$^{40}AR/^{39}AR$ GEOCHRONOLOGY DATA FROM THE TANACROSS AND EAGLE QUADRANGLES, ALASKA

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Raw Data File 2023-23

2023
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Suggested citation:
Naibert, T.J., Heizler, M.T., Newberry, R.J., Twelker, Evan, and Wypych, Alicja, 2023, 40Ar/39Ar geochronology data from the Tanacross and Eagle quadrangles, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2023-23, 19 p.
https://doi.org/10.14509/31085

$^{40}AR/^{39}AR$ GEOCHRONOLOGY DATA FROM THE TANACROSS AND EAGLE QUADRANGLES, ALASKA

Travis J. Naibert[1], Matthew T. Heizler[2], Rainer J. Newberry[1], Evan Twelker[1], and Alicja Wypych[1]

INTRODUCTION

During the 2021 field season, geologists from the Alaska Division of Geological & Geophysical Surveys (DGGS) conducted geologic mapping and sampling in the Western Tanacross and Taylor Mountain project areas north of Tok, Alaska, within the Tanacross and southern Eagle quadrangles (fig. 1). These projects were funded by the U.S. Geological Survey (USGS) Earth Mapping Resources Initiative (EarthMRI) and State of Alaska (SOA) capital project funds. Recent compilation mapping of published geologic maps in the eastern Tanacross Quadrangle (Wypych and others, 2021; Twelker and others, 2021; Solie and others, 2019) was funded by SOA capital project funds and the USGS STATEMAP program. The Tanacross and southern Eagle quadrangles are within the Yukon Tanana Uplands, which DGGS and USGS identified as having the potential to host deposits of multiple critical minerals (Hammarstrom and Dicken, 2019; Kreiner and Jones, 2020; Kreiner and others, 2022), as well as gold, copper, molybdenum, lead, zinc, and silver. Most of the known mineralization in the region is related to Mesozoic–Paleogene magmatism. Igneous rocks intrude a composite metamorphic province that includes parautochthonous North America and the allochthonous Yukon Tanana Terrane, which are multiply deformed and apparently juxtaposed along low-angle faults. Samples were collected for $^{40}Ar/^{39}Ar$ geochronology to understand the crystallization ages of igneous rocks, the exhumation history of metamorphic rocks, and the timing of mineralization. The 22 $^{40}Ar/^{39}Ar$ ages reported here include six mineralization/alteration ages, one volcanic crystallization age, seven metamorphic cooling ages from the Yukon-Tanana terrane (YTT), and eight metamorphic cooling ages from parautochthonous North American rocks (pNA).

Cretaceous ages were recorded by white mica from two vein-selvage samples from the A.R. trend (as defined in Twelker and others, 2020) (21ET169, 114.2 ± 0.4 Ma 21ET179, 120.3 ± 0.9 Ma). A similar Cretaceous age was recorded by phlogopite from skarn near the Eagle prospect (21RN239, 111.8 ± 4.8 Ma), suggesting widespread hydrothermal alteration in the pNA rocks in the Cretaceous. Within YTT, white mica from mineralized veins yielded Jurassic ages at the Tweeden gold prospect (21ET252, 190.7 ± 2.6 Ma) and the Lilliwig Creek gold prospect (21ET242, 191.4 ± 1.1 Ma). Phlogopite from skarn at the Fish prospect yielded an integrated age of 85.6 ± 0.2 Ma (21RN612), which is not interpreted as a meaningful age of skarn formation based on lack of intrusions of similar age in the region.

A phlogopite-bearing trachybasalt sample (21RN530) was dated at 100.8 ± 0.5 Ma. The trachybasalt overlies West Fork felsic tuffs dated at ca. 108 Ma (Gavel and others, 2023). The age is significantly older than other alkalic magmatism in the area (Twelker and others, 2021). It is unclear if volcanism of this age is widespread or if this sample represents late-stage mafic volcanism following the West Fork tuff eruptions.

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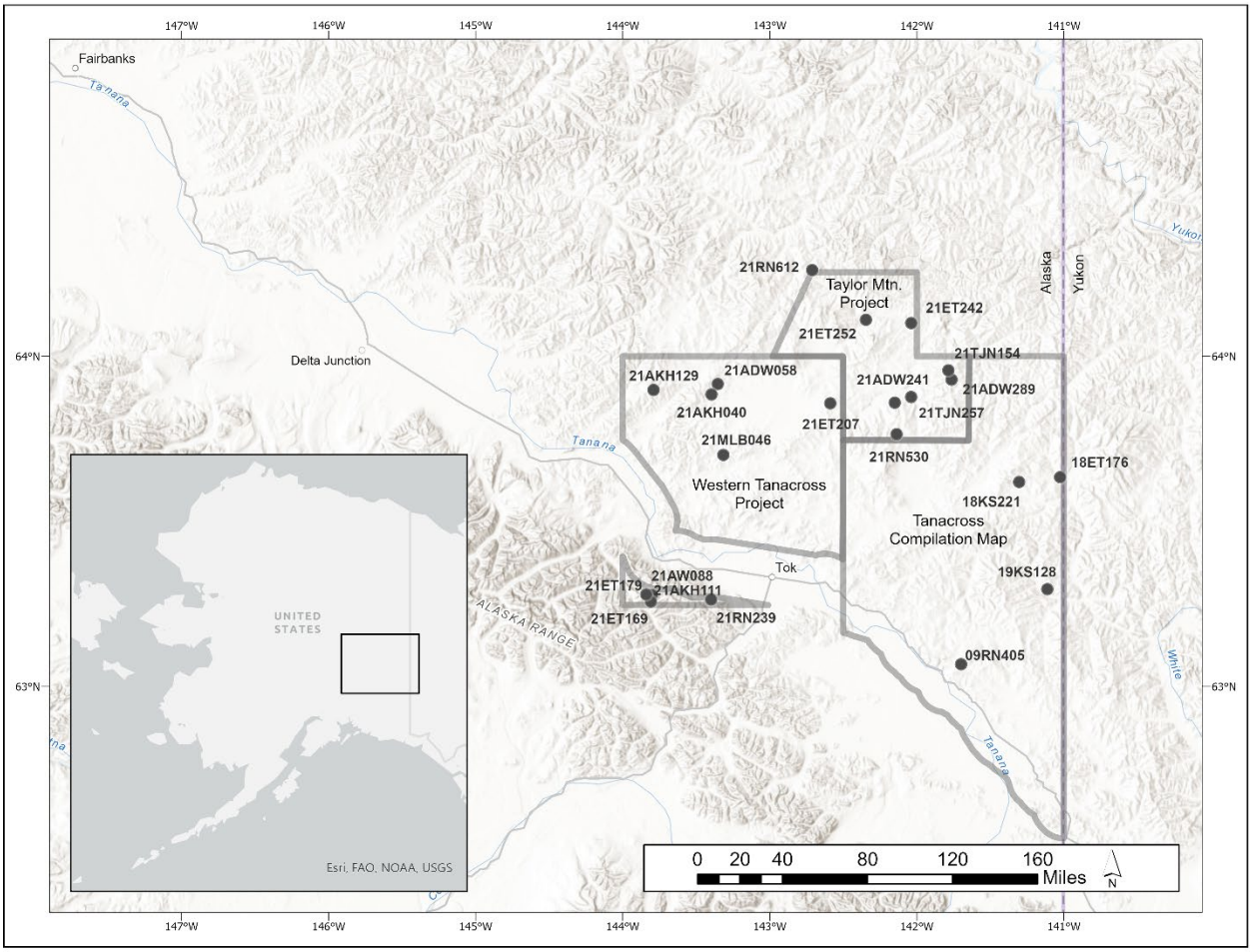

Figure 1. Map showing the location of samples in this report (black circles), the Western Tanacross and Taylor Mountain project areas, and the Tanacross geologic map compilation.

