Alaska Division of Geological & Geophysical Surveys

Raw Data File 2014-19

$^{40}Ar/^{39}Ar$ DATA, RAY MOUNTAINS AREA, BETTLES QUADRANGLE, ALASKA

by

Amy L. Tuzzolino, Rainer J. Newberry, Jeffrey A. Benowitz., Paul W. Layer, Larry K. Freeman

$2.00

October 2014

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Released by:

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
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by

Amy L. Tuzzolino[1,2], Rainer J. Newberry[2], Jeffrey A. Benowitz[3], Paul W. Layer[3], and Larry K. Freeman[1]

SUMMARY

^{40}Ar/^{39}Ar analyses were performed on igneous rocks from the Ray Mountains area of west-central Alaska. The plutonic samples have ages from about 89 Ma to 109 Ma, while the volcanic samples show ranges from about 30 Ma to 64 Ma. The three volcanic samples fall into two age groups: the younger sample, a basalt, has an age of about 30 Ma, while the two older, rhyolitic samples fall between 58 Ma and 64 Ma.

INTRODUCTION

In 2012, the State of Alaska established its Strategic and Critical Minerals (SCM) Assessment project, a State-funded Capital Improvement Project (CIP), to evaluate Alaska's statewide potential for SCM resources. The project is being implemented by the Alaska Division of Geological & Geophysical Surveys (DGGS), and involves obtaining new airborne-geophysical, geological, and geochemical data.

DGGS conducted a multi-year project from 2012 through 2013 studying the geology and economic potential of rare-earth elements (REEs) and base metals in the Ray Mountains in the Beaver, Bettles, Livengood, and Tanana quadrangles (Bachmann and others, 2013). As part of the bedrock geologic mapping, seven samples in the Bettles Quadrangle were collected for geochronologic analyses using ^{40}Ar/^{39}Ar techniques. These new age dates will allow us to better evaluate the geochronology of the granitic rocks that are the apparent source of the alluvial REE resources, and the geochronology of the volcanic rocks that relate to the development of the basins hosting the alluvial deposits. Previously published ages are listed in table 1. Ages from the Kanuti and Hot Springs plutons are significantly younger than those of the other plutons in the field area. Therefore, we resampled and re-dated granites from the Kanuti and Hot Springs plutons to establish precision. No ages have been previously published for the No Name Creek and Ray River plutons, or for the rhyolites near the Kanuti pluton.

The purpose of this DGGS Raw Data File is to present the ^{40}Ar/^{39}Ar age results of the Ray Mountains study. Analyses were performed by the University of Alaska Fairbanks Geochronology Laboratory, and results were reported by Paul Layer and Jeff Benowitz. Additional new U/Pb ages from the Ruby Batholith are being published in a separate release (Tuzzolino and others, *in preparation*).

The text and analytical spectra plots are being published as .pdf files; location coordinates and analytical data are being released as .csv files. A detailed description of the data files can be found in the associated metadata file. All are available from the DGGS website (doi:10.14509/29124) at no charge.

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Table 1. Published ages within the study area.

Map Unit Name	Igneous Rock Type	Dating Technique	Dated Material	Preferred Age	Source
Tb	Volcanic	K/Ar	Plagioclase feldspar	30.59 ± 0.92 Ma	Albanese, 1987
Tv	Volcanic	K/Ar	Glass shards and feldspar phenocrysts	38.6 ± 1.6 Ma	Barker, 1981
Kgr—Hot Springs Pluton	Plutonic	K/Ar	Biotite	96.3 ± 1.7 Ma	Miller, 1989
Kgr—Kanuti Pluton	Plutonic	K/Ar	Biotite	98.0 ± 1.7 Ma	Miller, 1989
Kgr—Kanuti Pluton	Plutonic	K/Ar	Biotite	99.0 ± 1.1 Ma	Miller, 1989
Kgr—Ray Mountains Pluton	Plutonic	K/Ar	Biotite	104 ± 3 Ma	Miller, 1989
Kgr—Sithylemenkat Pluton	Plutonic	K/Ar	Biotite	106.0 ± 3.0 Ma	Miller, 1989
Kgr—Sithylemenkat Pluton	Plutonic	K/Ar	Biotite	106.0 ± 2.0 Ma	Miller, 1989
Kgr—Ray Mountains Pluton	Plutonic	K/Ar	Biotite	107.0 ± 1.9 Ma	Miller, 1989
Kgr—Ray Mountains Pluton	Plutonic	K/Ar	Biotite	107.1 ± 1.8 Ma	Miller, 1989
Kgr—Ray Mountains Pluton	Plutonic	U/Pb	Zircon	109.6 Ma	Patton and others, 1987
Kgr—Ray Mountains Pluton	Plutonic	U/Pb	Zircon	112.1 Ma	Patton and others, 1987

