 7.10 |
| 2.8 | 8.2359 | 0.001 ± 0.0002 | 0.002 ± 117.542 | 0.045 ± 0.001 | 89.168 ± 0.198 | 0.4 | 88.855 ± 0.203 | 4.0 | 1737.92 ± 2.54 |
| 3.0 | 18.4797 | 0.0013 ± 0.0003 | 0.003 ± 74.059 | 0.045 ± 0.001 | 89.085 ± 0.496 | 0.4 | 88.689 ± 0.502 | 9.0 | 1735.83 ± 6.31 |
| 3.4 | 18.0873 | 0.001 ± 0.0003 | 0.004 ± 229.253 | 0.048 ± 0.001 | 88.422 ± 0.327 | 0.4 | 88.099 ± 0.337 | 8.8 | 1728.40 ± 4.26 |
| 4.0 | 16.6161 | 0.0015 ± 0.0002 | 0.004 ± 156.259 | 0.048 ± 0.001 | 88.772 ± 0.402 | 0.5 | 88.324 ± 0.406 | 8.1 | 1731.24 ± 5.12 |
| 20.0 | 6.5376 | 0.0035 ± 0.0002 | 0.006 ± 39.753 | 0.048 ± 0.001 | 89.301 ± 0.336 | 1.1 | 88.275 ± 0.338 | 3.2 | 1730.63 ± 4.27 |
| | | | | | *Aliquot: B* | | | | |
| *1.0 | 0.0982 | 0.1340 ± 0.0080 | 0.122 ± 358.130 | 0.092 ± 0.008 | 66.796 ± 2.385 | 59.3 | 27.194 ± 1.725 | 0.1 | 726.58 ± 37.95 |
| *1.5 | 9.0267 | 0.0025 ± 0.0002 | 0.003 ± 156.910 | 0.042 ± 0.001 | 86.573 ± 0.164 | 0.9 | 85.824 ± 0.170 | 4.4 | 1699.45 ± 2.18 |
| 1.8 | 14.772 | 0.0015 ± 0.0002 | 0.002 ± 737.692 | 0.042 ± 0.001 | 87.452 ± 0.327 | 0.5 | 87.018 ± 0.333 | 7.2 | 1714.70 ± 4.24 |
| 2.0 | 7.6331 | 0.0007 ± 0.0002 | 0.003 ± 188.375 | 0.041 ± 0.001 | 87.469 ± 0.435 | 0.2 | 87.260 ± 0.436 | 3.7 | 1717.78 ± 5.54 |
| 2.2 | 10.9009 | 0.0005 ± 0.0001 | 0.002 ± 315.536 | 0.041 ± 0.001 | 87.757 ± 0.268 | 0.2 | 87.607 ± 0.268 | 5.3 | 1722.18 ± 3.40 |
| 2.4 | 7.4602 | 0.0006 ± 0.0002 | 0.002 ± 259.148 | 0.042 ± 0.001 | 87.772 ± 0.496 | 0.2 | 87.590 ± 0.500 | 3.7 | 1721.96 ± 6.33 |
| 2.6 | 17.4477 | 0.0009 ± 0.0002 | 0.011 ± 96.023 | 0.041 ± 0.001 | 88.383 ± 0.368 | 0.3 | 88.107 ± 0.374 | 8.5 | 1728.51 ± 4.71 |
| 2.8 | 2.763 | 0.0014 ± 0.0005 | 0.020 ± 22.704 | 0.041 ± 0.001 | 87.731 ± 0.450 | 0.5 | 87.331 ± 0.462 | 1.4 | 1718.67 ± 5.87 |
| 3.0 | 4.2464 | 0.0009 ± 0.0003 | 0.086 ± 17.672 | 0.042 ± 0.001 | 88.100 ± 0.319 | 0.3 | 87.846 ± 0.325 | 2.1 | 1725.20 ± 4.11 |
| 3.4 | 4.5104 | 0.0010 ± 0.0002 | 0.110 ± 21.906 | 0.040 ± 0.002 | 88.041 ± 0.539 | 0.3 | 87.746 ± 0.540 | 2.2 | 1723.93 ± 6.82 |
| 4.0 | 1.4669 | 0.0025 ± 0.0007 | 0.344 ± 32.864 | 0.046 ± 0.003 | 88.410 ± 1.574 | 0.8 | 87.681 ± 1.576 | 0.7 | 1723.11 ± 19.96 |
| 20.0 | 2.0994 | 0.0025 ± 0.0006 | 0.330 ± 28.570 | 0.042 ± 0.001 | 88.308 ± 0.567 | 0.8 | 87.560 ± 0.578 | 1.0 | 1721.58 ± 7.32 |
| **PHA-97-H479 Hornblende; J=0.01819780 (Z5435)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.0 | 0.4696 | 0.8680 ± 0.0226 | 1.875 ± 48.191 | 0.284 ± 0.013 | 349.296 ± 8.321 | 73.4 | 92.796 ± 10.665 | 0.6 | 1784.35 ± 130.22 |
| *2.5 | 4.0937 | 0.0191 ± 0.0006 | 4.924 ± 9.266 | 0.260 ± 0.003 | 99.202 ± 0.542 | 5.7 | 93.553 ± 0.566 | 5.1 | 1793.56 ± 6.87 |
| 2.8 | 4.0938 | 0.0048 ± 0.0003 | 4.933 ± 18.086 | 0.254 ± 0.003 | 92.185 ± 1.081 | 1.5 | 90.778 ± 1.083 | 5.1 | 1759.54 ± 13.41 |
| 3.0 | 21.0367 | 0.0013 ± 0.0002 | 5.042 ± 10.484 | 0.250 ± 0.003 | 90.990 ± 0.563 | 0.4 | 90.620 ± 0.565 | 26.0 | 1757.57 ± 7.01 |
| 3.2 | 1.9799 | 0.0037 ± 0.0007 | 5.099 ± 8.970 | 0.240 ± 0.004 | 90.005 ± 0.388 | 1.2 | 88.911 ± 0.416 | 2.5 | 1736.28 ± 5.22 |
| 3.4 | 1.8088 | 0.0031 ± 0.0005 | 5.112 ± 12.980 | 0.243 ± 0.005 | 90.349 ± 0.614 | 1 | 89.430 ± 0.612 | 2.2 | 1742.77 ± 7.64 |
| *3.6 | 0.4605 | 0.0159 ± 0.0022 | 4.309 ± 18.643 | 0.215 ± 0.006 | 89.933 ± 0.730 | 5.2 | 85.221 ± 0.762 | 0.6 | 1689.39 ± 9.80 |
| 4.0 | 1.7147 | 0.0035 ± 0.0006 | 4.646 ± 8.403 | 0.236 ± 0.006 | 90.586 ± 0.470 | 1.1 | 89.556 ± 0.475 | 2.1 | 1744.35 ± 5.92 |
| 5.0 | 5.4965 | 0.0018 ± 0.0002 | 5.238 ± 7.099 | 0.252 ± 0.002 | 90.400 ± 0.351 | 0.6 | 89.877 ± 0.354 | 6.8 | 1748.34 ± 4.41 |
| 20.0 | 2.357 | 0.0084 ± 0.0004 | 6.591 ± 19.623 | 0.250 ± 0.004 | 94.293 ± 1.245 | 2.6 | 91.801 ± 1.245 | 2.9 | 1772.16 ± 15.30 |
| | | | | | *Aliquot: B* | | | | |
| *2.0 | 0.3306 | 1.3643 ± 0.0210 | 4.030 ± 23.299 | 1.952 ± 0.034 | 523.271 ± 5.534 | 77 | 120.132 ± 8.276 | 0.4 | 2090.61 ± 85.27 |
| *2.5 | 1.9921 | 0.0149 ± 0.0005 | 5.200 ± 7.842 | 0.277 ± 0.005 | 109.562 ± 0.319 | 4 | 105.148 ± 0.325 | 2.5 | 1929.20 ± 3.66 |
| *2.8 | 25.4783 | 0.0014 ± 0.0003 | 5.660 ± 7.072 | 0.256 ± 0.002 | 93.301 ± 0.336 | 0.4 | 92.893 ± 0.351 | 31.5 | 1785.53 ± 4.28 |
| 3.0 | 6.101 | 0.0021 ± 0.0002 | 5.484 ± 6.150 | 0.256 ± 0.003 | 90.691 ± 0.319 | 0.7 | 90.079 ± 0.323 | 7.5 | 1750.87 ± 4.03 |
| 3.4 | 0.5979 | 0.0097 ± 0.0018 | 5.162 ± 18.267 | 0.243 ± 0.005 | 92.671 ± 1.039 | 3.1 | 89.796 ± 1.063 | 0.7 | 1747.34 ± 13.25 |
| *4.0 | 0.1309 | 0.0398 ± 0.0091 | 4.861 ± 28.420 | 0.261 ± 0.016 | 92.318 ± 2.069 | 12.7 | 80.561 ± 2.617 | 0.2 | 1628.41 ± 34.85 |
| 5.0 | 1.3899 | 0.0064 ± 0.0006 | 5.729 ± 16.967 | 0.234 ± 0.005 | 93.331 ± 1.039 | 2 | 91.425 ± 1.035 | 1.7 | 1767.53 ± 12.75 |
| 20.0 | 1.4309 | 0.0042 ± 0.0006 | 9.350 ± 12.749 | 0.268 ± 0.004 | 90.670 ± 0.733 | 1.4 | 89.435 ± 0.731 | 1.8 | 1742.83 ± 9.13 |
| **PHA-97-H348 Biotite; J=0.01814680 (Z5437)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.0 | 0.1113 | 0.2877 ± 0.0234 | 0.239 ± 141.274 | 0.072 ± 0.009 | 110.356 ± 2.949 | 77 | 25.348 ± 7.082 | 0.2 | 682.72 ± 158.81 |
| *3.0 | 4.9835 | 0.0033 ± 0.0002 | 0.006 ± 200.038 | 0.012 ± 0.001 | 82.856 ± 0.270 | 1.2 | 81.881 ± 0.271 | 9.1 | 1642.86 ± 3.56 |
| *3.4 | 10.5195 | 0.0013 ± 0.0001 | 0.004 ± 181.774 | 0.007 ± 0.000 | 87.332 ± 0.495 | 0.4 | 86.944 ± 0.495 | 19.3 | 1708.34 ± 6.29 |
| 3.8 | 5.3694 | 0.0014 ± 0.0002 | 0.003 ± 455.841 | 0.008 ± 0.000 | 87.602 ± 0.746 | 0.5 | 87.182 ± 0.746 | 9.9 | 1711.36 ± 9.46 |
| 4.2 | 7.7729 | 0.0007 ± 0.0002 | 0.004 ± 286.085 | 0.007 ± 0.000 | 87.722 ± 0.482 | 0.2 | 87.504 ± 0.483 | 14.3 | 1715.43 ± 6.11 |
| 5.0 | 6.2431 | 0.0011 ± 0.0003 | 0.006 ± 132.224 | 0.009 ± 0.001 | 88.088 ± 0.433 | 0.4 | 87.754 ± 0.442 | 11.5 | 1718.60 ± 5.59 |
| 5.7 | 8.84 | 0.0007 ± 0.0001 | 0.009 ± 113.191 | 0.007 ± 0.000 | 88.158 ± 0.463 | 0.2 | 87.946 ± 0.463 | 16.2 | 1721.01 ± 5.85 |
| 6.4 | 5.6594 | 0.0012 ± 0.0002 | 0.036 ± 37.178 | 0.008 ± 0.000 | 88.559 ± 0.203 | 0.4 | 88.210 ± 0.208 | 10.4 | 1724.34 ± 2.62 |
| 6.9 | 2.9229 | 0.0022 ± 0.0006 | 0.022 ± 57.958 | 0.009 ± 0.001 | 88.966 ± 0.602 | 0.7 | 88.323 ± 0.620 | 5.4 | 1725.76 ± 7.79 |
| 12.0 | 2.1004 | 0.0035 ± 0.0005 | 0.243 ± 55.894 | 0.010 ± 0.000 | 89.375 ± 0519 | 1.1 | 88.351 ± 0.524 | 3.9 | 1726.12 ± 6.59 |

a - As measured by laser in % of full nominal power (10W)
b - Fraction 39Ar as percent of total run
c - Errors are analytical only and do not reflect error in irradiation parameter J
d - Nominal J-value, referenced to PP-20 (Hb3gr)=1072 Ma (Roddick, 1983).
* - Step not included in plateau or inverse isotope correlation age determination
All uncertainties quoted at 2s level