Multiple authors have used different metamorphic cooling ages to distinguish rocks in the Yukon-Tanana Terrane from those with North American affinity (Hansen, 1990; Dusel-Bacon and others, 2002; Wypych and others, 2021; Twelker and others, 2021). The 15 metamorphic cooling ages reported here were collected to aid DGGS field mapping along the YTT-pNA terrane boundary. One sample from the Ladue River unit (19KS128) yielded a muscovite cooling age of 198.2 ± 0.1 Ma. Six samples from the Fortymile River assemblage of the YTT yielded cooling ages between ca. 115 and 193 Ma. A sample tentatively mapped as Chicken assemblage yielded a muscovite cooling age of 103.4 ± 0.4 Ma, considerably younger than expected from Yukon-Tanana Terrane samples. Eight samples from the Jarvis belt and Lake George assemblage yielded cooling ages between ca. 99 and 130 Ma, which are consistent with previously reported Early to mid-Cretaceous cooling ages in parautochthonous North America (Hansen, 1990; Dusel-Bacon and others, 2002; Wypych and others, 2021).

The analytical data tables associated with this report are available in digital format as comma-separated value (CSV) files. Additional details about the organization of information are noted in the accompanying metadata file. All files can be downloaded from the DGGS website (https://doi.org/10.14509/31085).

Samples collected during the project will be stored at the DGGS Fairbanks office for the project's duration. Once the project concludes, the samples will be stored at the DGGS Geologic Materials Center in Anchorage. Samples will be available for public viewing upon request.

DOCUMENTATION OF METHODS

Sample Collection

DGGS field geologists collected fresh, unweathered samples from surface outcrops based on the presence of sufficiently large crystals appropriate for dating. Sample 21RN612 from the Fish prospect is from a drill core obtained by Rainer Newberry from the USGS. Sample location coordinates (in WGS84 datum) were obtained using GPS-enabled field tablets with a typical reported accuracy of ± 10 meters. Samples were examined under a binocular microscope and/or in thin section to select unaltered mineral phases before sample preparation.

Sample Preparation

Twenty-seven samples were submitted to the New Mexico Geochronological Research Laboratory (NMGRL) in Socorro, New Mexico. Twenty-two samples yielded acceptable mineral separates for $^{40}Ar/^{39}Ar$ geochronology. Muscovite, biotite, phlogopite, hornblende, and sericite were separated from rock samples using standard magnetic, heavy liquid, and handpicking procedures. The samples were loaded into machined aluminum discs and irradiated for 20 hours at the USGS reactor in Denver, Colorado (NM-327), along with the Fish Canyon Tuff sanidine standard (FC-2; assigned age – 28.201 Ma; Kuiper and others, 2008) as a neutron flux monitor.

Analytical Methods

After irradiation, the samples and monitors were analyzed by step-heating with a defocused 810 nm diode laser. The samples were step-heated using between 10 and 17 increments, and most separates yielded moderate-quality to complex age-spectra patterns. Reactive gases were removed by a 45-second reaction with a SAES GP-50 getter at 450 °C, and gas was also exposed to a cold finger at -140 °C. The samples were analyzed in a Thermo-Fisher Scientific Helix MC-plus mass spectrometer at NMGRL. Total system blanks were 3.5×10^{-17} mol ^{40}Ar, 8×10^{-18} mol ^{39}Ar, 5×10^{-19} mol ^{38}Ar, 3×10^{-18} mol ^{37}Ar, 5×10^{-19} mol ^{36}Ar. Isotopic ratios were corrected for blank, radioactive decay, and mass discrimination but were not corrected for interfering reactions.

RESULTS AND SAMPLE DESCRIPTIONS

A summary of the $^{40}Ar/^{39}Ar$ results is provided in table 1, with age errors quoted at the ± 2-sigma (σ) level. Accompanying digital data tables contain more detailed results, with age errors quoted at the ± 1σ level. The integrated age is the age given by the total gas measured and is equivalent to a potassium-argon (K-Ar) age. Age spectra plots are included in the appendix. The spectra yield plateau ages if three or more consecutive gas fractions represent at least 50 percent of the total gas release and are within two standard deviations of each other (Mean Square Weighted Deviation [MSWD] less than 2.5). When spectra did not provide a plateau age under the above definition, a weighted-mean age was calculated, or the integrated age was used as the preferred age for the sample. Below are sample descriptions and additional discussion of the results of each age analysis, noting our preferred age determination.

09RN405A – Orthogneiss from the Jarvis belt (pNA)

Sample 09RN405A is a foliated, light-green metarhyolite with biotite-rich gneissic banding within Jarvis belt metafelsic rocks in the Alaska Highway Corridor map area (Solie and others, 2019). A muscovite separate yielded a weighted-mean age (99.3 ± 0.3 Ma) and an integrated age (99.4 ± 0.1 Ma) within uncertainty. The preferred age for this sample is the weighted-mean age of **99.3 ± 0.3 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

18ET176 – Muscovite schist from the Fortymile River assemblage (YTT)

Sample 18ET176 is a garnet-bearing muscovite schist with up to 1 percent garnet within Fortymile River assemblage metasedimentary rocks in the Northeast Tanacross map area (Wypych and others, 2021). A mix of lithologies were described at the sample location including garnet-muscovite schist, micaceous schist, and quartz-mica schist. A muscovite separate yielded an integrated age of 111.2 ± 0.1 Ma. The age spectrum yields a climbing pattern where the higher-temperature heating steps have older ages. A weighted mean age of 118.4 ± 1.9 Ma was calculated from the last three heating steps representing 18 percent of the total gas release. Due to the climbing age spectrum pattern, the preferred age for this sample is the weighted-mean age of **118.4 ± 1.9 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

18KS221 – Graphitic schist from the Lake George assemblage (pNA)

Sample 18KS221 is a gray, crenulated graphitic schist with grain size between 0.1 and 1.0 mm with 1–2 cm fold wavelengths within Lake George assemblage metasedimentary rocks in the Northeast Tanacross map area (Wypych and others, 2021). A muscovite separate yielded an integrated age of 108.5 ± 0.1 Ma. The age spectrum is flat, with younger ages for the first and last heating steps. A weighted-mean age of 109.1 ± 0.2 Ma was calculated from 15 heating steps representing 90 percent of the total gas release. Due to the flat age spectrum, the preferred age for this sample is the weighted mean age of **109.1 ± 0.2 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

19KS128 – Orthogneiss from the Ladue River assemblage (YTA)

Sample 19KS128 gray, foliated orthogneiss within the Ladue River assemblage porphyroclastic orthogneiss unit in the Ladue River–Mount Fairplay map area (Twelker and others, 2021). Feldspar porphyroclasts are 2 to 4 mm in diameter. Mineralogy includes quartz, feldspar, muscovite, and chlorite. A muscovite separate yielded an integrated age of 198.2 ± 0.1 Ma. The age spectrum is undulatory, and a plateau age was not calculated. Therefore, the preferred age for this sample is the integrated age of **198.2 ± 0.1 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21ADW058 – Amphibolite from the Fortymile River assemblage (YTT)

Sample 21ADW058 is a dark gray, gneissic amphibolite with white streaks defined by quartz and plagioclase within the Fortymile River assemblage amphibolite unit in the Western Tanacross map area. Observed grain sizes are between 0.5 and 1.0 mm. Mineralogy includes amphibole, feldspar,

biotite, quartz, and magnetite. A hornblende separate yielded an integrated age of 170.0 ± 0.2 Ma. The age spectrum is hump-shaped with younger ages for initial heating steps and slightly younger ages for later heating steps. A weighted mean age of 176.1 ± 1.1 Ma was calculated from four heating steps representing 54 percent of the total gas release. The preferred age for this sample is the weighted mean age of **176.1 ± 1.1 Ma**, which is interpreted to record the sample's cooling through the hornblende's closure temperature.