METHODOLOGY

Field Procedures

Field geologists collected rock samples from the surface or within 0.5 m of the surface. Care was taken to collect fresh, unweathered samples with large grains to be used for mineral and pumice separates, whereas volcanic rocks with the freshest-appearing groundmass were selected for the whole-rock samples. Locations were recorded using handheld, WAAS-enabled GPS devices. WAAS-enabled GPS devices have a reported error of about 1 m (NSTB/WAAS T&E Team, 2006). Depending on degradation of the WAAS and GPS signals, the horizontal position error of sample locations in this report is in the range of 1–10 m. The originating coordinate system for each sample location varied according to the GPS settings specified by the collector. To provide a consistent coordinate system for all samples, all location coordinates were converted to decimal degrees, North American Datum of 1983 (NAD 83). Sample location coordinates are provided in the accompanying .csv file.

Analytical Methods

The selected rock samples were submitted to the University of Alaska Fairbanks Geochronology Laboratory. There, the samples were crushed, washed, sieved, and then hand-picked for phenocryst-free whole-rock chips and pumice, and for datable mineral phases. The monitor mineral, MMhb-1 (Samson and Alexander, 1987), with an age of 523.5 Ma (Renne and others, 1994), was used to monitor neutron flux and calculate the irradiation parameter, J. The samples and standards were wrapped in aluminum foil and loaded into aluminum cans of 2.5 cm diameter and 6 cm height. The plutonic samples were irradiated in position 8b of the uranium-enriched research reactor of McMaster University in Hamilton, Ontario, Canada, for 150 megawatt-hours, while the volcanic samples were irradiated in position 5c for 20 megawatt-hours.

Upon their return from the reactor, the samples and monitors were loaded into 2-mm-diameter holes in a copper tray that was then loaded into an ultra-high-vacuum extraction line. The monitors were fused, and samples heated, using a 6 watt argon-ion laser following the technique described in York and others (1981), Layer and others (1987), and Layer (2000). Argon purification was achieved using a liquid nitrogen cold trap and a SAES Zr-Al getter at 400°C. Samples were analyzed in a VG-3600 mass spectrometer at the Geophysical Institute, University of Alaska Fairbanks. The measured argon isotopes were corrected for system blank and mass discrimination, as well as calcium-, potassium-, and chlorine-interference reactions following procedures outlined in McDougall and Harrison (1999). Interference corrections were: $(^{39}Ar/^{37}Ar)Ca = 0.000706$, $(^{36}Ar/^{37}Ar)Ca = 0.000279$, and $(^{40}Ar/^{39}Ar)K = 0.0297$. System blanks generally were 2×10^{-16} mol ^{40}Ar, 3×10^{-18} mol ^{39}Ar, 9×10^{-18} mol ^{38}Ar, and 2×10^{-18} mol ^{36}Ar, which are 10 to 50 times smaller than the fraction volumes. Mass discrimination was monitored by running calibrated air shots. These measurements were made on a weekly to monthly basis to check for changes in mass discrimination.

The age, Ca/K, and Cl/K spectrum plots for each sample are shown in the appendices. The Ca/K ratio is determined from ^{37}Ar produced from ^{40}Ca and ^{39}Ar produced from ^{39}K, and the Cl/K ratio as determined from ^{38}Ar produced from ^{37}Cl and ^{39}Ar produced from ^{39}K. Detailed step-heating data for each sample, as well as files summarizing the $^{40}Ar/^{39}Ar$ results, are presented in .csv files accompanying this report. These data and summaries report all ages to the ±1 sigma level and were calculated using the constants of Renne and others (2010). The integrated age is the age given by the total gas measured and is equivalent to a potassium-argon (K-Ar) age. The spectrum provides a plateau age 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). All samples show well-defined plateaus. Weighted averages of the plateaus are reported.

Discussion of Results

Much of the following discussion is derived from the laboratory report on the analytical results. The samples are presented in chronologic order, from oldest apparent age to youngest.

12RN352C—Muscovite from the interior of the Ray River pluton: A muscovite separate from sample 12RN352C was analyzed. The integrated age (108.5 ± 0.6 Ma) is within the error of the plateau age (108.0 ± 0.6 Ma). We prefer the plateau age of 108.0 ± 0.6 Ma because of the high atmospheric content of the first low-temperature heating steps, which is associated with loss/alteration. This age represents the greisen alteration and veining, which likely occurred during final crystallization of the host granite. Therefore, this age can be used to constrain the age of pluton emplacement and crystallization. No isochron age determination was possible due to the generally homogenous radiogenic content of the steps used for the weighted average age determination.