**Table 2.** (cont.)

| Power[a] | Volume $^{39}Ar$ $\times 10^{-11}$ cc | $^{36}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{38}Ar/^{39}Ar$ | $^{40}Ar/^{39}Ar$ | % $^{40}Ar$ ATM | $*^{40}Ar/^{39}Ar$ | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **PHA-97-H524A Biotite; J=0.01796820 (Z5442)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| 1.5 | 6.9859 | 0.0147 ± 0.0002 | 0.020 ± 36.113 | 0.016 ± 0.001 | 115.974 ± 0.641 | 3.7 | 111.638 ± 0.642 | 7.0 | 1985.57 ± 6.93 |
| 1.8 | 14.7246 | 0.0025 ± 0.0003 | 0.015 ± 118.431 | 0.010 ± 0.000 | 117.606 ± 0.330 | 0.6 | 116.870 ± 0.340 | 14.7 | 2041.13 ± 3.55 |
| 2.0 | 1.9449 | 0.0046 ± 0.0005 | 0.011 ± 230.586 | 0.009 ± 0.002 | 120.568 ± 0.442 | 1.1 | 119.218 ± 0.448 | 1.9 | 2065.51 ± 4.62 |
| 2.2 | 9.5161 | 0.0021 ± 0.0004 | 0.020 ± 123.611 | 0.010 ± 0.001 | 121.604 ± 1.090 | 0.5 | 120.986 ± 1.097 | 9.5 | 2083.66 ± 11.20 |
| 2.4 | 4.2569 | 0.0012 ± 0.0004 | 0.017 ± 30.459 | 0.009 ± 0.000 | 121.251 ± 0.575 | 0.3 | 120.904 ± 0.584 | 4.3 | 2082.83 ± 5.96 |
| 2.6 | 9.8475 | 0.0016 ± 0.0007 | 0.029 ± 38.925 | 0.009 ± 0.001 | 119.663 ± 0.618 | 0.4 | 119.188 ± 0.650 | 9.8 | 2065.20 ± 6.70 |
| 2.8 | 3.5623 | 0.0026 ± 0.0002 | 0.033 ± 25.427 | 0.010 ± 0.000 | 116.839 ± 0.886 | 0.7 | 116.079 ± 0.886 | 3.6 | 2032.84 ± 9.30 |
| 3.0 | 4.515 | 0.0026 ± 0.0003 | 0.054 ± 47.391 | 0.010 ± 0.000 | 112.904 ± 0.567 | 0.7 | 112.146 ± 0.569 | 4.5 | 1991.04 ± 6.12 |
| 3.4 | 1.2437 | 0.0073 ± 0.0007 | 0.115 ± 28.270 | 0.013 ± 0.001 | 107.515 ± 1.181 | 2 | 105.349 ± 1.175 | 1.2 | 1916.44 ± 13.16 |
| 20.0 | 2.7218 | 0.0072 ± 0.0004 | 0.106 ± 58.731 | 0.010 ± 0.000 | 93.536 ± 0.630 | 2.3 | 91.416 ± 0.634 | 2.7 | 1753.14 ± 7.77 |
| | | | | | *Aliquot: B* | | | | |
| 1.5 | 9.3904 | 0.0123 ± 0.0002 | 0.028 ± 48.663 | 0.018 ± 0.001 | 105.577 ± 0.883 | 3.4 | 101.945 ± 0.884 | 9.4 | 1877.89 ± 10.12 |
| 1.8 | 20.0719 | 0.0012 ± 0.0003 | 0.036 ± 26.019 | 0.013 ± 0.000 | 109.724 ± 0.650 | 0.3 | 109.382 ± 0.656 | 20.0 | 1961.08 ± 7.17 |
| 2.0 | 2.4622 | 0.0014 ± 0.0006 | 0.043 ± 37.948 | 0.014 ± 0.000 | 111.611 ± 0.846 | 0.4 | 111.200 ± 0.856 | 2.5 | 1980.85 ± 9.26 |
| 2.2 | 5.3413 | 0.0011 ± 0.0002 | 0.364 ± 13.797 | 0.012 ± 0.000 | 106.890 ± 0.557 | 0.3 | 106.576 ± 0.557 | 5.3 | 1930.14 ± 6.19 |
| 2.4 | 0.7349 | 0.0048 ± 0.0016 | 0.988 ± 20.201 | 0.017 ± 0.002 | 79.202 ± 0.602 | 1.8 | 77.778 ± 0.662 | 0.7 | 1577.57 ± 8.95 |
| 2.8 | 0.2823 | 0.0086 ± 0.0033 | 1.059 ± 35.042 | 0.025 ± 0.005 | 98.727 ± 1.284 | 2.6 | 96.189 ± 1.270 | 0.3 | 1810.77 ± 15.08 |
| 20.0 | 2.6222 | 0.0023 ± 0.0008 | 0.181 ± 47.218 | 0.008 ± 0.001 | 71.374 ± 0.541 | 0.9 | 70.705 ± 0.576 | 2.6 | 1479.31 ± 8.22 |
| **PHA-97-H161 Hornblende; J=0.01834190 (Z5444)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.0 | 0.3552 | 0.2027 ± 0.0053 | 3.279 ± 39.277 | 0.857 ± 0.024 | 846.620 ± 15.260 | 7.1 | 786.714 ± 15.317 | 0.5 | 4936.56 ± 32.86 |
| *2.2 | 5.8831 | 0.0049 ± 0.0009 | 5.489 ± 16.608 | 0.157 ± 0.003 | 199.414 ± 1.927 | 0.7 | 197.963 ± 1.946 | 7.8 | 2765.29 ± 13.91 |
| *2.4 | 0.5893 | 0.0085 ± 0.0023 | 4.867 ± 21.887 | 0.114 ± 0.003 | 167.626 ± 2.117 | 1.5 | 165.102 ± 2.173 | 0.8 | 2513.72 ± 17.85 |
| *2.6 | 6.4227 | 0.0047 ± 0.0007 | 5.706 ± 15.243 | 0.144 ± 0.002 | 194.448 ± 1.837 | 0.7 | 193.073 ± 1.850 | 8.5 | 2730.00 ± 13.47 |
| *2.8 | 12.4301 | 0.0020 ± 0.0006 | 5.788 ± 12.154 | 0.128 ± 0.002 | 184.135 ± 1.212 | 0.3 | 183.551 ± 1.222 | 16.4 | 2659.24 ± 9.27 |
| *3.0 | 1.6171 | 0.0037 ± 0.0009 | 5.525 ± 21.808 | 0.089 ± 0.003 | 175.770 ± 2.315 | 0.6 | 174.682 ± 2.323 | 2.1 | 2590.76 ± 18.29 |
| *3.4 | 0.3178 | 0.0141 ± 0.0030 | 6.935 ± 25.397 | 0.113 ± 0.003 | 172.687 ± 2.173 | 2.4 | 168.513 ± 2.169 | 0.4 | 2541.53 ± 17.54 |
| *4.0 | 0.8367 | 0.0073 ± 0.0012 | 5.155 ± 21.713 | 0.085 ± 0.002 | 142.874 ± 1.885 | 1.5 | 140.722 ± 1.887 | 1.1 | 2301.44 ± 17.44 |
| *20.0 | 2.0796 | 0.0089 ± 0.0009 | 8.876 ± 16.705 | 0.124 ± 0.003 | 163.106 ± 1.779 | 1.6 | 160.480 ± 1.794 | 2.7 | 2475.35 ± 15.06 |
| | | | | | *Aliquot: B* | | | | |
| *2.0 | 0.1648 | 0.5382 ± 0.0168 | 3.946 ± 34.042 | 1.786 ± 0.054 | 1396.404 ± 21.335 | 11.4 | 1237.361 ± 21.839 | 0.2 | 5710.49 ± 30.50 |
| *2.2 | 0.2332 | 0.0742 ± 0.0037 | 3.882 ± 29.292 | 0.267 ± 0.008 | 211.214 ± 2.565 | 10.4 | 189.279 ± 2.506 | 0.3 | 2702.14 ± 18.55 |
| *2.4 | 0.2891 | 0.0268 ± 0.0038 | 3.141 ± 61.343 | 0.082 ± 0.017 | 132.886 ± 3.150 | 6 | 124.978 ± 3.196 | 0.4 | 2149.75 ± 32.12 |
| *2.6 | 4.5957 | 0.0047 ± 0.0006 | 5.915 ± 11.144 | 0.197 ± 0.003 | 200.425 ± 1.176 | 0.7 | 199.026 ± 1.190 | 6.1 | 2772.86 ± 8.47 |
| 2.8 | 4.2871 | 0.0019 ± 0.0002 | 5.190 ± 16.129 | 0.158 ± 0.002 | 179.598 ± 1.751 | 0.3 | 179.049 ± 1.751 | 5.6 | 2624.80 ± 13.52 |
| 3.0 | 18.6968 | 0.0014 ± 0.0004 | 5.322 ± 7.219 | 0.136 ± 0.001 | 179.171 ± 0.667 | 0.2 | 178.762 ± 0.679 | 24.6 | 2622.59 ± 5.26 |
| 3.2 | 5.1406 | 0.0012 ± 0.0003 | 5.431 ± 10.190 | 0.124 ± 0.003 | 178.413 ± 1.107 | 0.2 | 178.071 ± 1.109 | 6.8 | 2617.23 ± 8.61 |
| 3.4 | 7.0839 | 0.0023 ± 0.0008 | 5.573 ± 19.847 | 0.102 ± 0.003 | 179.780 ± 1.809 | 0.4 | 179.090 ± 1.823 | 9.3 | 2625.12 ± 14.08 |
| *4.0 | 0.6679 | 0.0062 ± 0.0014 | 6.282 ± 29.428 | 0.128 ± 0.005 | 169.428 ± 2.480 | 1.1 | 167.593 ± 2.480 | 0.9 | 2534.07 ± 20.15 |
| *20.0 | 4.2555 | 0.0014 ± 0.0005 | 6.792 ± 8.177 | 0.125 ± 0.001 | 163.871 ± 0.847 | 0.3 | 163.457 ± 0.857 | 5.6 | 2500.16 ± 7.08 |
| **PHA-97-N48 Muscovite; J=0.01825610 (Z5447)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| 3.0 | 0.0104 | 0.5278 ± 0.1458 | 1.552 ± 665.602 | 0.259 ± 0.136 | 130.972 ± 35.226 | 119.1 | -24.995 ± -48.631 | 0.0 | -1099.39 ± -2946.00 |
| 3.8 | 0.0038 | 0.3851 ± 0.4571 | 4.613 ± 1129.731 | 1.220 ± 0.960 | 251.750 ± 218.535 | 45.2 | 137.966 ± 246.192 | 0.0 | 2269.73 ± 2304.40 |
| 4.2 | 0.0065 | 0.4794 ± 0.2312 | 3.506 ± 368.800 | 0.200 ± 0.175 | 141.564 ± 52.082 | 100.1 | -0.101 ± -74.197 | 0.0 | -3.34 ± -2449.30 |
| 5.0 | 0.0066 | 0.7255 ± 0.4951 | 2.742 ± 938.427 | 0.035 ± 0.184 | 181.684 ± 127.562 | 118 | -32.707 ± -189.447 | 0.0 | -1640.06 ± -15487.00 |
| 5.4 | 0.0075 | 0.7167 ± 0.4132 | 2.877 ± 725.957 | 0.400 ± 0.292 | 129.782 ± 80.733 | 163.2 | -82.009 ± -141.521 | 0.0 | 0.00 ± 0.00 |
| 12.0 | 40.227 | 0.0008 ± 0.0001 | 0.002 ± 293.958 | 0.003 ± 0.000 | 88.583 ± 0.316 | 0.3 | 88.346 ± 0.318 | 32.4 | 1732.74 ± 4.01 |
| | | | | | *Aliquot: B* | | | | |
| 3.0 | 46.0863 | 0.0010 ± 0.0002 | 2.261 ± 378.362 | 0.003 ± 0.000 | 88.938 ± 0.206 | 0.3 | 88.644 ± 0.224 | 37.1 | 1736.48 ± 2.82 |
| 3.5 | 19.6508 | 0.0003 ± 0.0005 | 5.382 ± 316.505 | 0.003 ± 0.001 | 88.758 ± 0.488 | 0.1 | 88.676 ± 0.523 | 15.8 | 1736.89 ± 6.58 |
| 4.0 | 1.4476 | 0.0033 ± 0.0015 | 6.579 ± 859.005 | 0.005 ± 0.001 | 90.629 ± 0.787 | 1.1 | 89.662 ± 0.964 | 1.2 | 1749.25 ± 12.04 |
| 12.0 | 3.4466 | 0.0000 ± 0.0006 | 7.037 ± 203.486 | 0.002 ± 0.001 | 89.275 ± 0.453 | 0 | 89.271 ± 0.492 | 2.8 | 1744.35 ± 6.16 |
| **PHA-97-N48 Biotite; J=0.01822390 (Z5447)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.0 | 0.1455 | 0.1515 ± 0.0056 | 0.172 ± 179.486 | 0.159 ± 0.007 | 74.033 ± 1.895 | 60.5 | 29.274 ± 1.599 | 0.3 | 771.34 ± 34.29 |
| *2.4 | 0.3748 | 0.0303 ± 0.0024 | 0.059 ± 260.698 | 0.086 ± 0.003 | 74.221 ± 1.285 | 12.1 | 65.266 ± 1.252 | 0.9 | 1413.74 ± 18.81 |
| *3.0 | 3.5964 | 0.0031 ± 0.0003 | 0.005 ± 549.052 | 0.049 ± 0.001 | 90.064 ± 0.278 | 1 | 89.152 ± 0.283 | 8.4 | 1740.89 ± 3.54 |
| *3.4 | 1.6257 | 0.0047 ± 0.0005 | 0.016 ± 193.260 | 0.048 ± 0.002 | 93.888 ± 0.707 | 1.5 | 92.485 ± 0.700 | 3.8 | 1782.16 ± 8.57 |
| *3.8 | 1.0102 | 0.0058 ± 0.0017 | 0.019 ± 392.087 | 0.050 ± 0.002 | 94.648 ± 0.917 | 1.8 | 92.947 ± 1.005 | 2.4 | 1787.81 ± 12.27 |
| *4.2 | 0.5404 | 0.0086 ± 0.0033 | 0.036 ± 232.810 | 0.052 ± 0.002 | 95.634 ± 1.899 | 2.7 | 93.081 ± 2.073 | 1.3 | 1789.46 ± 25.28 |
| *5.2 | 0.5336 | 0.0173 ± 0.0015 | 0.044 ± 102.123 | 0.050 ± 0.002 | 96.996 ± 1.589 | 5.3 | 91.876 ± 1.567 | 1.2 | 1774.70 ± 19.27 |
| *12.0 | 0.6721 | 0.0136 ± 0.0016 | 0.024 ± 377.732 | 0.046 ± 0.002 | 94.795 ± 1.283 | 4.2 | 90.788 ± 1.299 | 1.6 | 1761.27 ± 16.09 |