21ADW241 – Orthogneiss from the Lake George assemblage (pNA)

Sample 21ADW241 is a tan orthogneiss with grain size between 2 and 5 mm within the Lake George assemblage in the Taylor Mountain map area. Mineralogy includes feldspar, quartz, biotite, and muscovite. A muscovite separate yielded an integrated age of 108.9 ± 0.1 Ma. The age spectrum yields a climbing pattern where the higher-temperature heating steps have older ages. A weighted-mean age of 109.6 ± 0.4 Ma was calculated from eight heating steps representing 49 percent of the total gas release. Due to the climbing age spectrum pattern, the preferred age for this sample is the weighted-mean age of **109.6 ± 0.4 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21ADW289 – Paragneiss from the Fortymile River assemblage (YTT)

Sample 21ADW289 is a dark gray, quartz-eye paragneiss with grain size between 0.5 and 6 mm within the Lake George assemblage in the Taylor Mountain map area. Mineralogy includes quartz, muscovite, biotite, chlorite, feldspar, and magnetite. A muscovite separate yielded an integrated age of 127.2 ± 0.1 Ma. The age spectrum yields a climbing pattern where the higher-temperature heating steps have older ages. A weighted-mean age of 130.6 ± 1.4 Ma was calculated from 10 heating steps representing 68 percent of the total gas release. Due to the climbing age spectrum pattern, the preferred age for this sample is the weighted-mean age of **130.6 ± 1.4 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21AKH040 – Augen gneiss from the Lake George assemblage (pNA)

Sample 21AKH040 is a white and black augen orthogneiss within the Lake George assemblage Divide Mountain augen gneiss in the Western Tanacross map area. Outcrop description includes potassium feldspar augen up to 20 mm in diameter and mineralogy including feldspar, quartz, muscovite, and biotite. A muscovite separate yielded an integrated age of 111.3 ± 0.1 Ma. The age spectrum is flat with younger ages in the initial two heating steps. A weighted-mean age of 112.3 ± 0.2 Ma was calculated from eight heating steps representing 34 percent of the total gas release. Due to the flat age spectrum, the preferred age for this sample is the weighted mean age of **112.3 ± 0.2 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21AKH111 – Quartzite from the Jarvis belt (pNA)

Sample 21AKH111 is a feldspathic quartzite within the Jarvis belt in the Western Tanacross map area. Grain size ranges from 0.1 to 2 mm. Mineralogy includes quartz, feldspar, muscovite, and calcite. A muscovite separate yielded an integrated age of 128.2 ± 0.1 Ma. The age spectrum is mostly flat with slightly older ages in the later three heating steps. A weighted-mean age of 130.2 ± 1.0 Ma was

calculated from three heating steps representing 19 percent of the total gas release. Due to the older ages for the three higher temperature heating steps, the preferred age for this sample is the weighted-mean age of **130.2 ± 1.0 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21AKH129 – Orthogneiss from the Lake George assemblage (pNA)

Sample 21AKH129 is a biotite-bearing tonalite orthogneiss within the Lake George assemblage orthogneiss unit in the Western Tanacross map area. Grain size ranges from 0.5 to 2 mm. Mineralogy includes quartz, feldspar, and biotite. A biotite separate yielded an integrated age of 110.3 ± 0.1 Ma. The age spectrum is flat with two younger initial heating steps. A plateau age of 110.8 ± 0.1 Ma was calculated. Due to the flat step-heating age spectrum, the preferred age for this sample is the plateau age of **110.8 ± 0.1 Ma**, which is interpreted to record the sample's cooling through biotite's closure temperature.

21AW088 – Metavolcanic rock from the Lake George assemblage (pNA)

Sample 21AW088 is a greenish-gray, porphyroclastic metavolcanic rock within the Lake George assemblage in the Western Tanacross map area. The sample is described as schistose with grain sizes between 0.01 and 7 mm. Mineralogy includes feldspar, quartz, muscovite, and chlorite. A muscovite separate yielded an integrated age of 116.9 ± 0.10 Ma. The age spectrum has a crankshaft shape, and an intermediate part of the spectrum was used to calculate a weighted-mean age of 120.0 ± 0.3 Ma from four heating steps representing 29 percent of total gas release. Due to the complex age spectrum, the preferred age for this sample is the weighted mean age of **120.0 ± 0.3 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21ET169 – Vein selvage in quartzite from the Jarvis belt (pNA)

Sample 21ET169 is a light-yellow, bleached, and strongly altered quartzite with grain size between 0.5 and 2 mm at the Dave's Zone prospect in the Jarvis belt (USGS, 1996). Mineralogy includes quartz and muscovite. The quartzite is cut by 1- to 2-mm-wide quartz veinlets spaced 10 to 50 mm apart in a ladder pattern. A muscovite separate from the vein selvage yielded an integrated age of 108.2 ± 0.2 Ma. The age spectrum has a climbing pattern with the oldest ages associated with the highest-temperature heating steps. A weighted-mean age of 114.2 ± 0.4 Ma was calculated from five heating steps representing 15 percent of total gas release. Due to the climbing age spectrum, the preferred age for this sample is the weighted mean age of **114.2 ± 0.4 Ma**, which is interpreted to record the timing of vein formation and related mineralization at the Dave's Zone prospect in the eastern Alaska Range.

21ET179 – Mineralized vein selvage in quartzite from the Jarvis belt (pNA)

Sample 21ET179 is a white- to medium-gray, brecciated quartz vein sample from the Discovery Zone prospect in the Jarvis belt (USGS, 1996). The vein cuts foliation, but it also disappears into or is offset by foliation-parallel shear planes. The vein comprises brecciated milky white quartz and wall-rock fragments with fine-grained arsenopyrite and pyrite-infilling fractures. A sericite separate yielded an integrated age of 117.9 ± 0.1 Ma. The age spectrum has a climbing pattern with the oldest ages from the highest temperature heating steps. A weighted-mean age of 120.3 ± 0.9 Ma was calculated from

three heating steps representing 25 percent of total gas release. Due to the climbing age spectrum, the preferred age for this sample is the weighted mean age of **120.3 ± 0.9 Ma**, which is interpreted to record the timing of vein formation and related mineralization at the Discovery Zone prospect in the eastern Alaska Range.

21ET207 – Paragneiss from the Fortymile River assemblage (YTT)

Sample 21ET207 is a gray to tan paragneiss with grain sizes between 0.5 and 1 mm within the Fortymile River assemblage metasedimentary unit in the Western Tanacross map area. Mineralogy includes quartz, feldspar, amphibole, biotite, and chlorite. A hornblende separate yielded an integrated age of 186.6 ± 1.5 Ma. The age spectrum is variable. The preferred age for this sample is the plateau age of **192.9 ± 2.0 Ma**, which is interpreted to record the sample's cooling through the hornblende's closure temperature.

21ET242 – Mineralized vein sample in quartz diorite

Sample 21ET242 is a vein with an alteration halo cutting quartz diorite at the Lilliwig Creek prospect (USGS, 1996) in the Taylor Mountain map area. A sericite separate yielded an integrated age of 187.0 ± 1.6 Ma. The age spectrum has a climbing pattern with the oldest ages from the highest temperature heating steps. A plateau age of 191.4 ± 1.1 Ma was calculated. Due to the climbing age spectrum, the preferred age for this sample is the plateau age of **191.4 ± 1.1 Ma**, which is interpreted to record the timing of vein formation and related mineralization at the Lilliwig Creek prospect.

21ET252 – Mineralized vein sample in the Chicken assemblage (YTT)

Sample 21ET252 is a vein with an alteration halo within the greenstone of the Chicken assemblage at the Tweeden prospect (USGS, 1996) in the Taylor Mountain map area. A sericite separate yielded an integrated age of 187.3 ± 0.9 Ma. The age spectrum is variable. A weighted-mean age of 190.7 ± 2.6 Ma was calculated from 11 heating steps representing 96 percent of the total gas release. Due to the variability in the age spectrum, the preferred age for this sample is the weighted mean age of **190.7 ± 2.6 Ma**, which is interpreted to record the timing of vein formation and related mineralization at the Tweeden prospect.