12LF322A—Muscovite from the eastern portion of the Hot Springs pluton: A muscovite separate from sample 12LF322A was analyzed. The integrated age (107.0 ± 0.6 Ma) is within the error of the plateau age (106.8 ± 0.8 Ma). We prefer the plateau age of 106.8 ± 0.8 Ma because of the high atmospheric content of the first low-temperature heating steps, which is associated with loss/alteration. This age represents the greisen alteration and veining, which likely occurred during final crystallization of the host granite. Therefore, this age can be used to constrain the age of pluton emplacement and crystallization. No isochron age determination was possible due to the generally homogenous radiogenic content of the steps used for the weighted average age determination.

13LF416A—Muscovite from the western portion of the No Name pluton: A muscovite separate from sample 13LF416A was analyzed. The integrated age (105.8 ± 0.6 Ma) is within the error of the plateau age (105.6 ± 0.6

Ma). We prefer the plateau age of 105.6 ± 0.6 Ma because of the high atmospheric content of the first low-temperature heating steps, which is associated with loss/alteration. The muscovite in this sample is modal muscovite, and hence its age likely represents the age of crystallization. No isochron age determination was possible due to the generally homogenous radiogenic content of the steps used for the weighted average age determination.

12LF247A—Muscovite from the northern part of the Kanuti pluton: A muscovite separate from sample 12LF247A was analyzed. The integrated age (90.2 ± 0.5 Ma) is within the error of the plateau age (90.0 ± 0.5Ma). We prefer the plateau age of 90.0 ± 0.5 Ma because of the high atmospheric content of the first low-temperature heating steps, which is associated with loss/alteration. This age represents the greisen alteration and veining, which likely occurred during final crystallization of the host granite. Therefore, this age can be used to constrain the age of pluton emplacement and crystallization. No isochron age determination was possible due to the generally homogenous radiogenic content of the steps used for the weighted average age determination.

12LF123A—Pumice from a felsic volcaniclastic in the upper Kanuti River Volcanic field: A pumice separate from sample 12BG109A was analyzed. The integrated age (64.2 ± 0.5 Ma) is within the errors of both the plateau age (64.2 ± 0.5 Ma) and the isochron age (63.8 ± 0.4 Ma). We prefer the isochron age of 63.8 ± 0.4 Ma because of the evidence of slight excess ^{40}Ar and the higher precision over the plateau age determination. The isochron age thus represents the eruptive age of the rhyolite.

12CW033B—Whole rock from granite/rhyolite porphyry in the upper Kanuti River felsic volcanic field: A whole-rock separate from sample 12CW33B was analyzed. The integrated age (61.5 ± 0.3 Ma) is not within the error of the plateau age (58.8 ± 0.3 Ma). We prefer the plateau age of 58.8 ± 0.3 Ma because of the high atmospheric content of the first two steps. This age represents the cooling age of the porphyry. No isochron age determination was possible due to the generally homogenous radiogenic content of the steps used for the plateau age determination.

12RN060B—Whole rock from the Ray River basalt: A whole-rock separate from sample 12RN060B was analyzed. The integrated age (32.4 ± 0.3 Ma) is within the error of both the plateau age (30.6 ± 0.2 Ma) and the isochron age (30.0 ± 0.7 Ma). We prefer the plateau age of 30.6 ± 0.2 Ma because of the higher precision over the isochron age determination and the large error on the isochron regression to initial ^{40}Ar. The plateau age signifies the eruptive age of the basalt.

ACKNOWLEDGMENTS

This project was funded by the Alaska State Legislature through the Strategic and Critical Minerals Assessment Capital Improvement Project, a component of the Alaska Airborne Geophysical/Geological Mineral Inventory Program. Samples in this report were collected by Larry Freeman and Colby Wright of DGGS and by Rainer Newberry of the University of Alaska Fairbanks Department of Geology & Geophysics.