## Table 2. (cont.)

| Power[a] | Volume $^{39}$Ar x$10^{-11}$ cc | $^{36}$Ar/$^{39}$Ar | $^{37}$Ar/$^{39}$Ar | $^{38}$Ar/$^{39}$Ar | $^{40}$Ar/$^{39}$Ar | %$^{40}$Ar ATM | *$^{40}$Ar/$^{39}$Ar | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **PHA-97-N48 Biotite; J=0.01822390 (Z5447)** (cont.) | | | | | | | | | |
| | | | | | *Aliquot: B* | | | | |
| *2.4 | 1.4139 | 0.0173 ± 0.0013 | 0.013 ± 367.221 | 0.049 ± 0.002 | 77.370 ± 0.583 | 6.6 | 72.257 ± 0.663 | 3.3 | 1515.78 ± 9.40 |
| *2.9 | 3.9921 | 0.0030 ± 0.0003 | 0.008 ± 177.601 | 0.042 ± 0.001 | 88.091 ± 0.677 | 1 | 87.209 ± 0.678 | 9.3 | 1716.38 ± 8.62 |
| 4.0 | 15.273 | 0.0013 ± 0.0002 | 0.005 ± 317.224 | 0.042 ± 0.002 | 89.817 ± 0.674 | 0.4 | 89.424 ± 0.676 | 35.6 | 1744.30 ± 8.46 |
| 4.2 | 6.6377 | 0.0012 ± 0.0001 | 0.003 ± 365.383 | 0.040 ± 0.001 | 89.708 ± 0.323 | 0.4 | 89.341 ± 0.322 | 15.5 | 1743.26 ± 4.03 |
| 4.3 | 3.64 | 0.0014 ± 0.0003 | 0.004 ± 520.577 | 0.043 ± 0.001 | 90.115 ± 0.558 | 0.5 | 89.709 ± 0.558 | 8.5 | 1747.86 ± 6.96 |
| 5.7 | 2.0101 | 0.0026 ± 0.0006 | 0.007 ± 452.409 | 0.039 ± 0.001 | 89.537 ± 0.559 | 0.9 | 88.768 ± 0.568 | 4.7 | 1736.08 ± 7.14 |
| 6.6 | 0.7871 | 0.0069 ± 0.0011 | 0.022 ± 290.617 | 0.045 ± 0.002 | 89.994 ± 1.028 | 2.3 | 87.942 ± 1.013 | 1.8 | 1725.67 ± 12.80 |
| 12.0 | 0.655 | 0.0062 ± 0.0015 | 0.020 ± 468.781 | 0.049 ± 0.002 | 90.719 ± 2.055 | 2 | 88.878 ± 2.060 | 1.5 | 1737.46 ± 25.85 |
| **PHA-97-H487 Biotite; J=0.01819180 (Z5450)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.1 | 1.4395 | 0.0102 ± 0.0005 | 0.018 ± 181.243 | 0.065 ± 0.003 | 84.330 ± 0.593 | 3.6 | 81.307 ± 0.581 | 2.3 | 1637.95 ± 7.69 |
| 2.3 | 2.0434 | 0.0022 ± 0.0005 | 0.011 ± 175.174 | 0.056 ± 0.003 | 88.969 ± 0.521 | 0.7 | 88.331 ± 0.520 | 3.3 | 1728.61 ± 6.55 |
| 3.1 | 2.7012 | 0.0025 ± 0.0006 | 0.007 ± 462.472 | 0.056 ± 0.001 | 88.937 ± 0.571 | 0.8 | 88.207 ± 0.590 | 4.4 | 1727.05 ± 7.44 |
| 3.8 | 10.2418 | 0.0007 ± 0.0002 | 0.003 ± 165.080 | 0.055 ± 0.001 | 88.584 ± 0.431 | 0.2 | 88.365 ± 0.433 | 16.6 | 1729.05 ± 5.45 |
| 4.2 | 5.9446 | 0.0009 ± 0.0002 | 0.002 ± 305.680 | 0.056 ± 0.002 | 88.689 ± 0.426 | 0.3 | 88.425 ± 0.428 | 9.6 | 1729.80 ± 5.39 |
| 5.0 | 7.1903 | 0.0009 ± 0.0002 | 0.004 ± 154.128 | 0.053 ± 0.001 | 88.572 ± 0.524 | 0.3 | 88.314 ± 0.525 | 11.7 | 1728.41 ± 6.62 |
| 5.4 | 1.9234 | 0.0024 ± 0.0007 | 0.007 ± 355.350 | 0.053 ± 0.001 | 87.981 ± 0.615 | 0.8 | 87.275 ± 0.628 | 3.1 | 1715.27 ± 7.97 |
| *6.3 | 1.4549 | 0.0050 ± 0.0005 | 0.017 ± 101.204 | 0.057 ± 0.002 | 87.871 ± 0.816 | 1.7 | 86.386 ± 0.807 | 2.4 | 1703.97 ± 10.30 |
| *6.6 | 0.3102 | 0.0275 ± 0.0025 | 0.064 ± 75.838 | 0.082 ± 0.005 | 93.596 ± 2.195 | 8.7 | 85.480 ± 2.128 | 0.5 | 1692.37 ± 27.34 |
| *12.0 | 0.4393 | 0.0095 ± 0.0045 | 0.021 ± 1029.532 | 0.057 ± 0.006 | 90.419 ± 1.911 | 3.1 | 87.607 ± 2.247 | 0.7 | 1719.48 ± 28.43 |
| | | | | | *Aliquot: B* | | | | |
| *2.2 | 0.4113 | 0.0196 ± 0.0022 | 0.044 ± 209.101 | 0.065 ± 0.002 | 78.028 ± 1.325 | 7.4 | 72.246 ± 1.311 | 0.7 | 1513.81 ± 18.59 |
| *3.0 | 2.9038 | 0.0029 ± 0.0005 | 0.007 ± 286.233 | 0.052 ± 0.002 | 86.879 ± 0.360 | 1 | 86.009 ± 0.371 | 4.7 | 1699.15 ± 4.75 |
| 3.3 | 2.5427 | 0.0014 ± 0.0006 | 0.009 ± 120.739 | 0.052 ± 0.002 | 88.197 ± 0.779 | 0.5 | 87.786 ± 0.790 | 4.1 | 1721.74 ± 9.99 |
| *3.8 | 0.0154 | 0.0394 ± 0.0645 | 0.869 ± 379.695 | 0.306 ± 0.071 | 59.901 ± 14.594 | 19.4 | 48.273 ± 15.487 | 0.0 | 1137.13 ± 270.63 |
| 4.6 | 9.465 | 0.0006 ± 0.0002 | 0.003 ± 403.093 | 0.052 ± 0.001 | 87.583 ± 0.190 | 0.2 | 87.394 ± 0.196 | 15.3 | 1716.79 ± 2.48 |
| 5.1 | 5.0534 | 0.0009 ± 0.0002 | 0.004 ± 539.165 | 0.051 ± 0.001 | 87.823 ± 0.385 | 0.3 | 87.556 ± 0.387 | 8.2 | 1718.84 ± 4.90 |
| 5.7 | 2.1014 | 0.0018 ± 0.0006 | 0.007 ± 520.519 | 0.054 ± 0.003 | 88.095 ± 0.943 | 0.6 | 87.561 ± 0.951 | 3.4 | 1718.90 ± 12.04 |
| 6.7 | 4.7912 | 0.0020 ± 0.0003 | 0.007 ± 227.033 | 0.056 ± 0.002 | 89.423 ± 0.487 | 0.7 | 88.821 ± 0.491 | 7.8 | 1734.77 ± 6.16 |
| 12.0 | 0.755 | 0.0071 ± 0.0021 | 0.014 ± 550.980 | 0.054 ± 0.001 | 89.336 ± 1.045 | 2.4 | 87.224 ± 1.150 | 1.2 | 1714.63 ± 14.60 |
| **PHA-97-H487 Hornblende; J=0.01811670 (Z5450)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *4.0 | 0.0462 | 0.4018 ± 0.0303 | 2.785 ± 169.334 | 0.233 ± 0.042 | 357.311 ± 17.055 | 33.2 | 238.576 ± 18.270 | 0.2 | 3016.25 ± 112.20 |
| *4.4 | 0.0614 | 0.2347 ± 0.0156 | 3.101 ± 66.858 | 0.246 ± 0.027 | 159.347 ± 5.943 | 43.5 | 90.007 ± 5.967 | 0.3 | 1744.96 ± 74.13 |
| *4.9 | 0.1011 | 0.0389 ± 0.0103 | 5.690 ± 85.813 | 0.375 ± 0.022 | 111.492 ± 6.301 | 10.3 | 100.004 ± 6.423 | 0.5 | 1865.08 ± 74.67 |
| *5.1 | 0.1702 | 0.0293 ± 0.0063 | 4.979 ± 39.649 | 0.332 ± 0.013 | 122.362 ± 2.893 | 7.1 | 113.700 ± 3.012 | 0.8 | 2017.65 ± 32.17 |
| *5.3 | 0.1394 | 0.0358 ± 0.0057 | 5.033 ± 44.818 | 0.326 ± 0.011 | 101.179 ± 2.884 | 10.5 | 90.605 ± 2.656 | 0.6 | 1752.38 ± 32.86 |
| 5.6 | 8.9708 | 0.0011 ± 0.0002 | 5.220 ± 6.981 | 0.338 ± 0.002 | 94.756 ± 0.378 | 0.3 | 94.439 ± 0.383 | 40.9 | 1799.21 ± 4.63 |
| *6.2 | 0.2179 | 0.0221 ± 0.0032 | 5.535 ± 16.608 | 0.323 ± 0.008 | 96.890 ± 1.235 | 6.7 | 90.361 ± 0.854 | 1.0 | 1749.35 ± 10.58 |
| | | | | | *Aliquot: B* | | | | |
| *4.0 | 0.0689 | 0.5128 ± 0.0438 | 2.444 ± 78.955 | 0.485 ± 0.033 | 261.111 ± 13.970 | 58 | 109.565 ± 18.605 | 0.3 | 1972.94 ± 203.72 |
| 5.1 | 9.9617 | 0.0019 ± 0.0001 | 5.327 ± 4.753 | 0.335 ± 0.003 | 94.329 ± 0.291 | 0.6 | 93.781 ± 0.291 | 45.4 | 1791.26 ± 3.53 |
| *5.4 | 0.3851 | 0.0134 ± 0.0069 | 5.066 ± 20.999 | 0.321 ± 0.005 | 95.142 ± 0.948 | 4.2 | 91.189 ± 2.130 | 1.8 | 1759.59 ± 26.25 |
| *5.8 | 0.264 | 0.0120 ± 0.0058 | 4.492 ± 47.801 | 0.340 ± 0.021 | 90.338 ± 3.035 | 3.9 | 86.797 ± 3.326 | 1.2 | 1704.64 ± 42.26 |
| *12.0 | 1.5386 | 0.0025 ± 0.0008 | 5.466 ± 20.202 | 0.328 ± 0.006 | 92.527 ± 0.943 | 0.8 | 91.785 ± 0.956 | 7.0 | 1766.92 ± 11.74 |
| **PHA-97-J249 Biotite; J=0.01808450 (Z5451)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| 2.0 | 0.0366 | 0.2562 ± 0.0358 | 0.552 ± 210.150 | 0.213 ± 0.035 | 99.740 ± 10.166 | 75.9 | 24.029 ± 12.499 | 0.1 | 651.01 ± 284.26 |
| 2.7 | 1.0926 | 0.0077 ± 0.0008 | 0.015 ± 749.746 | 0.035 ± 0.001 | 81.655 ± 0.845 | 2.8 | 79.370 ± 0.837 | 1.5 | 1605.83 ± 11.22 |
| 3.0 | 1.5705 | 0.0049 ± 0.0005 | 0.010 ± 406.440 | 0.030 ± 0.001 | 86.173 ± 0.525 | 1.7 | 84.724 ± 0.512 | 2.2 | 1676.16 ± 6.59 |
| 3.9 | 2.2872 | 0.0060 ± 0.0005 | 0.008 ± 339.721 | 0.033 ± 0.001 | 89.959 ± 0.801 | 2 | 88.190 ± 0.804 | 3.2 | 1720.27 ± 10.11 |
| 4.6 | 9.1565 | 0.0010 ± 0.0002 | 0.003 ± 139.860 | 0.031 ± 0.001 | 89.148 ± 0.129 | 0.3 | 88.865 ± 0.136 | 12.7 | 1728.75 ± 1.70 |
| 5.0 | 2.0023 | 0.0030 ± 0.0007 | 0.004 ± 863.168 | 0.031 ± 0.001 | 87.851 ± 0.407 | 1 | 86.957 ± 0.439 | 2.8 | 1704.70 ± 5.57 |
| 5.5 | 1.3804 | 0.0043 ± 0.0007 | 0.016 ± 124.321 | 0.037 ± 0.002 | 89.045 ± 0.714 | 1.4 | 87.789 ± 0.715 | 1.9 | 1715.23 ± 9.01 |
| 6.5 | 0.8488 | 0.0057 ± 0.0019 | 0.018 ± 404.193 | 0.035 ± 0.002 | 90.256 ± 1.428 | 1.9 | 88.560 ± 1.498 | 1.2 | 1724.92 ± 18.78 |
| 12.0 | 0.4856 | 0.0108 ± 0.0015 | 0.026 ± 539.913 | 0.037 ± 0.002 | 88.914 ± 1.193 | 3.6 | 85.732 ± 1.136 | 0.7 | 1689.10 ± 14.54 |