21MLB046 – Augen gneiss from the Lake George assemblage (pNA)

Sample 21MLB046 is a light-tan augen orthogneiss with potassium feldspar porphyroclasts with grain sizes up to 30 mm in diameter within the Lake George assemblage in the Western Tanacross map area. Mineralogy includes feldspar, quartz, muscovite, and biotite. A muscovite separate yielded an integrated age (121.1 ± 0.1 Ma) and a weighted-mean age (120.9 ± 0.6 Ma) that are within uncertainty. The preferred age for this sample is the weighted mean age of **120.9 ± 0.6 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21RN239 – Garnet-bearing skarn from the Lake George assemblage

Sample 21RN239 is a garnet-bearing skarn within the Lake George assemblage metasedimentary unit near the Eagle prospect in the Western Tanacross map area (USGS, 1996). Grain size ranges from

0.1 to 10 mm. Mineralogy includes amphibole, quartz, calcite, phlogopite, clinozoisite, garnet, and chlorite. Coarse, randomly oriented calcite and amphibole in thin section suggest skarn formation post-dated deformation. A phlogopite separate yielded an integrated age of 104.3 ± 0.7 Ma. The age spectrum has a climbing pattern with younger ages from lower temperature heating steps. A weighted-mean age of 111.8 ± 4.8 Ma was calculated from five heating steps representing 79 percent of the total gas release. Low K/Ca values suggest a very low bulk K_2O content in the phlogopite separate, suggesting significant chlorite alteration. Due to the climbing age spectrum, the preferred age for this sample is the plateau age of **111.8 ± 4.8 Ma**, which is interpreted to record the timing of phlogopite growth during skarn formation.

21RN530 – Trachybasalt

Sample 21RN530 is a phlogopite-bearing trachybasalt in the Taylor Mountain map area. The sample is porphyritic with a dark-colored aphanitic groundmass. The grain size of phlogopite phenocrysts is up to 5 mm. A phlogopite separate yielded an integrated age of 101.7 ± 0.2 Ma. The age spectrum is discordant, but the highest-temperature heating steps have consistent ages. A weighted-mean age of 100.8 ± 0.5 Ma was calculated from six heating steps representing 65 percent of the total gas release. Due to the discordant age spectrum, the preferred age for this sample is the weighted mean age of **100.8 ± 0.5 Ma**, which is interpreted to record the crystallization age of the trachybasalt.

21RN612 – Mg-skarn from the Fortymile River assemblage (YTT)

Sample 21RN612 is a dark green to brown skarn from a drill core from the Fish prospect (USGS, 1996) within the Fortymile River assemblage northwest of the Taylor Mountain map area. Grain size ranges from 0.1 to 2 mm. Mineralogy includes diopside, calcite, chlorite, hematite, hornblende, magnetite, phlogopite, and serpentine. A phlogopite separate yielded an integrated age of 85.6 ± 0.2 Ma. The age spectrum is complex; neither a plateau nor weighted mean age was calculated. The integrated age (85.6 ± 0.2 Ma) does not overlap with any known pluton ages near the Fish prospect. Therefore, we have low confidence that the integrated age records the timing of phlogopite growth during skarn formation.

21TJN154 – Quartz schist from the Chicken assemblage (YTT)

Sample 21TJN154 is muscovite quartz schist interlayered with quartzite within the Chicken assemblage metasedimentary unit in the Taylor Mountain map area. The grain size is up to 1 mm. Mineralogy includes 80 percent quartz and 20 percent muscovite. A muscovite separate yielded an integrated age of 100.5 ± 0.1 Ma. The age spectrum has a climbing pattern with younger initial heating steps. A weighted-mean age of 103.4 ± 0.4 Ma was calculated from eight heating steps representing 57 percent of the total gas release. Due to the climbing pattern of the age spectrum, the preferred age for this sample is the weighted mean age of **103.4 ± 0.4 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

21TJN257 – Orthogneiss from the Fortymile River assemblage (YTT)

Sample 21TJN257 is an orthogneiss with large potassium feldspar porphyroblasts. The sample is considered part of the Fortymile River assemblage based on its association with nearby Triassic

plutonic rock. The gneiss has up to 30 percent muscovite, which is atypical for the Divide Mountain augen gneiss. Porphyroblasts are up to 40 mm in diameter. Mineralogy includes feldspar, muscovite, biotite, and quartz. A muscovite separate yielded an integrated age of 113.3 ± 0.1 Ma. The age spectrum is flat, with older ages in the two highest temperature heating steps. A weighted mean age of 115.4 ± 0.8 Ma was calculated from these two heating steps representing 15 percent of total gas released. Due to the climbing pattern of the age spectrum, the preferred age for this sample is the weighted mean age of **115.4 ± 0.8 Ma**, which is interpreted to record cooling of the sample through the closure temperature of muscovite.

Table 1. Age results, including integrated age, plateau or weighted-mean age, and interpretive details.

SAMPLE	MINERAL	INTEGRATED AGE (M.A.)	PLATEAU OR WEIGHTED-MEAN AGE (M.A.)	PREFERRED AGE INFORMATION
09RN405A	Muscovite	99.4 ± 0.1	**99.3 ± 0.3***	15 out of 16 fractions; 96.8 percent ^{39}Ar release; MSWD = 17.4
18ET176	Muscovite	111.2 ± 0.1	**118.4 ± 1.9***	3 out of 17 fractions; 18.0 percent ^{39}Ar release; MSWD = 986
18KS221	Muscovite	108.5 ± 0.1	**109.1 ± 0.2***	15 out of 17 fractions; 90.3 percent ^{39}Ar release; MSWD = 24.5
19KS128	Muscovite	**198.2 ± 0.1**		No plateau calculated
21ADW058	Hornblende	170.0 ± 0.2	**176.1 ± 1.1***	4 out of 14 fractions; 54.4 percent ^{39}Ar release; MSWD = 68.9
21ADW241	Muscovite	108.9 ± 0.1	**109.6 ± 0.4***	8 out of 17 fractions; 48.7 percent ^{39}Ar release; MSWD = 49.8
21ADW289	Muscovite	127.2 ± 0.1	**130.6 ± 1.4***	10 out of 17 fractions; 68.2 percent ^{39}Ar release; MSWD = 861
21AKH040	Muscovite	111.3 ± 0.1	**112.3 ± 0.2***	8 out of 17 fractions; 34.0 percent ^{39}Ar release; MSWD = 2.36
21AKH111	Muscovite	128.2 ± 0.1	**130.2 ± 1.0***	3 out of 13 fractions; 18.7 percent ^{39}Ar release; MSWD = 22.1
21AKH129	Biotite	110.3 ± 0.1	**110.8 ± 0.1**	4 out of 10 fractions; 64.0 percent ^{39}Ar release; MSWD = 0.75
21AW088	Muscovite	116.9 ± 0.1	**120.0 ± 0.3***	4 out of 17 fractions; 28.5 percent ^{39}Ar release; MSWD = 38.9
21ET169	Muscovite	108.2 ± 0.2	**114.2 ± 0.4***	5 out of 17 fractions; 14.6 percent ^{39}Ar release; MSWD = 1.51
21ET179	Muscovite	117.9 ± 0.1	**120.3 ± 0.9***	3 out of 17 fractions; 25.1 percent ^{39}Ar release; MSWD = 268
21ET207	Hornblende	186.6 ± 1.5	**192.9 ± 2.0**	8 out of 14 fractions; 67.5 percent ^{39}Ar release; MSWD = 1.88

SAMPLE	MINERAL	INTEGRATED AGE (M.A.)	PLATEAU OR WEIGHTED-MEAN AGE (M.A.)	PREFERRED AGE INFORMATION
21ET242	Sericite	187.0 ± 1.6	**191.4 ± 1.1**	7 out of 10 fractions; 87.3 percent ^{39}Ar release; MSWD = 1.26
21ET252	Sericite	187.3 ± 0.9	**190.7 ± 2.6***	11 out of 12 fractions; 95.8 percent ^{39}Ar release; MSWD = 12.9
21MLB046	Muscovite	121.1 ± 0.1	**120.9 ± 0.6***	5 out of 13 fractions; 76.6 percent ^{39}Ar release; MSWD = 1043
21RN239	Phlogopite	104.3 ± 0.7	**111.8 ± 4.8***	5 out of 12 fractions; 79.0 percent ^{39}Ar release; MSWD = 74.5
21RN530	Phlogopite	101.7 ± 0.2	**100.8 ± 0.5***	6 out of 12 fractions; 64.9 percent ^{39}Ar release; MSWD = 15.2
21RN612	Phlogopite	85.6 ± 0.2		No plateau calculated
21TJN154	Muscovite	100.5 ± 0.1	**103.4 ± 0.4***	8 out of 17 fractions; 57.4 percent ^{39}Ar release; MSWD = 43.1
21TJN257	Muscovite	113.3 ± 0.1	**115.4 ± 0.8***	2 out of 17 fractions; 14.7 percent ^{39}Ar release; MSWD = 134

Samples were analyzed with standard FC-2 with an age of 28.201 Ma.
*Did not meet all the criteria for a plateau age; hence, a weighted-mean age determination is presented
All errors reported are 2σ. Preferred age in **bold**.