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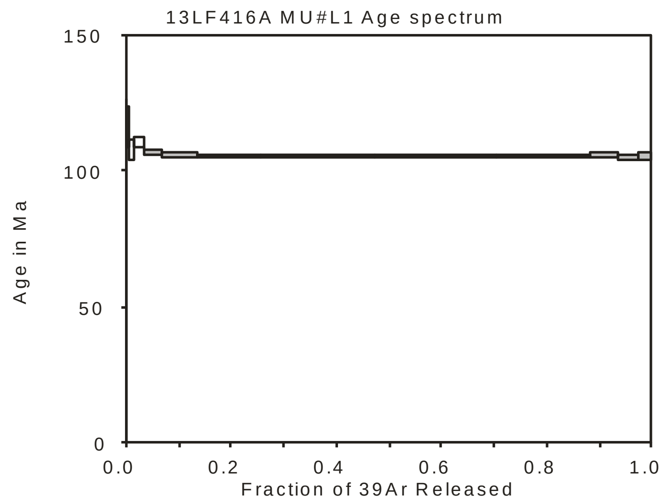
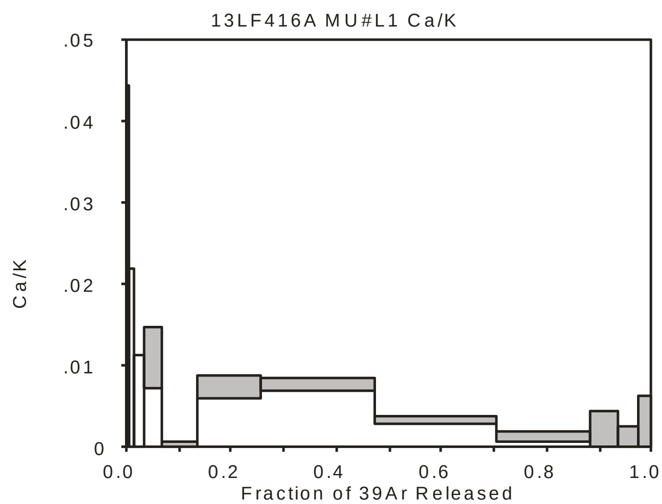
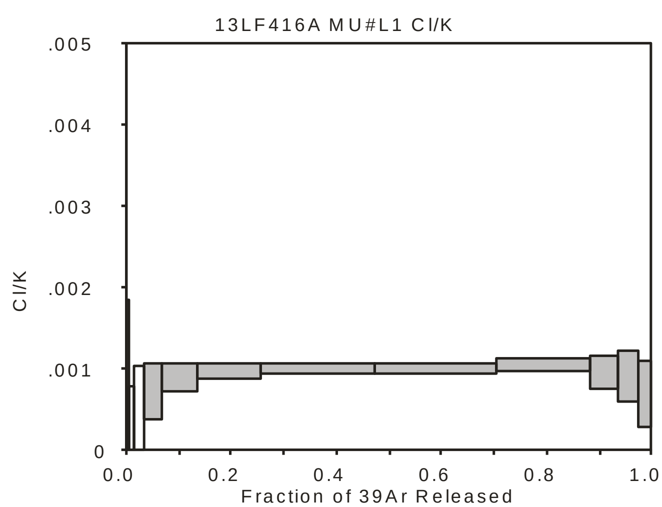
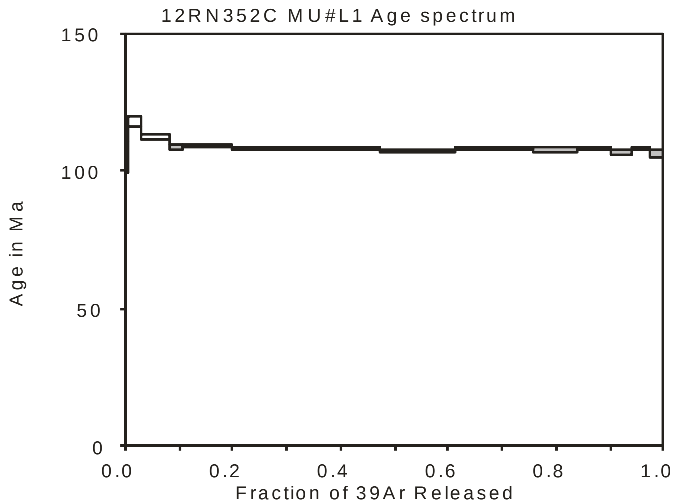
APPENDIX A-1: $^{40}Ar/^{39}Ar$ Age, Ca/K, and Cl/K Spectra Plots for Plutonic Samples