## Table 2. (cont.)

| Power[a] | Volume $^{39}Ar$ x$10^{-11}$ cc | $^{36}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{38}Ar/^{39}Ar$ | $^{40}Ar/^{39}Ar$ | % $^{40}Ar$ ATM | $*^{40}Ar/^{39}Ar$ | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **PHA-97-J249 Biotite; J=0.01808450 (Z5451)** (cont.) | | | | | | | | | |
| | | | | | *Aliquot: B* | | | | |
| *2.1 | 0.2849 | 0.0639 ± 0.0037 | 0.049 ± 345.532 | 0.063 ± 0.003 | 71.136 ± 1.565 | 26.5 | 52.258 ± 1.626 | 0.4 | 1200.26 ± 27.27 |
| *2.4 | 0.3903 | 0.0192 ± 0.0025 | 0.033 ± 760.619 | 0.040 ± 0.002 | 65.093 ± 0.824 | 8.7 | 59.408 ± 0.837 | 0.5 | 1316.36 ± 13.17 |
| *3.0 | 5.6199 | 0.0020 ± 0.0003 | 0.005 ± 131.691 | 0.032 ± 0.001 | 87.716 ± 0.341 | 0.7 | 87.134 ± 0.347 | 7.8 | 1706.94 ± 4.40 |
| 3.8 | 9.6749 | 0.0009 ± 0.0002 | 0.002 ± 300.500 | 0.031 ± 0.001 | 88.441 ± 0.250 | 0.3 | 88.161 ± 0.254 | 13.4 | 1719.91 ± 3.19 |
| 3.9 | 4.9264 | 0.0012 ± 0.0002 | 0.005 ± 355.675 | 0.031 ± 0.001 | 88.497 ± 0.496 | 0.4 | 88.146 ± 0.496 | 6.8 | 1719.72 ± 6.25 |
| 4.6 | 16.3056 | 0.0022 ± 0.0002 | 0.010 ± 94.543 | 0.031 ± 0.001 | 88.574 ± 0.466 | 0.7 | 87.910 ± 0.469 | 22.5 | 1716.75 ± 5.90 |
| 5.0 | 9.3302 | 0.0006 ± 0.0001 | 0.010 ± 155.135 | 0.030 ± 0.001 | 88.180 ± 0.294 | 0.2 | 88.000 ± 0.294 | 12.9 | 1717.88 ± 3.71 |
| 5.8 | 6.4458 | 0.0010 ± 0.0003 | 0.028 ± 20.809 | 0.032 ± 0.001 | 88.369 ± 0.325 | 0.3 | 88.072 ± 0.336 | 8.9 | 1718.79 ± 4.22 |
| *6.3 | 0.3264 | 0.0186 ± 0.0025 | 0.073 ± 158.812 | 0.039 ± 0.002 | 89.955 ± 2.300 | 6.1 | 84.445 ± 2.261 | 0.5 | 1672.57 ± 29.19 |
| *12.0 | 0.2446 | 0.0178 ± 0.0032 | 0.084 ± 343.587 | 0.055 ± 0.004 | 88.702 ± 1.903 | 5.9 | 83.446 ± 1.787 | 0.3 | 1659.61 ± 23.24 |
| **PHA-97-H506 Hornblende; J=0.01802020 (Z5467)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *3.0 | 0.0312 | 2.2520 ± 0.1817 | 5.170 ± 127.903 | 1.470 ± 0.138 | 2239.651 ± 154.530 | 29.7 | 1574.181 ± 163.353 | 0.1 | 6097.63 ± 180.84 |
| *4.0 | 0.0375 | 0.3115 ± 0.0247 | 2.376 ± 69.168 | 0.247 ± 0.031 | 381.483 ± 13.600 | 24.1 | 289.429 ± 13.484 | 0.1 | 3296.19 ± 70.54 |
| *4.6 | 0.3432 | 0.0273 ± 0.0027 | 3.684 ± 30.505 | 0.082 ± 0.002 | 183.856 ± 1.450 | 4.4 | 175.798 ± 1.440 | 0.9 | 2575.20 ± 11.23 |
| *4.9 | 0.0276 | 0.2863 ± 0.0433 | 6.861 ± 159.629 | 0.349 ± 0.046 | 285.008 ± 31.465 | 29.7 | 200.417 ± 32.397 | 0.1 | 2757.68 ± 228.39 |
| *5.2 | 2.4155 | 0.0039 ± 0.0006 | 5.545 ± 14.855 | 0.184 ± 0.003 | 193.800 ± 1.743 | 0.6 | 192.639 ± 1.747 | 6.4 | 2702.00 ± 12.70 |
| 5.3 | 0.4829 | 0.0145 ± 0.0025 | 5.411 ± 40.433 | 0.169 ± 0.008 | 189.180 ± 3.890 | 2.3 | 184.899 ± 3.918 | 1.3 | 2644.83 ± 29.41 |
| 5.5 | 1.2118 | 0.0045 ± 0.0010 | 5.378 ± 25.103 | 0.166 ± 0.004 | 184.772 ± 1.269 | 0.7 | 183.444 ± 1.282 | 3.2 | 2633.88 ± 9.69 |
| 6.0 | 1.9906 | 0.0037 ± 0.0007 | 5.638 ± 16.223 | 0.171 ± 0.004 | 187.596 ± 1.955 | 0.6 | 186.511 ± 1.960 | 5.3 | 2656.89 ± 14.62 |
| 6.6 | 3.7051 | 0.0027 ± 0.0004 | 5.578 ± 16.520 | 0.161 ± 0.003 | 186.694 ± 1.884 | 0.4 | 185.891 ± 1.885 | 9.8 | 2652.26 ± 14.09 |
| 12.0 | 14.1262 | 0.0021 ± 0.0003 | 5.955 ± 16.762 | 0.200 ± 0.003 | 186.780 ± 1.977 | 0.3 | 186.163 ± 1.979 | 37.4 | 2654.29 ± 14.77 |
| | | | | | *Aliquot: B* | | | | |
| *3.0 | 0.0256 | 0.9029 ± 0.0916 | 3.351 ± 141.452 | 1.317 ± 0.145 | 1562.392 ± 147.776 | 17.1 | 1295.576 ± 149.833 | 0.1 | 5759.39 ± 200.08 |
| *4.0 | 0.0333 | 0.1924 ± 0.0457 | 1.393 ± 250.267 | 0.186 ± 0.047 | 183.850 ± 31.727 | 30.9 | 127.004 ± 33.427 | 0.1 | 2147.73 ± 330.45 |
| 4.6 | 5.2009 | 0.0030 ± 0.0003 | 5.971 ± 9.659 | 0.219 ± 0.003 | 188.575 ± 0.601 | 0.5 | 187.698 ± 0.604 | 13.8 | 2665.72 ± 4.49 |
| 4.8 | 0.8116 | 0.0067 ± 0.0016 | 5.839 ± 33.431 | 0.212 ± 0.007 | 185.411 ± 3.277 | 1.1 | 183.441 ± 3.291 | 2.2 | 2633.85 ± 24.85 |
| 5.4 | 1.3365 | 0.0044 ± 0.0010 | 6.640 ± 26.968 | 0.168 ± 0.005 | 185.463 ± 2.629 | 0.7 | 184.158 ± 2.639 | 3.5 | 2639.26 ± 19.86 |
| 6.2 | 4.3469 | 0.0022 ± 0.0004 | 9.723 ± 10.517 | 0.109 ± 0.002 | 185.479 ± 0.844 | 0.4 | 184.828 ± 0.848 | 11.5 | 2644.29 ± 6.38 |
| 6.6 | 0.5127 | 0.0125 ± 0.0017 | 7.992 ± 33.182 | 0.160 ± 0.005 | 184.285 ± 3.957 | 2 | 180.588 ± 3.953 | 1.4 | 2612.18 ± 30.20 |
| *7.4 | 0.4057 | 0.0116 ± 0.0018 | 7.595 ± 28.413 | 0.207 ± 0.010 | 194.452 ± 2.227 | 1.8 | 191.025 ± 2.180 | 1.1 | 2690.23 ± 15.95 |
| *12.0 | 0.7387 | 0.0060 ± 0.0013 | 7.758 ± 21.215 | 0.163 ± 0.004 | 184.840 ± 2.249 | 1 | 183.076 ± 2.252 | 2.0 | 2631.09 ± 17.03 |
| **PHA-97-H319 Biotite; J=0.01863640 (Z5468)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *1.5 | 12.474 | 0.0079 ± 0.0009 | 0.012 ± 204.449 | 0.007 ± 0.001 | 82.648 ± 0.392 | 2.8 | 80.315 ± 0.473 | 5.2 | 1650.75 ± 6.37 |
| *1.7 | 3.6093 | 0.0012 ± 0.0005 | 0.008 ± 87.172 | 0.003 ± 0.001 | 86.269 ± 0.955 | 0.4 | 85.929 ± 0.965 | 1.5 | 1724.82 ± 12.47 |
| *1.9 | 15.4729 | 0.0016 ± 0.0002 | 0.011 ± 101.795 | 0.003 ± 0.000 | 85.867 ± 0.421 | 0.6 | 85.380 ± 0.423 | 6.4 | 1717.70 ± 5.50 |
| *2.2 | 23.1224 | 0.0011 ± 0.0001 | 0.009 ± 65.476 | 0.003 ± 0.000 | 86.174 ± 0.550 | 0.4 | 85.860 ± 0.551 | 9.6 | 1723.92 ± 7.12 |
| 2.4 | 15.3995 | 0.0012 ± 0.0003 | 0.015 ± 73.409 | 0.003 ± 0.001 | 87.378 ± 0.470 | 0.4 | 87.013 ± 0.479 | 6.4 | 1738.77 ± 6.14 |
| 2.6 | 28.3529 | 0.0007 ± 0.0002 | 0.015 ± 44.815 | 0.003 ± 0.000 | 87.552 ± 0.473 | 0.3 | 87.333 ± 0.478 | 11.7 | 1742.87 ± 6.11 |
| 2.8 | 7.0522 | 0.0006 ± 0.0001 | 0.005 ± 149.717 | 0.002 ± 0.000 | 87.530 ± 0.572 | 0.2 | 87.364 ± 0.571 | 2.9 | 1743.26 ± 7.31 |
| 3.4 | 12.2727 | 0.0009 ± 0.0004 | 0.011 ± 302.455 | 0.004 ± 0.000 | 87.225 ± 0.536 | 0.3 | 86.959 ± 0.546 | 5.1 | 1738.08 ± 7.01 |
| 20.0 | 7.6935 | 0.0008 ± 0.0002 | 0.007 ± 150.221 | 0.003 ± 0.000 | 86.560 ± 0.294 | 0.3 | 86.318 ± 0.298 | 3.2 | 1729.84 ± 3.84 |
| | | | | | *Aliquot: B* | | | | |
| *1.3 | 1.0538 | 0.0753 ± 0.0017 | 0.030 ± 224.521 | 0.026 ± 0.001 | 90.926 ± 0.913 | 24.5 | 68.682 ± 1.002 | 0.4 | 1486.89 ± 14.78 |
| *1.5 | 12.4842 | 0.0025 ± 0.0004 | 0.007 ± 230.881 | 0.006 ± 0.000 | 84.478 ± 0.367 | 0.9 | 83.741 ± 0.386 | 5.2 | 1696.31 ± 5.07 |
| 1.7 | 3.2686 | 0.0017 ± 0.0005 | 0.008 ± 237.837 | 0.004 ± 0.000 | 87.493 ± 0.627 | 0.6 | 86.986 ± 0.636 | 1.4 | 1738.43 ± 8.16 |
| 1.9 | 12.5001 | 0.0016 ± 0.0003 | 0.012 ± 47.568 | 0.005 ± 0.000 | 87.429 ± 0.562 | 0.5 | 86.965 ± 0.567 | 5.2 | 1738.16 ± 7.27 |
| 2.2 | 24.3219 | 0.0013 ± 0.0001 | 0.012 ± 70.034 | 0.003 ± 0.000 | 87.795 ± 0.297 | 0.4 | 87.405 ± 0.298 | 10.1 | 1743.80 ± 3.81 |
| 2.4 | 7.8696 | 0.0009 ± 0.0002 | 0.004 ± 171.266 | 0.003 ± 0.000 | 87.252 ± 0.251 | 0.3 | 86.987 ± 0.257 | 3.3 | 1738.44 ± 3.30 |
| 2.8 | 15.1019 | 0.0014 ± 0.0005 | 0.021 ± 42.121 | 0.003 ± 0.001 | 87.166 ± 0.550 | 0.5 | 86.753 ± 0.566 | 6.2 | 1735.43 ± 7.27 |
| 3.4 | 17.8079 | 0.0013 ± 0.0002 | 0.011 ± 156.052 | 0.002 ± 0.000 | 87.457 ± 0.693 | 0.5 | 87.059 ± 0.696 | 7.4 | 1739.35 ± 8.91 |
| 20.0 | 22.2172 | 0.0015 ± 0.0003 | 0.007 ± 309.144 | 0.003 ± 0.000 | 87.027 ± 0.622 | 0.5 | 86.571 ± 0.627 | 9.2 | 1733.09 ± 8.06 |
| **PHA-97-H521 Biotite; J=0.01857320 (Z5471)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.0 | 0.0846 | 0.2558 ± 0.0161 | 0.263 ± 136.451 | 0.125 ± 0.014 | 134.614 ± 6.808 | 56.2 | 59.012 ± 7.614 | 0.1 | 1335.12 ± 121.72 |
| 2.6 | 3.7008 | 0.0016 ± 0.0004 | 0.025 ± 79.773 | 0.009 ± 0.001 | 86.904 ± 0.478 | 0.6 | 86.425 ± 0.486 | 3.7 | 1727.43 ± 6.25 |
| 3.8 | 9.687 | 0.0005 ± 0.0002 | 0.015 ± 86.462 | 0.007 ± 0.000 | 86.933 ± 0.474 | 0.2 | 86.778 ± 0.476 | 9.6 | 1731.97 ± 6.10 |
| *4.6 | 6.5006 | 0.0008 ± 0.0002 | 0.160 ± 30.551 | 0.013 ± 0.000 | 90.031 ± 0.748 | 0.3 | 89.796 ± 0.749 | 6.4 | 1770.28 ± 9.41 |
| 5.0 | 5.9753 | 0.0008 ± 0.0002 | 0.021 ± 121.391 | 0.007 ± 0.000 | 86.395 ± 0.330 | 0.3 | 86.145 ± 0.333 | 5.9 | 1723.82 ± 4.30 |
| 5.8 | 7.5522 | 0.0010 ± 0.0002 | 0.045 ± 21.816 | 0.007 ± 0.000 | 86.285 ± 0.144 | 0.3 | 85.993 ± 0.152 | 7.5 | 1721.86 ± 1.96 |
| 12.0 | 7.2982 | 0.0016 ± 0.0002 | 1.182 ± 10.279 | 0.009 ± 0.000 | 85.925 ± 0.318 | 0.6 | 85.444 ± 0.320 | 7.2 | 1714.78 ± 4.13 |