ACKNOWLEDGEMENTS

U.S. Geological Survey EarthMRI funded sample collection and analyses for the Western Tanacross and Taylor Mountain projects awards G20AC00156 and G21AC10336 and State of Alaska capital project funds. Sample analyses for the compilation mapping in the eastern Yukon Tanana Upland were funded by USGS STATEMAP award G21AC10706. We are grateful to have had access to Doyon Limited lands within the study area. We thank the USGS for lending us core samples from the Fish prospect. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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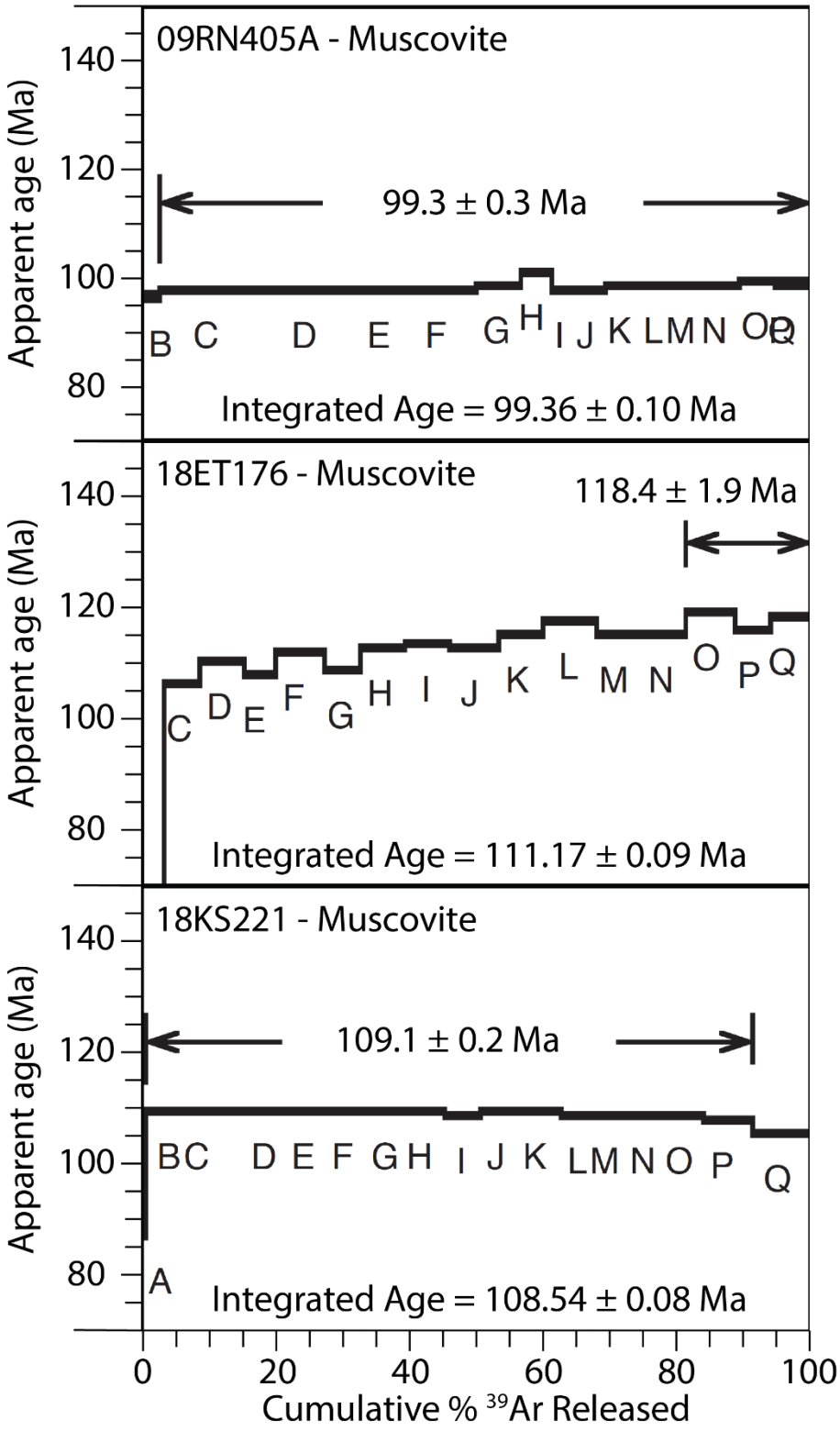
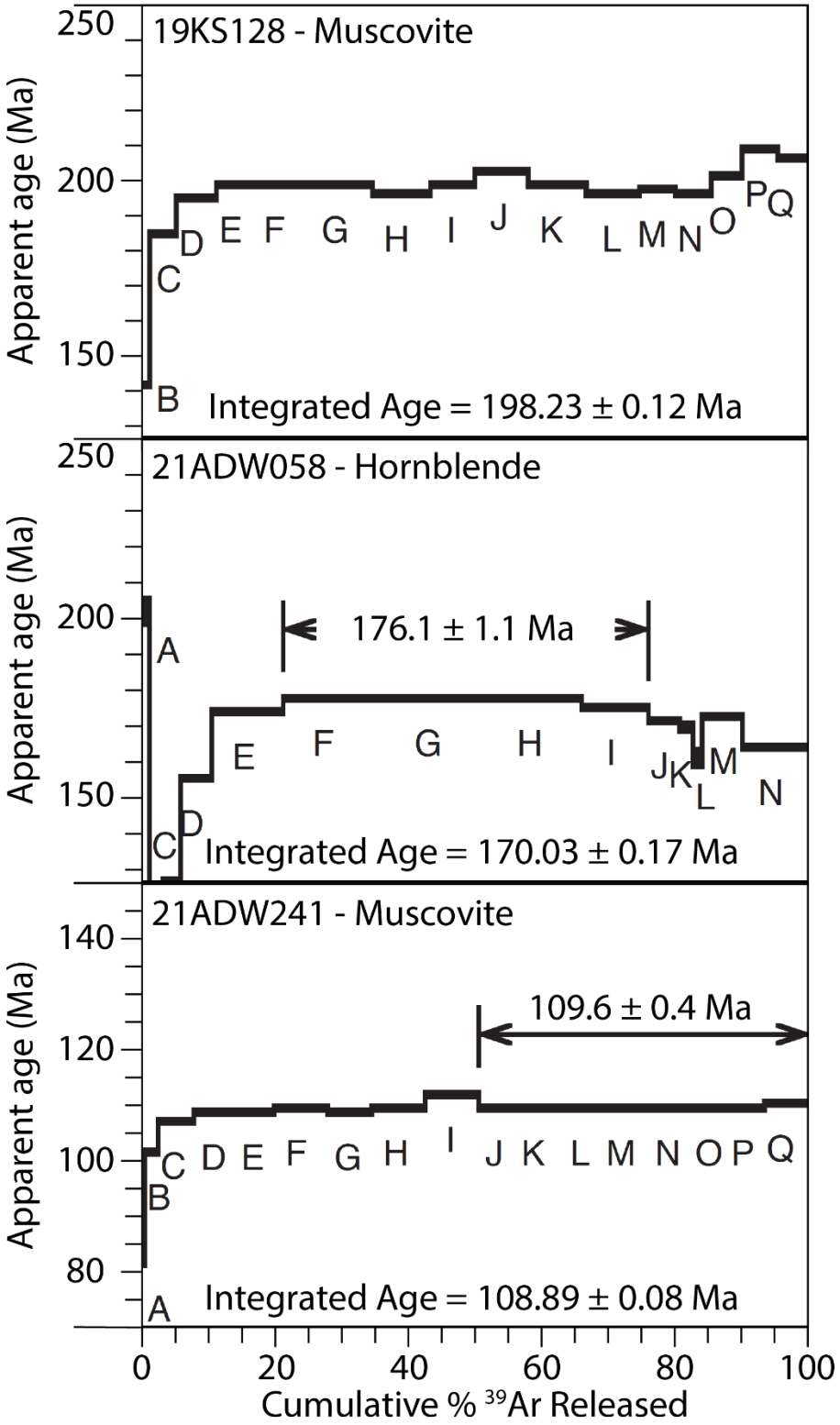
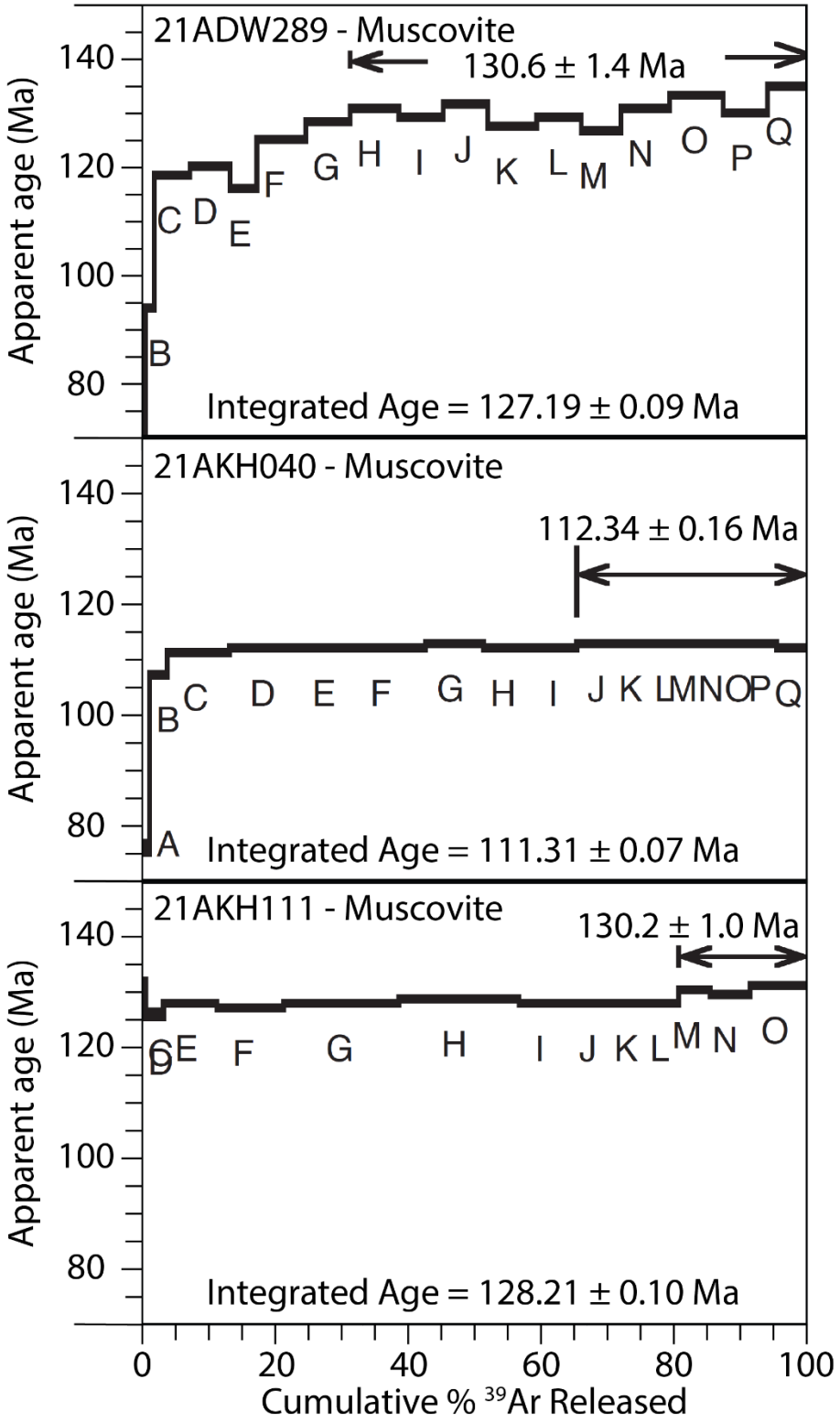
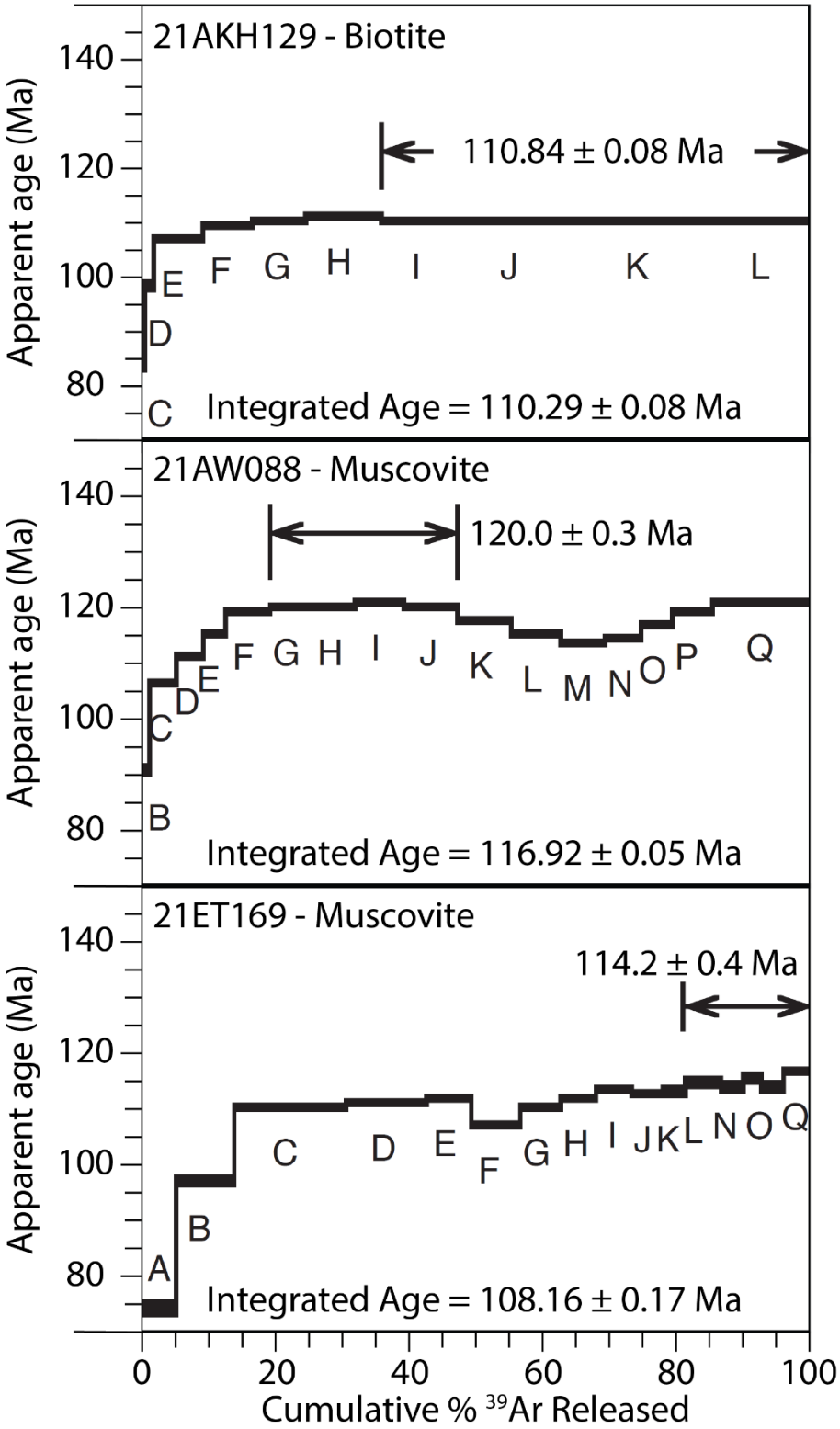
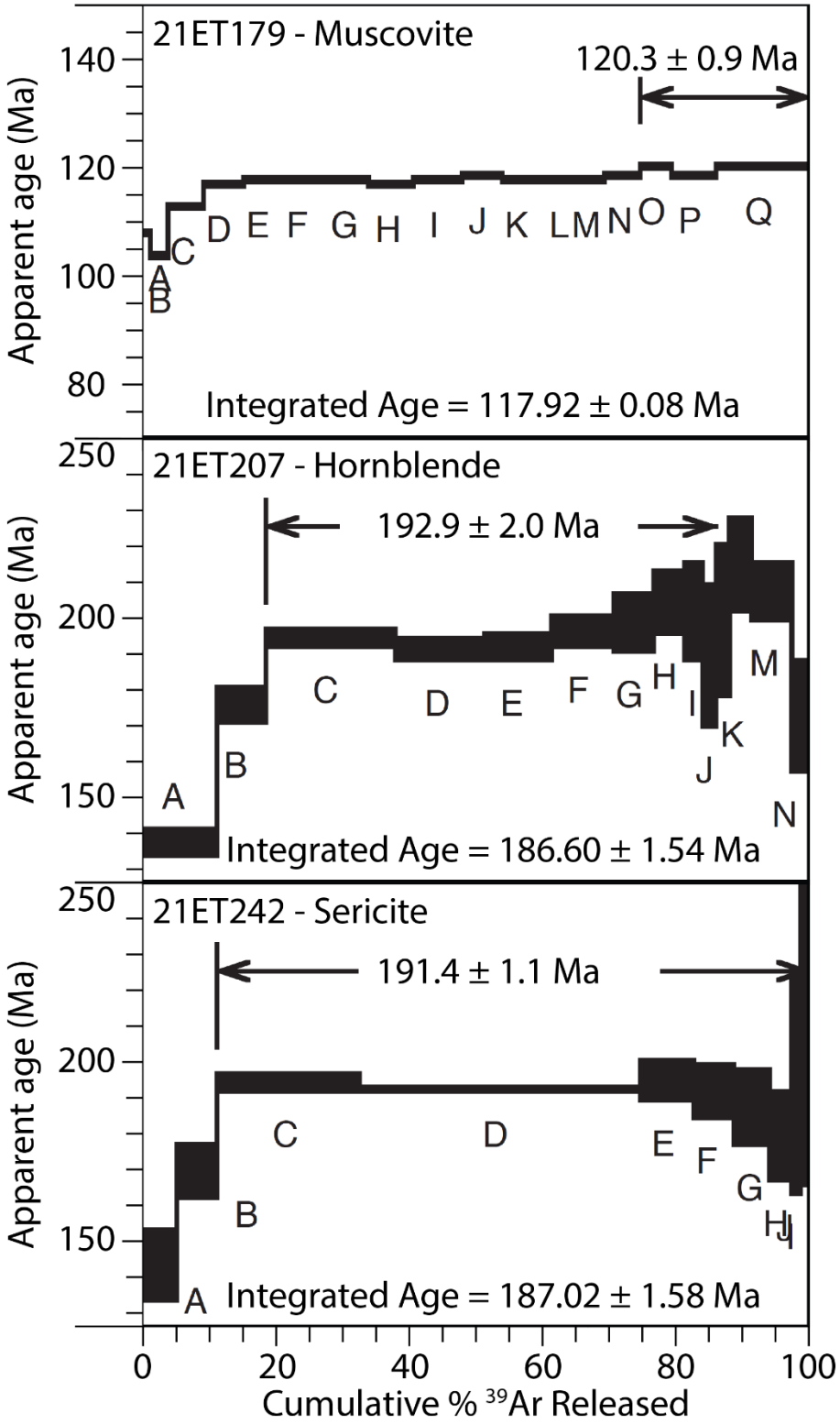
APPENDIX: PLOTS OF $^{40}AR/^{39}AR$ AGE SPECTRA