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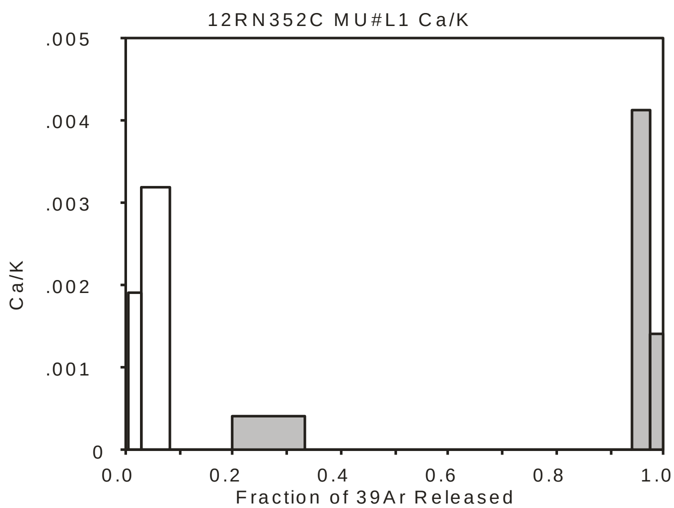
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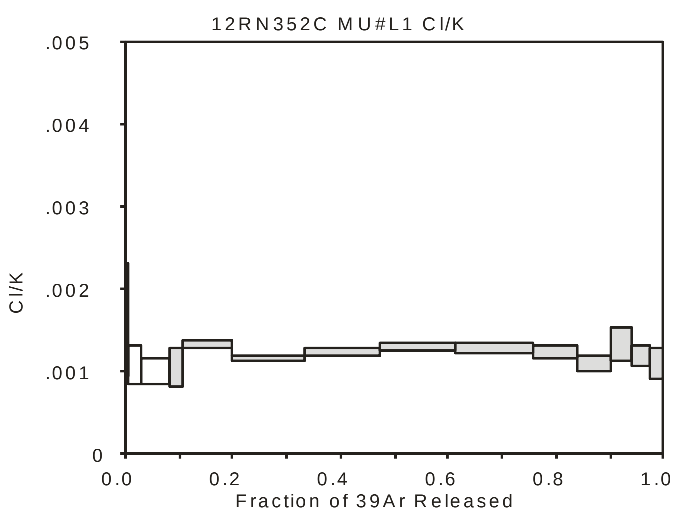
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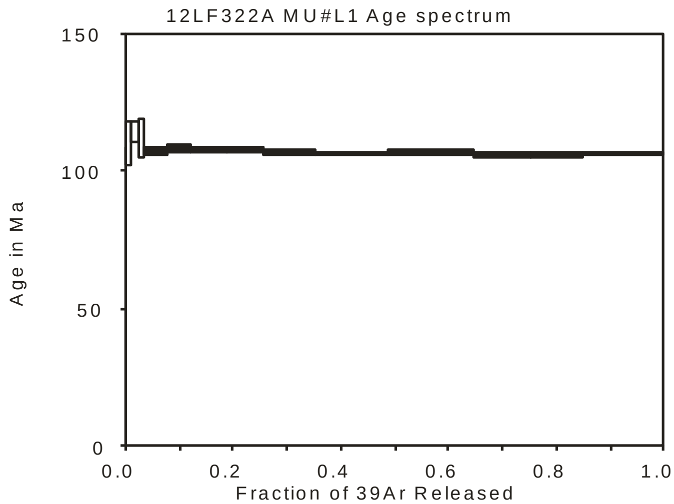
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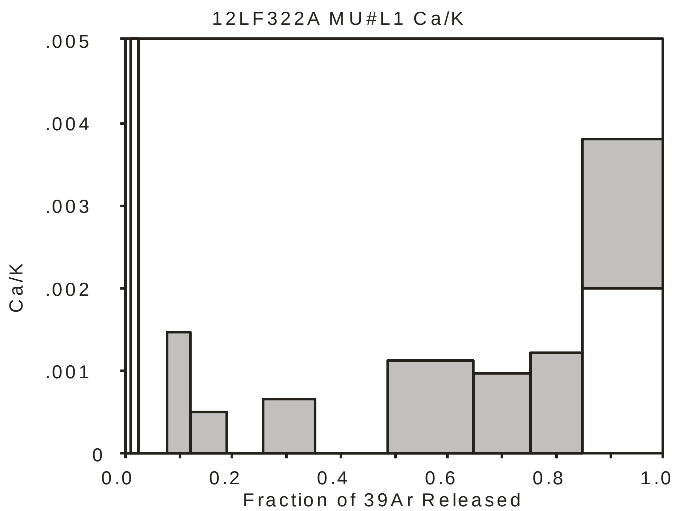