## Table 2. (cont.)

| Power[a] | Volume $^{39}Ar$ x$10^{-11}$ cc | $^{36}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{38}Ar/^{39}Ar$ | $^{40}Ar/^{39}Ar$ | % $^{40}Ar$ ATM | $*^{40}Ar/^{39}Ar$ | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **PHA-97-H521 Biotite; J=0.01857320 (Z5471)** (cont.) | | | | | | | | | |
| | | | | | *Aliquot: B* | | | | |
| *2.1 | 0.351 | 0.3384 ± 0.0094 | 0.064 ± 138.001 | 0.040 ± 0.008 | 155.171 ± 3.566 | 64.4 | 55.165 ± 4.448 | 0.4 | 1272.55 ± 73.63 |
| *2.3 | 0.5676 | 0.0506 ± 0.0018 | 0.030 ± 180.978 | 0.011 ± 0.003 | 85.397 ± 0.930 | 17.5 | 70.431 ± 0.956 | 0.6 | 1509.01 ± 13.89 |
| 3.0 | 7.9597 | 0.0026 ± 0.0003 | 0.009 ± 75.036 | 0.009 ± 0.000 | 86.162 ± 0.304 | 0.9 | 85.393 ± 0.314 | 7.9 | 1714.11 ± 4.07 |
| 3.8 | 11.0516 | 0.0009 ± 0.0002 | 0.006 ± 73.290 | 0.008 ± 0.000 | 86.125 ± 0.409 | 0.3 | 85.847 ± 0.411 | 10.9 | 1719.98 ± 5.31 |
| 4.4 | 8.2889 | 0.0015 ± 0.0002 | 0.006 ± 40.404 | 0.007 ± 0.000 | 86.455 ± 0.388 | 0.5 | 86.008 ± 0.392 | 8.2 | 1722.07 ± 5.06 |
| 5.1 | 8.2919 | 0.0008 ± 0.0001 | 0.008 ± 67.192 | 0.008 ± 0.000 | 85.889 ± 0.569 | 0.3 | 85.652 ± 0.570 | 8.2 | 1717.46 ± 7.37 |
| 5.8 | 16.1607 | 0.0014 ± 0.0002 | 0.012 ± 121.006 | 0.009 ± 0.000 | 86.726 ± 0.536 | 0.5 | 86.320 ± 0.540 | 16.0 | 1726.08 ± 6.94 |
| 6.5 | 6.76 | 0.0013 ± 0.0002 | 0.017 ± 38.924 | 0.009 ± 0.001 | 86.257 ± 0.501 | 0.4 | 85.881 ± 0.505 | 6.7 | 1720.42 ± 6.52 |
| 12.0 | 0.8566 | 0.0095 ± 0.0010 | 0.334 ± 45.979 | 0.013 ± 0.002 | 87.760 ± 1.882 | 3.2 | 84.965 ± 1.879 | 0.9 | 1708.55 ± 24.41 |
| **PHA-97-H418 Hornblende; J=0.01848480 (Z5475)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *3.0 | 0.0983 | 0.2905 ± 0.0158 | 1.287 ± 49.445 | 0.399 ± 0.024 | 718.217 ± 11.503 | 12 | 632.377 ± 12.085 | 0.8 | 4583.79 ± 31.76 |
| 4.0 | 0.0989 | 0.0836 ± 0.0089 | 1.060 ± 101.956 | 0.080 ± 0.023 | 210.608 ± 8.415 | 11.7 | 185.906 ± 8.343 | 0.8 | 2687.84 ± 62.71 |
| 4.7 | 0.4339 | 0.0129 ± 0.0028 | 5.716 ± 29.744 | 0.077 ± 0.002 | 187.115 ± 2.678 | 2 | 183.295 ± 2.722 | 3.7 | 2668.10 ± 20.69 |
| *5.0 | 3.177 | 0.0032 ± 0.0005 | 7.065 ± 13.740 | 0.087 ± 0.002 | 198.291 ± 1.378 | 0.5 | 197.336 ± 1.385 | 27.1 | 2771.78 ± 9.94 |
| 5.1 | 1.571 | 0.0038 ± 0.0019 | 6.815 ± 19.299 | 0.078 ± 0.002 | 179.521 ± 2.088 | 0.6 | 178.393 ± 2.151 | 13.4 | 2630.47 ± 16.70 |
| 5.3 | 0.5962 | 0.0079 ± 0.0017 | 6.598 ± 23.102 | 0.084 ± 0.002 | 176.259 ± 2.348 | 1.3 | 173.923 ± 2.357 | 5.1 | 2595.44 ± 18.65 |
| 5.5 | 0.3601 | 0.0139 ± 0.0028 | 6.851 ± 39.550 | 0.082 ± 0.008 | 179.294 ± 2.793 | 2.3 | 175.172 ± 2.810 | 3.1 | 2605.30 ± 22.11 |
| 6.0 | 0.1938 | 0.0419 ± 0.0046 | 6.633 ± 18.910 | 0.088 ± 0.007 | 180.901 ± 1.795 | 6.8 | 168.513 ± 1.712 | 1.7 | 2552.12 ± 13.88 |
| 12.0 | 2.623 | 0.0022 ± 0.0010 | 7.955 ± 9.612 | 0.085 ± 0.001 | 186.845 ± 1.106 | 0.3 | 186.202 ± 1.143 | 22.3 | 2690.06 ± 8.58 |
| | | | | | *Aliquot: B* | | | | |
| *3.0 | 0.0674 | 0.2389 ± 0.0167 | 1.258 ± 101.614 | 0.824 ± 0.049 | 1027.150 ± 47.890 | 6.9 | 956.546 ± 47.961 | 0.6 | 5281.57 ± 85.62 |
| *4.0 | 0.0741 | 0.2761 ± 0.0218 | 0.736 ± 89.436 | 0.167 ± 0.015 | 227.916 ± 11.572 | 35.8 | 146.333 ± 12.681 | 0.6 | 2362.77 ± 114.15 |
| *4.7 | 0.127 | 0.0423 ± 0.0084 | 0.808 ± 55.086 | 0.117 ± 0.006 | 150.238 ± 3.700 | 8.3 | 137.752 ± 3.869 | 1.1 | 2283.83 ± 36.39 |
| *4.9 | 0.0934 | 0.0535 ± 0.0168 | 1.983 ± 69.090 | 0.116 ± 0.008 | 142.465 ± 3.905 | 11.1 | 126.643 ± 5.539 | 0.8 | 2176.22 ± 55.29 |
| *5.1 | 0.0327 | 0.1971 ± 0.0317 | 2.336 ± 134.537 | 0.198 ± 0.031 | 156.968 ± 15.023 | 37.1 | 98.720 ± 15.458 | 0.3 | 1873.46 ± 182.48 |
| *5.3 | 0.0583 | 0.0558 ± 0.0146 | 2.636 ± 55.836 | 0.105 ± 0.025 | 138.795 ± 6.123 | 11.9 | 122.304 ± 5.712 | 0.5 | 2132.37 ± 58.41 |
| *5.5 | 0.1351 | 0.0538 ± 0.0056 | 4.821 ± 39.912 | 0.141 ± 0.009 | 245.386 ± 3.262 | 6.5 | 229.479 ± 2.999 | 1.2 | 2988.82 ± 19.09 |
| 7.5 | 1.4601 | 0.0026 ± 0.0010 | 6.910 ± 17.516 | 0.097 ± 0.003 | 188.573 ± 1.979 | 0.4 | 187.791 ± 1.992 | 12.4 | 2701.95 ± 14.86 |
| 12.0 | 0.5423 | 0.0145 ± 0.0016 | 8.062 ± 17.827 | 0.096 ± 0.004 | 180.942 ± 1.606 | 2.4 | 176.649 ± 1.588 | 4.6 | 2616.88 ± 12.41 |
| **PHA-97-N50a Biotite; J=0.01858680 (Z4796)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.0 | 0.026 | 0.5247 ± 0.0823 | 0.586 ± 484.063 | 0.158 ± 0.058 | 194.570 ± 28.878 | 79.7 | 39.528 ± 36.176 | 0.0 | 993.77 ± 699.30 |
| *2.3 | 0.0067 | 0.8753 ± 0.1897 | 3.128 ± 340.051 | 0.410 ± 0.227 | 229.553 ± 50.201 | 112.7 | -29.095 ± -62.374 | 0.0 | -1404.01 ± -4554.60 |
| *3.1 | 4.6074 | 0.0031 ± 0.0002 | 0.020 ± 25.989 | 0.027 ± 0.001 | 80.090 ± 0.529 | 1.1 | 79.175 ± 0.530 | 6.2 | 1632.47 ± 7.19 |
| 3.8 | 4.3204 | 0.0012 ± 0.0003 | 0.009 ± 288.809 | 0.025 ± 0.000 | 85.266 ± 0.394 | 0.4 | 84.912 ± 0.398 | 5.9 | 1708.68 ± 5.19 |
| 3.9 | 7.4751 | 0.0010 ± 0.0002 | 0.004 ± 217.916 | 0.027 ± 0.001 | 85.810 ± 0.478 | 0.4 | 85.500 ± 0.481 | 10.1 | 1716.31 ± 6.23 |
| 4.2 | 2.1252 | 0.0025 ± 0.0006 | 0.016 ± 310.626 | 0.026 ± 0.001 | 86.048 ± 0.874 | 0.8 | 85.320 ± 0.881 | 2.9 | 1713.98 ± 11.43 |
| 5.0 | 9.261 | 0.0007 ± 0.0002 | 0.005 ± 166.974 | 0.027 ± 0.001 | 85.039 ± 0.383 | 0.3 | 84.824 ± 0.386 | 12.6 | 1707.53 ± 5.02 |
| 5.6 | 3.6391 | 0.0017 ± 0.0003 | 0.011 ± 118.194 | 0.027 ± 0.001 | 85.797 ± 0.336 | 0.6 | 85.286 ± 0.340 | 4.9 | 1713.54 ± 4.41 |
| 6.4 | 2.8459 | 0.0026 ± 0.0004 | 0.011 ± 267.231 | 0.025 ± 0.001 | 86.130 ± 0.786 | 0.9 | 85.352 ± 0.790 | 3.9 | 1714.38 ± 10.24 |
| 12.0 | 12.2531 | 0.0006 ± 0.0001 | 0.004 ± 156.762 | 0.025 ± 0.001 | 85.446 ± 0.242 | 0.2 | 85.283 ± 0.243 | 16.6 | 1713.50 ± 3.15 |
| | | | | | *Aliquot: B* | | | | |
| *2.0 | 0.4386 | 0.0224 ± 0.0030 | 0.041 ± 304.859 | 0.047 ± 0.004 | 69.619 ± 1.763 | 9.5 | 63.014 ± 1.862 | 0.6 | 1398.70 ± 28.76 |
| *2.8 | 3.9543 | 0.0019 ± 0.0004 | 0.005 ± 234.936 | 0.024 ± 0.001 | 84.328 ± 0.275 | 0.7 | 83.763 ± 0.287 | 5.4 | 1693.67 ± 3.77 |
| 3.1 | 2.4293 | 0.0022 ± 0.0004 | 0.011 ± 96.408 | 0.024 ± 0.001 | 86.291 ± 0.748 | 0.8 | 85.635 ± 0.750 | 3.3 | 1718.06 ± 9.70 |
| 3.8 | 6.2023 | 0.0008 ± 0.0002 | 0.004 ± 503.557 | 0.020 ± 0.000 | 85.778 ± 0.277 | 0.3 | 85.555 ± 0.278 | 8.4 | 1717.02 ± 3.60 |
| 3.9 | 2.0875 | 0.0024 ± 0.0004 | 0.005 ± 988.614 | 0.021 ± 0.001 | 86.464 ± 0.612 | 0.8 | 85.749 ± 0.611 | 2.8 | 1719.53 ± 7.89 |
| 4.4 | 3.2631 | 0.0020 ± 0.0003 | 0.008 ± 131.662 | 0.023 ± 0.000 | 84.999 ± 0.644 | 0.7 | 84.421 ± 0.645 | 4.4 | 1702.28 ± 8.41 |
| 5.0 | 4.3466 | 0.0010 ± 0.0003 | 0.005 ± 436.661 | 0.022 ± 0.001 | 85.849 ± 0.463 | 0.4 | 85.541 ± 0.467 | 5.9 | 1716.84 ± 6.05 |
| 5.8 | 2.5838 | 0.0027 ± 0.0005 | 0.011 ± 175.677 | 0.024 ± 0.001 | 85.623 ± 0.642 | 0.9 | 84.834 ± 0.652 | 3.5 | 1707.67 ± 8.49 |
| 6.1 | 0.8691 | 0.0053 ± 0.0012 | 0.025 ± 346.237 | 0.030 ± 0.002 | 86.405 ± 2.358 | 1.8 | 84.852 ± 2.361 | 1.2 | 1707.90 ± 30.71 |
| 12.0 | 1.0453 | 0.0052 ± 0.0012 | 0.015 ± 439.298 | 0.025 ± 0.001 | 86.141 ± 0.530 | 1.8 | 84.613 ± 0.574 | 1.4 | 1704.79 ± 7.48 |
| **PHA-97-H418 Biotite; J=0.01854540 (Z5475)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.1 | 0.3282 | 0.1785 ± 0.0052 | 0.227 ± 38.575 | 0.161 ± 0.011 | 133.894 ± 2.351 | 39.4 | 81.157 ± 2.677 | 0.7 | 1656.75 ± 35.75 |
| *2.6 | 1.4962 | 0.0092 ± 0.0010 | 0.122 ± 32.503 | 0.046 ± 0.003 | 96.090 ± 0.972 | 2.8 | 93.378 ± 0.999 | 3.2 | 1813.00 ± 12.24 |
| 3.0 | 6.5359 | 0.0018 ± 0.0003 | 0.063 ± 26.227 | 0.028 ± 0.001 | 102.356 ± 0.443 | 0.5 | 101.836 ± 0.450 | 13.8 | 1913.73 ± 5.21 |
| 3.8 | 11.2999 | 0.0017 ± 0.0003 | 0.064 ± 28.506 | 0.025 ± 0.001 | 102.368 ± 0.365 | 0.5 | 101.876 ± 0.378 | 23.8 | 1914.20 ± 4.38 |
| *4.6 | 1.7038 | 0.0030 ± 0.0007 | 0.117 ± 58.169 | 0.024 ± 0.001 | 101.644 ± 0.837 | 0.9 | 100.747 ± 0.844 | 3.6 | 1901.07 ± 9.84 |
| *5.0 | 1.1423 | 0.0040 ± 0.0011 | 0.245 ± 55.598 | 0.028 ± 0.001 | 99.553 ± 0.971 | 1.2 | 98.380 ± 0.999 | 2.4 | 1873.25 ± 11.82 |
| *5.9 | 1.0219 | 0.0095 ± 0.0008 | 0.799 ± 42.825 | 0.026 ± 0.001 | 94.172 ± 0.673 | 3 | 91.371 ± 0.659 | 2.2 | 1788.26 ± 8.18 |
| *6.2 | 0.9424 | 0.0049 ± 0.0017 | 1.916 ± 32.602 | 0.031 ± 0.001 | 94.223 ± 0.830 | 1.5 | 92.786 ± 0.925 | 2.0 | 1805.74 ± 11.37 |
| *12.0 | 1.0467 | 0.0059 ± 0.0014 | 1.611 ± 30.195 | 0.033 ± 0.001 | 98.532 ± 0.857 | 1.8 | 96.801 ± 0.914 | 2.2 | 1854.45 ± 10.93 |