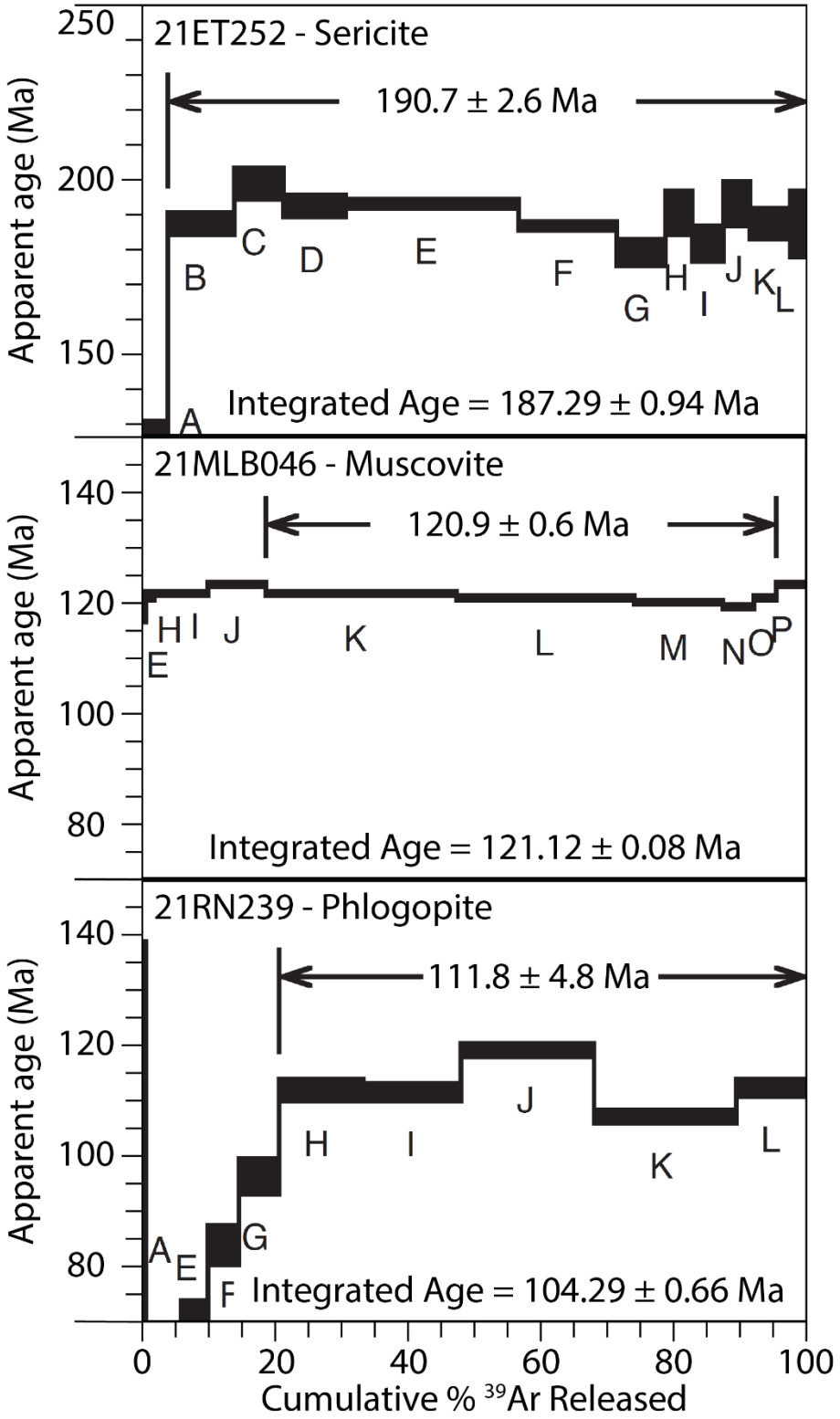


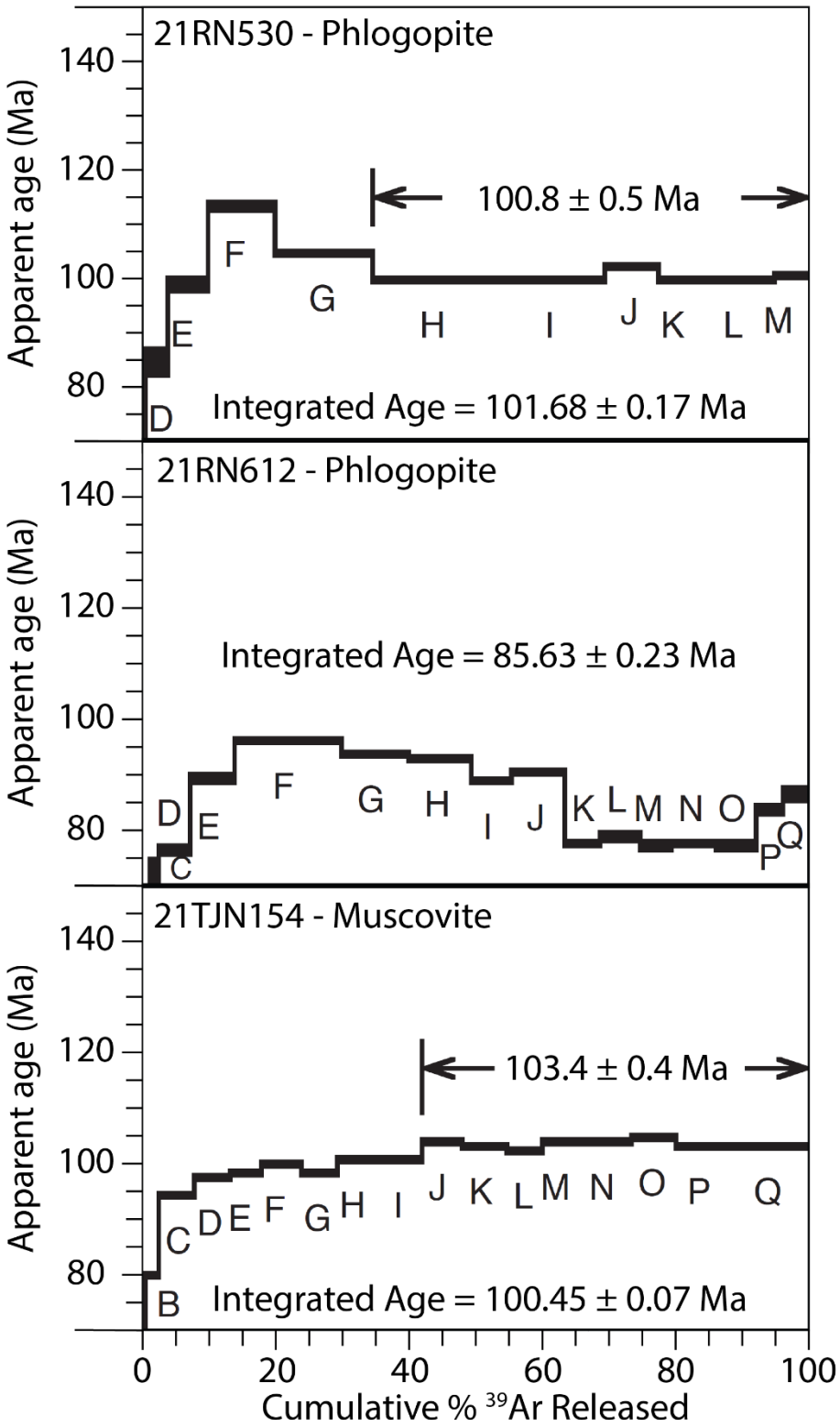

19KS128 - Muscovite
Integrated Age = 198.23 ± 0.12 Ma
21ADW058 - Hornblende
176.1 ± 1.1 Ma
Integrated Age = 170.03 ± 0.17 Ma
21ADW241 - Muscovite
109.6 ± 0.4 Ma
Integrated Age = 108.89 ± 0.08 Ma
Apparent age (Ma)
Cumulative % 39Ar Released

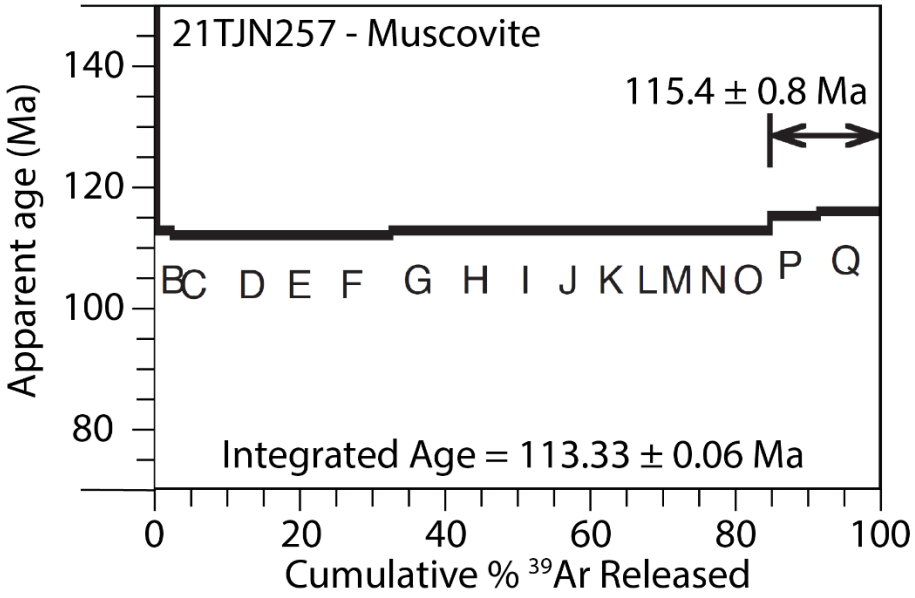

21ADW289 - Muscovite
130.6 ± 1.4 Ma
Integrated Age = 127.19 ± 0.09 Ma
21AKH040 - Muscovite
112.34 ± 0.16 Ma
Integrated Age = 111.31 ± 0.07 Ma
21AKH111 - Muscovite
130.2 ± 1.0 Ma
Integrated Age = 128.21 ± 0.10 Ma
Apparent age (Ma)
140
120
100
80
0
20
40
60
80
100
Cumulative % 39Ar Released


21AKH129 - Biotite
110.84 ± 0.08 Ma
Integrated Age = 110.29 ± 0.08 Ma
21AW088 - Muscovite
120.0 ± 0.3 Ma
Integrated Age = 116.92 ± 0.05 Ma
21ET169 - Muscovite
114.2 ± 0.4 Ma
Integrated Age = 108.16 ± 0.17 Ma
Apparent age (Ma)
140
120
100
80
0
20
40
60
80
100
Cumulative % 39Ar Released


21ET179 - Muscovite
120.3 ± 0.9 Ma
Integrated Age = 117.92 ± 0.08 Ma