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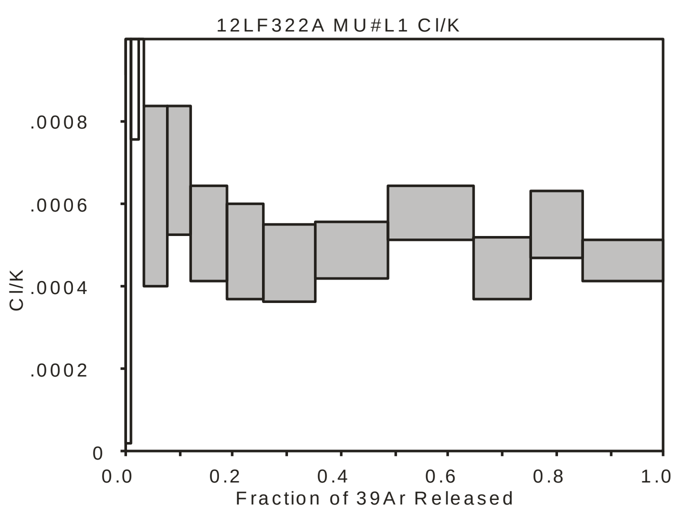
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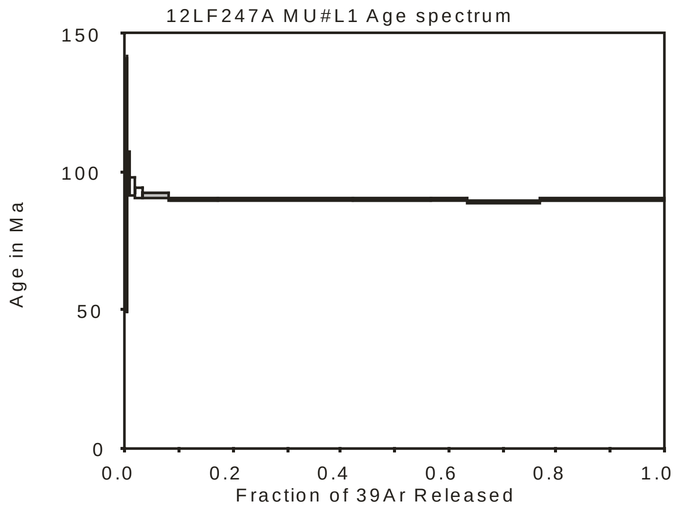
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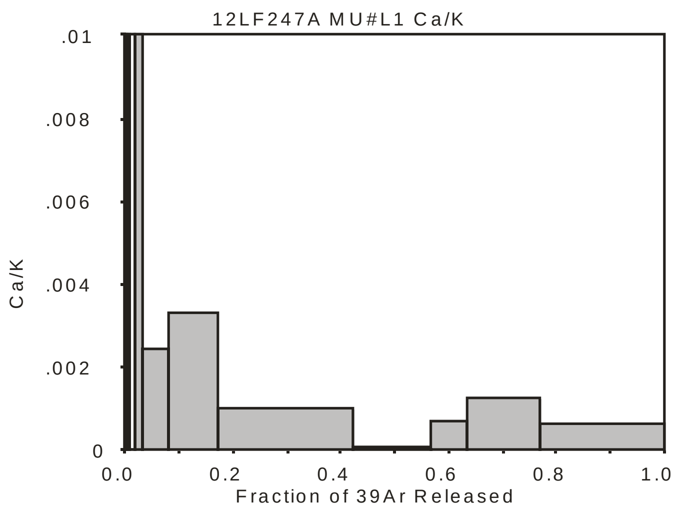
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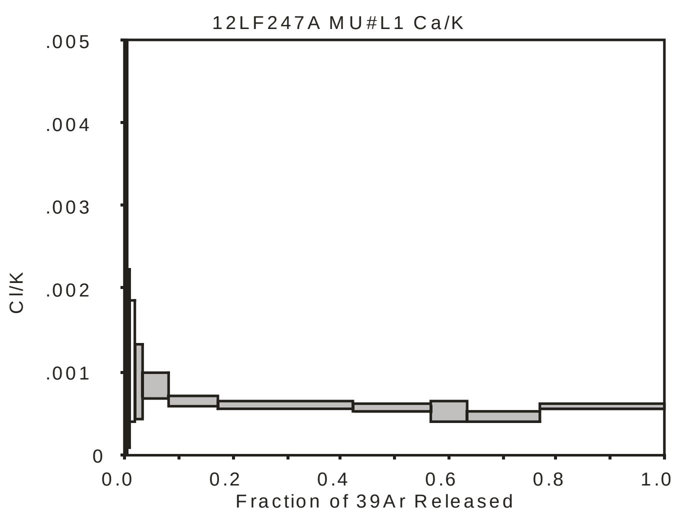