## Table 2. (cont.)

| Power[a] | Volume $^{39}Ar$ $\times 10^{-11}$ cc | $^{36}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{38}Ar/^{39}Ar$ | $^{40}Ar/^{39}Ar$ | % $^{40}Ar$ ATM | $*^{40}Ar/^{39}Ar$ | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **PHA-97-H418 Biotite; J=0.01854540 (Z5475)** (cont.) | | | | | | | | | |
| | | | | | *Aliquot: B* | | | | |
| *2.0 | 0.2179 | 0.1109 ± 0.0048 | 0.237 ± 62.673 | 0.106 ± 0.006 | 105.001 ± 2.332 | 31.2 | 72.230 ± 2.399 | 0.5 | 1533.40 ± 34.31 |
| *2.5 | 0.6042 | 0.0134 ± 0.0016 | 0.231 ± 68.712 | 0.048 ± 0.002 | 78.289 ± 0.801 | 5.1 | 74.329 ± 0.808 | 1.3 | 1563.17 ± 11.37 |
| 3.4 | 13.0217 | 0.0017 ± 0.0003 | 0.049 ± 59.084 | 0.027 ± 0.001 | 104.834 ± 0.522 | 0.5 | 104.330 ± 0.528 | 27.4 | 1942.39 ± 6.02 |
| 3.8 | 3.5968 | 0.0013 ± 0.0004 | 0.041 ± 38.866 | 0.022 ± 0.001 | 105.064 ± 0.510 | 0.4 | 104.676 ± 0.515 | 7.6 | 1946.33 ± 5.86 |
| *5.3 | 2.4883 | 0.0017 ± 0.0007 | 0.556 ± 21.231 | 0.024 ± 0.001 | 101.322 ± 0.743 | 0.5 | 100.820 ± 0.761 | 5.2 | 1901.93 ± 8.87 |
| *5.4 | 1.0082 | 0.0056 ± 0.0010 | 1.049 ± 21.534 | 0.028 ± 0.001 | 100.478 ± 0.914 | 1.7 | 98.820 ± 0.920 | 2.1 | 1878.45 ± 10.86 |
| *6.1 | 0.3138 | 0.0140 ± 0.0048 | 1.234 ± 26.692 | 0.046 ± 0.002 | 105.581 ± 1.815 | 3.9 | 101.438 ± 2.129 | 0.7 | 1909.12 ± 24.73 |
| *12.0 | 0.7163 | 0.0103 ± 0.0010 | 0.940 ± 54.706 | 0.027 ± 0.001 | 100.144 ± 0.875 | 3 | 97.106 ± 0.838 | 1.5 | 1858.09 ± 10.01 |
| **AM98-7116A Hornblende; J=0.01835500 (Z5472)** | | | | | | | | | |
| | | | | | *Aliquot A* | | | | |
| *2.5 | 0.0285 | 0.4690 ± 0.0986 | 11.856 ± 282.558 | 3.915 ± 0.771 | 1589.184 ± 295.014 | 8.7 | 1450.600 ± 296.285 | 0.1 | 5987.35 ± 355.15 |
| *3.0 | 0.034 | 0.7488 ± 0.0886 | 108.871 ± 162.796 | 4.376 ± 0.457 | 4640.077 ± 465.601 | 4.8 | 4418.820 ± 466.186 | 0.1 | 7952.52 ± 188.02 |
| *3.5 | 0.0216 | 0.4142 ± 0.0657 | 64.115 ± 163.089 | 3.424 ± 0.368 | 2028.659 ± 208.539 | 6 | 1906.256 ± 209.040 | 0.1 | 6464.49 ± 192.34 |
| *3.9 | 0.0702 | 0.1475 ± 0.0167 | 19.014 ± 106.730 | 1.380 ± 0.085 | 380.717 ± 22.586 | 11.5 | 337.121 ± 22.769 | 0.2 | 3558.40 ± 104.90 |
| *4.1 | 0.0258 | 0.0783 ± 0.0681 | 19.423 ± 89.815 | 1.550 ± 0.141 | 316.042 ± 18.527 | 7.3 | 292.902 ± 25.099 | 0.1 | 3342.23 ± 130.34 |
| *4.2 | 2.6656 | 0.0076 ± 0.0006 | 22.513 ± 13.733 | 0.675 ± 0.008 | 250.604 ± 2.263 | 0.9 | 248.355 ± 2.267 | 8.2 | 3094.64 ± 13.51 |
| *4.3 | 0.809 | 0.0073 ± 0.0015 | 22.556 ± 37.744 | 0.591 ± 0.012 | 223.921 ± 2.828 | 1 | 221.760 ± 2.843 | 2.5 | 2928.82 ± 18.56 |
| 4.6 | 6.6719 | 0.0013 ± 0.0004 | 22.795 ± 6.192 | 0.340 ± 0.003 | 163.025 ± 0.549 | 0.2 | 162.634 ± 0.558 | 20.6 | 2494.30 ± 4.64 |
| 5.0 | 1.4308 | 0.0033 ± 0.0011 | 22.581 ± 10.578 | 0.347 ± 0.005 | 159.413 ± 0.644 | 0.6 | 158.453 ± 0.700 | 4.4 | 2459.22 ± 5.93 |
| *5.6 | 0.1621 | 0.0143 ± 0.0065 | 22.822 ± 47.038 | 0.393 ± 0.013 | 153.413 ± 2.380 | 2.8 | 149.192 ± 2.508 | 0.5 | 2379.00 ± 22.21 |
| 12.0 | 0.9625 | 0.0027 ± 0.0012 | 24.151 ± 13.808 | 0.454 ± 0.007 | 160.020 ± 0.650 | 0.5 | 159.228 ± 0.681 | 3.0 | 2465.77 ± 5.75 |
| | | | | | *Aliquot: B* | | | | |
| *3.0 | 0.0389 | 0.3745 ± 0.0667 | 45.854 ± 172.788 | 2.985 ± 0.351 | 728.236 ± 83.009 | 15.2 | 617.581 ± 85.010 | 0.1 | 4532.80 ± 228.20 |
| *3.9 | 0.0475 | 0.2196 ± 0.0347 | 33.210 ± 128.108 | 2.432 ± 0.199 | 915.306 ± 72.277 | 7.1 | 850.415 ± 72.762 | 0.2 | 5069.46 ± 145.06 |
| *4.2 | 0.0567 | 0.1425 ± 0.0300 | 13.150 ± 98.847 | 1.074 ± 0.059 | 399.171 ± 17.840 | 10.5 | 357.062 ± 19.285 | 0.2 | 3648.00 ± 84.55 |
| *4.4 | 0.049 | 0.0505 ± 0.0331 | 12.763 ± 145.335 | 0.553 ± 0.056 | 246.167 ± 20.537 | 6.1 | 231.254 ± 22.015 | 0.2 | 2989.77 ± 139.00 |
| *4.6 | 2.5262 | 0.0031 ± 0.0007 | 21.513 ± 16.847 | 0.358 ± 0.004 | 183.859 ± 1.401 | 0.5 | 182.948 ± 1.412 | 7.8 | 2655.67 ± 10.73 |
| 5.0 | 8.429 | 0.0042 ± 0.0008 | 21.819 ± 23.128 | 0.391 ± 0.007 | 167.848 ± 1.244 | 0.7 | 166.614 ± 1.265 | 26.0 | 2527.08 ± 10.33 |
| 12.0 | 8.335 | 0.0068 ± 0.0005 | 22.116 ± 15.532 | 0.367 ± 0.006 | 168.824 ± 1.203 | 1.2 | 166.803 ± 1.214 | 25.8 | 2528.61 ± 9.90 |
| **BH98-9059 Biotite; J=0.01850750 (Z5473)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.2 | 8.6597 | 0.0856 ± 0.0007 | 0.036 ± 142.083 | 0.054 ± 0.002 | 91.112 ± 0.367 | 27.7 | 65.831 ± 0.418 | 3.1 | 1437.45 ± 6.29 |