21ET207 - Hornblende
192.9 ± 2.0 Ma
Integrated Age = 186.60 ± 1.54 Ma
21ET242 - Sericite
191.4 ± 1.1 Ma
Integrated Age = 187.02 ± 1.58 Ma
Apparent age (Ma)
Cumulative % 39Ar Released


21ET252 - Sericite
190.7 ± 2.6 Ma
Integrated Age = 187.29 ± 0.94 Ma
21MLB046 - Muscovite
120.9 ± 0.6 Ma
Integrated Age = 121.12 ± 0.08 Ma
21RN239 - Phlogopite
111.8 ± 4.8 Ma
Integrated Age = 104.29 ± 0.66 Ma
Apparent age (Ma)
Cumulative % 39Ar Released


21RN530 - Phlogopite
Apparent age (Ma)
140
120
100
80
100.8 ± 0.5 Ma
D
E
F
G
H
I
J
K
L
M
Integrated Age = 101.68 ± 0.17 Ma
21RN612 - Phlogopite
Integrated Age = 85.63 ± 0.23 Ma
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
21TJN154 - Muscovite
103.4 ± 0.4 Ma
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
Integrated Age = 100.45 ± 0.07 Ma
0
20
40
60
80
100
Cumulative % 39Ar Released


21TJN257 - Muscovite
115.4 ± 0.8 Ma
Integrated Age = 113.33 ± 0.06 Ma
Apparent age (Ma)
140
120
100
80
0
20
40
60
80
100
Cumulative % 39Ar Released
B C D E F G H I J K L M N O P Q