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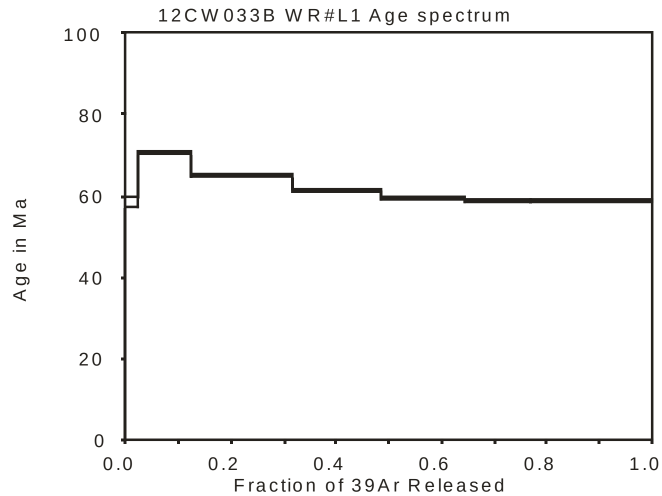
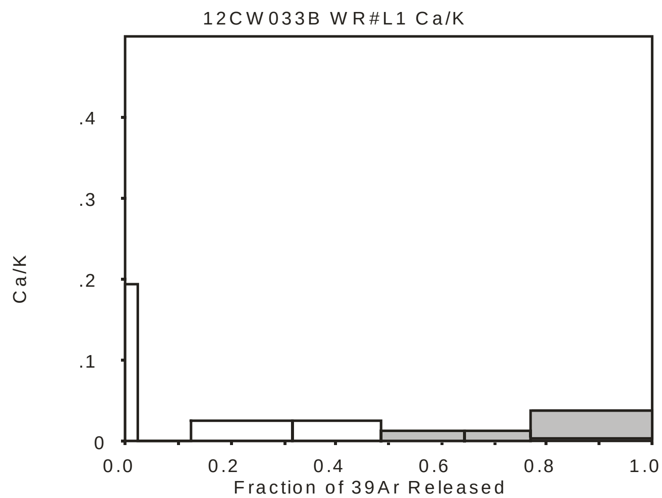
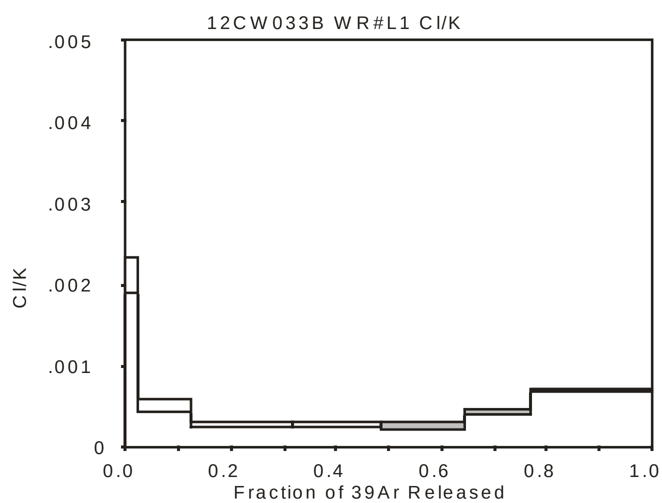
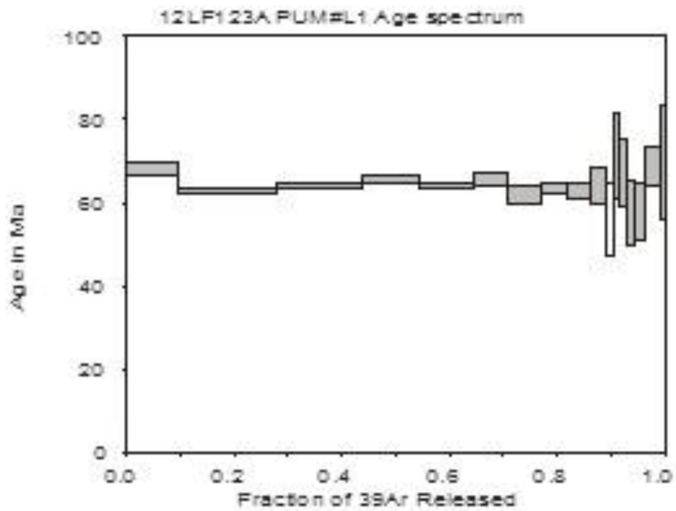
APPENDIX A-2: $^{40}Ar/^{39}Ar$ Age, Ca/K, and Cl/K Spectra Plots for Volcanic Samples