| *2.4 | 2.1776 | 0.0098 ± 0.0004 | 0.037 ± 92.502 | 0.053 ± 0.002 | 85.405 ± 0.629 | 3.4 | 82.500 ± 0.625 | 0.8 | 1672.36 ± 8.26 |
| *2.6 | 15.6112 | 0.0041 ± 0.0006 | 0.024 ± 465.053 | 0.054 ± 0.001 | 89.137 ± 0.325 | 1.3 | 87.939 ± 0.372 | 5.7 | 1742.84 ± 4.73 |
| *2.8 | 5.6599 | 0.0043 ± 0.0003 | 0.017 ± 238.283 | 0.056 ± 0.001 | 91.316 ± 0.451 | 1.4 | 90.053 ± 0.460 | 2.1 | 1769.51 ± 5.76 |
| 3.0 | 15.1987 | 0.0045 ± 0.0004 | 0.031 ± 175.680 | 0.057 ± 0.001 | 92.803 ± 0.518 | 1.4 | 91.461 ± 0.529 | 5.5 | 1787.06 ± 6.56 |
| 3.2 | 5.7236 | 0.0036 ± 0.0004 | 0.036 ± 196.075 | 0.055 ± 0.001 | 92.079 ± 0.335 | 1.2 | 91.007 ± 0.350 | 2.1 | 1781.41 ± 4.36 |
| 3.4 | 19.9604 | 0.0037 ± 0.0008 | 0.043 ± 122.044 | 0.051 ± 0.001 | 91.345 ± 0.974 | 1.2 | 90.263 ± 0.999 | 7.2 | 1772.13 ± 12.50 |
| 3.6 | 4.5854 | 0.0019 ± 0.0005 | 0.015 ± 443.501 | 0.053 ± 0.001 | 91.774 ± 0.648 | 0.6 | 91.206 ± 0.659 | 1.7 | 1783.89 ± 8.19 |
| 3.8 | 8.1949 | 0.0012 ± 0.0002 | 0.021 ± 98.096 | 0.053 ± 0.001 | 91.593 ± 0.378 | 0.4 | 91.231 ± 0.380 | 3.0 | 1784.20 ± 4.72 |
| 4.2 | 23.565 | 0.0014 ± 0.0004 | 0.029 ± 203.830 | 0.053 ± 0.001 | 92.539 ± 0.591 | 0.4 | 92.127 ± 0.603 | 8.5 | 1795.29 ± 7.45 |
| *12.0 | 35.023 | 0.0015 ± 0.0002 | 0.060 ± 57.663 | 0.062 ± 0.001 | 95.092 ± 0.350 | 0.5 | 94.646 ± 0.356 | 12.7 | 1826.11 ± 4.31 |
| | | | | | *Aliquot: B* | | | | |
| *2.4 | 3.3105 | 0.1823 ± 0.0014 | 0.080 ± 44.521 | 0.054 ± 0.001 | 122.861 ± 0.544 | 43.9 | 68.984 ± 0.685 | 1.2 | 1484.30 ± 10.04 |
| *2.6 | 8.0474 | 0.0100 ± 0.0004 | 0.051 ± 27.943 | 0.056 ± 0.001 | 88.135 ± 0.385 | 3.3 | 85.191 ± 0.402 | 2.9 | 1707.58 ± 5.21 |
| *2.8 | 2.7779 | 0.0084 ± 0.0008 | 0.042 ± 342.127 | 0.055 ± 0.001 | 89.876 ± 0.570 | 2.8 | 87.403 ± 0.607 | 1.0 | 1736.01 ± 7.74 |
| *3.0 | 15.7326 | 0.0051 ± 0.0004 | 0.036 ± 200.811 | 0.057 ± 0.001 | 90.279 ± 0.674 | 1.7 | 88.765 ± 0.683 | 5.7 | 1753.31 ± 8.64 |
| *3.2 | 5.1873 | 0.0046 ± 0.0006 | 0.022 ± 201.105 | 0.053 ± 0.000 | 89.673 ± 0.479 | 1.5 | 88.315 ± 0.505 | 1.9 | 1747.61 ± 6.40 |
| 3.4 | 20.1784 | 0.0021 ± 0.0002 | 0.026 ± 417.604 | 0.051 ± 0.000 | 90.733 ± 0.536 | 0.7 | 90.100 ± 0.540 | 7.3 | 1770.10 ± 6.75 |
| 3.6 | 6.6539 | 0.0025 ± 0.0003 | 0.038 ± 42.684 | 0.052 ± 0.001 | 91.216 ± 0.574 | 0.8 | 90.464 ± 0.578 | 2.4 | 1774.65 ± 7.22 |
| 3.9 | 11.657 | 0.0018 ± 0.0001 | 0.027 ± 74.564 | 0.052 ± 0.001 | 91.093 ± 0.410 | 0.6 | 90.561 ± 0.411 | 4.2 | 1775.85 ± 5.13 |
| 4.4 | 18.5672 | 0.0014 ± 0.0005 | 0.042 ± 163.959 | 0.053 ± 0.001 | 91.725 ± 0.272 | 0.5 | 91.310 ± 0.307 | 6.7 | 1785.18 ± 3.81 |
| 12.0 | 39.5654 | 0.0015 ± 0.0002 | 0.078 ± 17.139 | 0.056 ± 0.001 | 92.608 ± 0.261 | 0.5 | 92.164 ± 0.270 | 14.3 | 1795.75 ± 3.33 |
| **BH98-9059 Hornblende; J=0.01849550 (Z5473)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.5 | 0.0661 | 0.1437 ± 0.0203 | 3.196 ± 60.989 | 0.641 ± 0.060 | 1516.492 ± 40.260 | 2.8 | 1474.024 ± 40.477 | 0.0 | 6028.48 ± 47.80 |
| *3.0 | 0.1686 | 0.0492 ± 0.0153 | 8.061 ± 67.469 | 0.426 ± 0.019 | 910.394 ± 32.312 | 1.6 | 895.850 ± 32.582 | 0.1 | 5170.82 ± 61.89 |
| *3.5 | 0.4721 | 0.0104 ± 0.0027 | 2.840 ± 46.324 | 0.181 ± 0.009 | 130.566 ± 0.847 | 2.4 | 127.478 ± 1.002 | 0.2 | 2185.27 ± 9.96 |
| *3.9 | 1.8427 | 0.0031 ± 0.0008 | 2.864 ± 36.686 | 0.130 ± 0.003 | 131.786 ± 0.946 | 0.7 | 130.856 ± 0.964 | 0.8 | 2218.52 ± 9.41 |
| 4.2 | 82.8254 | 0.0008 ± 0.0002 | 4.497 ± 15.468 | 0.048 ± 0.001 | 157.684 ± 0.703 | 0.2 | 157.434 ± 0.707 | 36.8 | 2460.79 ± 6.03 |
| *4.6 | 2.206 | 0.0027 ± 0.0007 | 4.587 ± 26.099 | 0.062 ± 0.001 | 144.268 ± 2.000 | 0.6 | 143.458 ± 2.006 | 1.0 | 2337.46 ± 18.32 |
| *4.8 | 0.4194 | 0.0054 ± 0.0038 | 4.912 ± 50.576 | 0.059 ± 0.003 | 145.980 ± 1.284 | 1.1 | 144.374 ± 1.569 | 0.2 | 2345.81 ± 14.27 |
| *5.0 | 0.443 | 0.0042 ± 0.0035 | 5.637 ± 34.437 | 0.093 ± 0.004 | 144.857 ± 0.994 | 0.9 | 143.615 ± 1.285 | 0.2 | 2338.89 ± 11.73 |
| *5.6 | 0.1979 | 0.0187 ± 0.0083 | 5.545 ± 78.348 | 0.080 ± 0.013 | 132.684 ± 2.112 | 4.2 | 127.171 ± 2.906 | 0.1 | 2182.21 ± 28.92 |
| *12.0 | 3.0513 | 0.0008 ± 0.0004 | 4.848 ± 19.659 | 0.056 ± 0.001 | 120.954 ± 0.949 | 0.2 | 120.712 ± 0.952 | 1.4 | 2116.74 ± 9.83 |