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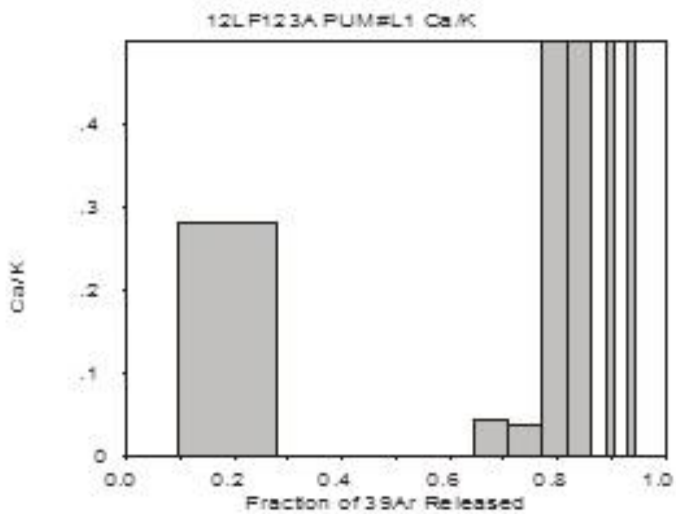
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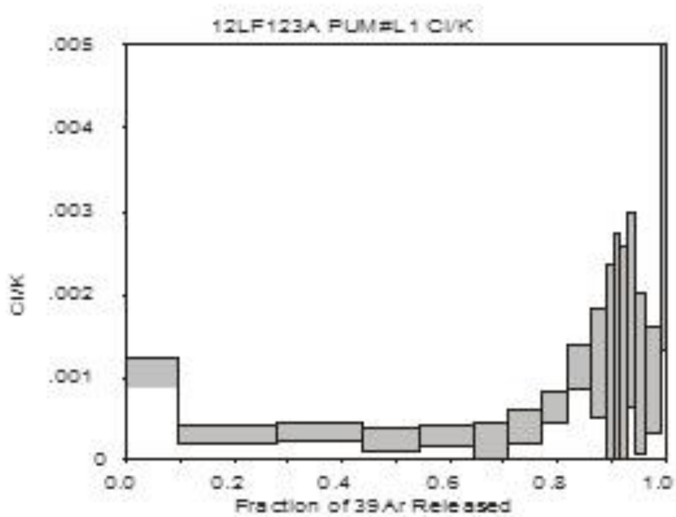
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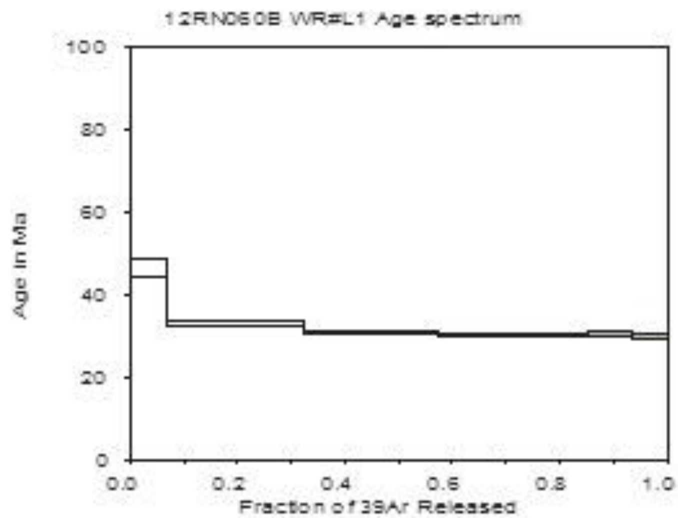
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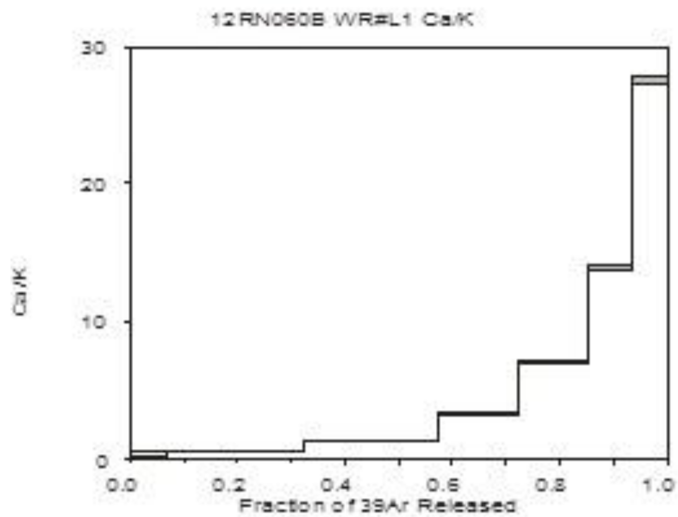
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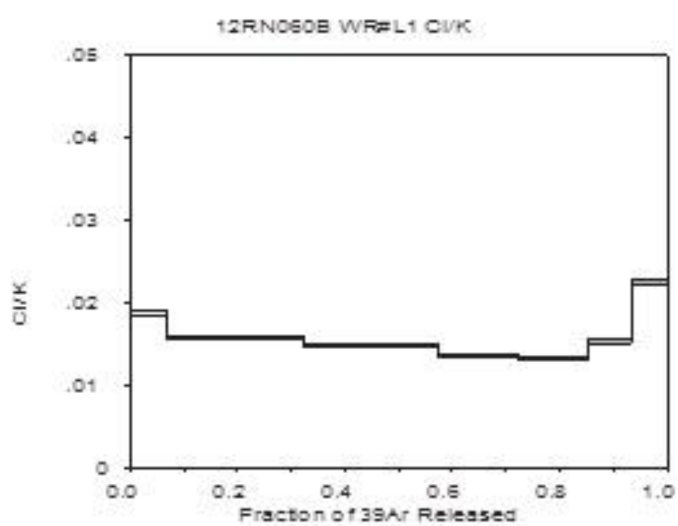
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Fraction of 39Ar Released