## Table 2. (cont.)

| Power[a] | Volume $^{39}Ar$ x$10^{-11}$ cc | $^{36}Ar/^{39}Ar$ | $^{37}Ar/^{39}Ar$ | $^{38}Ar/^{39}Ar$ | $^{40}Ar/^{39}Ar$ | % $^{40}Ar$ ATM | $*^{40}Ar/^{39}Ar$ | $f_{39}$[b] (%) | Apparent Age Ma[c] |
|---|---|---|---|---|---|---|---|---|---|
| **BH98-9059 Hornblende; J=0.01849550 (Z5473)** (cont.) | | | | | | | | | |
| | | | | | *Aliquot: B* | | | | |
| *3.0 | 0.175 | 0.1126 ± 0.0079 | 7.552 ± 54.861 | 0.658 ± 0.023 | 2291.389 ± 70.392 | 1.5 | 2258.127 ± 70.408 | 0.1 | 6775.70 ± 54.94 |
| *3.5 | 0.3443 | 0.0101 ± 0.0032 | 3.744 ± 27.301 | 0.225 ± 0.004 | 212.065 ± 1.148 | 1.4 | 209.082 ± 1.250 | 0.2 | 2854.98 ± 8.57 |
| *3.9 | 1.3024 | 0.0052 ± 0.0012 | 4.548 ± 32.749 | 0.167 ± 0.005 | 267.402 ± 2.825 | 0.6 | 265.869 ± 2.837 | 0.6 | 3207.50 ± 16.00 |
| *4.1 | 8.4993 | 0.0019 ± 0.0007 | 4.803 ± 40.298 | 0.092 ± 0.002 | 204.011 ± 2.922 | 0.3 | 203.440 ± 2.932 | 3.8 | 2815.87 ± 20.53 |
| *4.2 | 4.2609 | 0.0008 ± 0.0003 | 4.840 ± 18.650 | 0.069 ± 0.001 | 159.065 ± 1.128 | 0.2 | 158.822 ± 1.128 | 1.9 | 2472.60 ± 9.56 |
| *4.3 | 6.748 | 0.0006 ± 0.0003 | 4.789 ± 11.136 | 0.047 ± 0.001 | 153.621 ± 0.582 | 0.1 | 153.433 ± 0.586 | 3.0 | 2426.34 ± 5.09 |
| 4.5 | 34.0842 | 0.0007 ± 0.0003 | 4.456 ± 10.629 | 0.049 ± 0.001 | 157.163 ± 0.535 | 0.1 | 156.963 ± 0.540 | 15.2 | 2456.77 ± 4.62 |
| *12.0 | 11.2565 | 0.0014 ± 0.0007 | 4.624 ± 33.374 | 0.052 ± 0.001 | 152.141 ± 1.833 | 0.3 | 151.727 ± 1.843 | 5.0 | 2411.45 ± 16.16 |
| | | | | | *Aliquot: C* | | | | |
| *3.0 | 0.1623 | 0.1160 ± 0.0160 | 16.455 ± 51.867 | 0.454 ± 0.018 | 1137.211 ± 37.297 | 3 | 1102.943 ± 37.555 | 0.1 | 5526.62 ± 58.56 |
| *3.5 | 0.1592 | 0.0365 ± 0.0101 | 22.548 ± 39.006 | 0.228 ± 0.016 | 241.474 ± 4.375 | 4.5 | 230.700 ± 4.999 | 0.1 | 2997.41 ± 31.68 |
| *3.9 | 0.1546 | 0.0517 ± 0.0072 | 5.692 ± 67.748 | 0.218 ± 0.023 | 173.898 ± 6.686 | 8.8 | 158.613 ± 6.779 | 0.1 | 2470.82 ± 57.51 |
| *4.2 | 2.8789 | 0.0025 ± 0.0009 | 6.602 ± 19.831 | 0.684 ± 0.008 | 152.655 ± 1.163 | 0.5 | 151.905 ± 1.188 | 1.3 | 2413.01 ± 10.41 |
| 4.6 | 57.9184 | 0.0009 ± 0.0009 | 4.838 ± 26.846 | 0.080 ± 0.001 | 157.556 ± 0.567 | 0.2 | 157.298 ± 0.631 | 25.8 | 2459.64 ± 5.38 |
| *12.0 | 5.1702 | 0.0017 ± 0.0004 | 4.720 ± 13.600 | 0.121 ± 0.001 | 140.621 ± 0.626 | 0.4 | 140.121 ± 0.635 | 2.3 | 2306.72 ± 5.89 |
| **CS-96-1302 Hornblende; J=0.01831060 (Z5977)** | | | | | | | | | |
| | | | | | *Aliquot: A* | | | | |
| *2.5 | 0.0461 | 2.0182 ± 0.1471 | 93.114 ± 108.325 | 57.792 ± 4.003 | 4858.097 ± 333.492 | 12.3 | 4261.713 ± 336.121 | 0.1 | 7883.71 ± 140.49 |
| *3.0 | 0.0581 | 1.1368 ± 0.0331 | 1498.412 ± 43.544 | 26.280 ± 0.600 | 1747.712 ± 36.221 | 19.2 | 1411.785 ± 34.885 | 0.1 | 5936.01 ± 42.93 |
| *3.5 | 0.0561 | 0.4101 ± 0.0450 | 566.504 ± 117.674 | 13.575 ± 0.845 | 420.931 ± 26.299 | 28.8 | 299.741 ± 29.021 | 0.1 | 3373.71 ± 147.76 |
| *3.9 | 4.3682 | 0.0044 ± 0.0007 | 43.800 ± 11.368 | 28.819 ± 0.215 | 205.005 ± 1.515 | 0.6 | 203.693 ± 1.530 | 10.8 | 2803.34 ± 10.68 |
| *4.2 | 11.8418 | 0.0038 ± 0.0005 | 36.567 ± 12.163 | 29.182 ± 0.231 | 195.411 ± 1.487 | 0.6 | 194.283 ± 1.494 | 29.3 | 2736.39 ± 10.84 |
| 4.4 | 0.8137 | 0.0098 ± 0.0012 | 37.328 ± 22.123 | 30.479 ± 0.411 | 189.775 ± 2.538 | 1.5 | 186.885 ± 2.538 | 2.0 | 2681.95 ± 18.96 |
| 4.6 | 1.5767 | 0.0063 ± 0.0009 | 35.776 ± 17.037 | 29.665 ± 0.329 | 186.178 ± 2.044 | 1 | 184.309 ± 2.053 | 3.9 | 2662.60 ± 15.50 |
| 5.0 | 0.4192 | 0.0247 ± 0.0027 | 50.865 ± 22.994 | 26.455 ± 0.398 | 191.969 ± 2.758 | 3.8 | 184.659 ± 2.794 | 1.0 | 2665.24 ± 21.06 |
| 5.8 | 0.3983 | 0.0157 ± 0.0035 | 49.475 ± 19.791 | 27.129 ± 0.306 | 189.996 ± 2.094 | 2.4 | 185.364 ± 2.232 | 1.0 | 2670.55 ± 16.78 |
| *12.0 | 1.3037 | 0.0058 ± 0.0007 | 44.891 ± 19.854 | 29.043 ± 0.362 | 190.290 ± 2.365 | 0.9 | 188.564 ± 2.366 | 3.2 | 2694.45 ± 17.56 |
| | | | | | *Aliquot: B* | | | | |
| *3.0 | 0.1453 | 1.7413 ± 0.0718 | 872.306 ± 68.734 | 71.302 ± 2.435 | 4703.558 ± 159.143 | 10.9 | 4189.003 ± 157.088 | 0.4 | 7853.06 ± 66.78 |
| *3.8 | 0.7724 | 0.0529 ± 0.0040 | 141.731 ± 6.876 | 23.032 ± 0.110 | 291.454 ± 1.033 | 5.4 | 275.820 ± 1.542 | 1.9 | 3247.61 ± 8.42 |
| *4.0 | 1.8574 | 0.0033 ± 0.0012 | 60.125 ± 13.183 | 24.428 ± 0.177 | 195.301 ± 1.402 | 0.5 | 194.341 ± 1.438 | 4.6 | 2736.81 ± 10.42 |
| *4.2 | 1.2688 | 0.0101 ± 0.0012 | 59.789 ± 13.612 | 25.217 ± 0.203 | 239.682 ± 1.919 | 1.2 | 236.696 ± 1.941 | 3.1 | 3020.26 ± 12.02 |
| *4.4 | 0.5759 | 0.0148 ± 0.0020 | 60.170 ± 10.073 | 27.460 ± 0.151 | 225.875 ± 1.120 | 1.9 | 221.500 ± 1.174 | 1.4 | 2923.61 ± 7.66 |
| *4.6 | 9.6582 | 0.0048 ± 0.0008 | 48.547 ± 18.404 | 27.282 ± 0.308 | 196.119 ± 2.200 | 0.7 | 194.702 ± 2.216 | 23.9 | 2739.42 ± 16.03 |
| 5.0 | 1.0226 | 0.0072 ± 0.0011 | 52.824 ± 14.868 | 26.007 ± 0.256 | 187.419 ± 1.788 | 1.1 | 185.302 ± 1.799 | 2.5 | 2670.09 ± 13.53 |
| 5.8 | 0.7007 | 0.0121 ± 0.0018 | 60.842 ± 7.519 | 24.788 ± 0.092 | 189.205 ± 0.692 | 1.9 | 185.631 ± 0.770 | 1.7 | 2672.56 ± 5.78 |
| *12.0 | 3.4981 | 0.0025 ± 0.0004 | 61.102 ± 12.329 | 25.738 ± 0.195 | 191.498 ± 1.436 | 0.4 | 190.769 ± 1.440 | 8.7 | 2710.73 ± 10.59 |

[a] - As measured by laser in % of full nominal power (10W).
[b] - Fraction $^{39}Ar$ as percent of total run.
[c] - Errors are analytical only and do not reflect error in irradiation parameter J.
[d] - Nominal J-value, referenced to PP-20 (Hb3gr)=1072 Ma (Roddick, 1983).
* - Step not included in plateau or inverse isotope-correlation age determination.
All uncertainties quoted at 2σ level

**Table 3.** Summary of $^{40}Ar$-$^{39}Ar$ results.

| Sample | Mineral | Integrated age[a] | "Plateau age"[b] | Correlation age[c] (MSWD)[f] | Best estimate[d] $^{40}Ar$-$^{39}Ar$ | U-Pb age[e] |
|---|---|---|---|---|---|---|
| ***Kaminak Belt*** | | | | | | |
| PHA-97-H506 | Hornblende | 2669 ± 15 | 2652 ± 15 | 2654 ± 14 (7.5) | 2652 ± 14 | $2679^{+3}_{-2}$ |
| PHA-97-H161 | Hornblende | 2681 ± 14 | 2623 ± 15 | 2622 ± 14 (0.6) | 2623 ± 14 | $2679^{+3}_{-2}$ |
| PHA-97-H418 | Hornblende | 2743 ± 15 | 2660 ± 15 | 2646 ± 15 (54.8) | 2660 ± 15 | 2681 ± 1 |
| | Biotite | 1904 ± 12 | 1914±12 & 1943±13 | NC | 1943 ± 13[M] | 2681 ± 1 |
| PHA-97-H524 | Biotite | 1980 ± 12 | NC | NC | 2084 ± 11[M] | $2679^{+3}_{-2}$ |
| PHA-97-H521 | Biotite | 1723 ± 11 | 1722 ± 11 | 1721 ± 11 (4.1) | 1722 ± 11 | ca. 2679 |
| ***Yathkyed belt*** | | | | | | |
| CS-96-1302 | Hornblende | 2901 ± 16 | 2670 ± 16 | 2630 ± 78 (73.5) | 2630 ± 78[M] | ca. 2692 |
| YD97-7116a | Hornblende | 2662 ± 15 | 2513 ± 14 | 2485 ± 14 (72.2) | 2513 ± 14 | ca. 2692 |
| YD97-9059 | Hornblende | 2493 ± 14 | 2460 ± 14 | 2459 ± 14 (0.7) | 2460 ± 14 | ca. 2692 |
| | Biotite | 1768 ± 11 | 1785 ± 11 | 1785 ± 11 (9.8) | 1785 ± 11 | ca. 2692 |
| ***Intervening domain*** | | | | | | |
| PHA-97-H487 | Hornblende | 1797 ± 12 | 1795 ± 12 | NC | 1795 ± 12 | ca. 2680 |
| | Biotite | 1720 ± 11 | 1725 ± 11 | 1722 ± 11 (6.0) | 1725 ± 11 | ca. 2680 |
| PHA-97-N48c | Muscovite | 1736 ± 11 | 1736 ± 11 | 1737 ± 11 (4.0) | 1736 ± 11 | ca. 2680 |
| | Biotite | 1732 ± 12 | 1743 ± 12 | 1742 ± 12 (2.6) | 1743 ± 12 | ca. 2680 |
| PHA-97-J249 | Biotite | 1711 ± 11 | 1718 ± 11 | 1719 ± 11 (0.3) | 1718 ± 11 | ca. 2680 |
| PHA-97-H348 | Biotite | 1707 ± 11 | 1718 ± 11 | 1722 ± 11 (2.8) | 1718 ± 11 | ca. 2680 |
| PHA-97-H479 | Hornblende | 1772 ± 12 | 1754 ± 12 | 1748 ± 11 (5.9) | 1754 ± 12 | ca. 1830 |
| | Biotite | 1721 ± 11 | 1727 ± 11 | 1727 ± 11 (10.0) | 1727 ± 11 | ca. 1830 |
| PHA-97-H319 | Biotite | 1728 ± 11 | 1739 ± 11 | 1738 ± 11 (3.1) | 1739 ± 11 | ca. 1830 |
| PHA-97-N50a | Biotite | 1705 ± 11 | 1713 ± 11 | 1713 ± 11 (2.3) | 1713 ± 11 | 1827 ± 3 |

a – Total-gas integrated age (equivalent to K-Ar age).
b – Plateau age or "pseudo-plateau" age (see text).
c – Inverse isotope correlation age.
d – Best estimate $^{40}Ar$-$^{39}Ar$ age. Those marked with a superscript M are maximum ages.
e – U-Pb zircon or monazite age (known or inferred; Davis et al., 2000).
f – MSWD is the mean square of the weighted deviates. The majority of these correlation ages would be considered to define errorchrons. All ages are quoted in Ma. NC means not calculated.