

To my parents – thanks for the perspective.

Joshua D. Feldman
New Mexico Institute of Mining and Technology
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**THE EMPLACEMENT AND EXHUMATION HISTORY OF THE
TWIN LAKES BATHOLITH AND IMPLICATIONS FOR THE
LARAMIDE OROGENY AND FLAT SLAB SUBDUCTION**

by

Joshua D. Feldman

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ABSTRACT

U/Pb zircon, $^{40}\text{Ar}/^{39}\text{Ar}$ hornblende, mica, and K-feldspar, apatite fission track (AFT), and (U-Th)/He apatite (AHe) geo and thermochronology of the Twin Lakes batholith (TLB), located in central Colorado, reveal multiple intrusions and pulsed exhumation, and constrain a complex Cenozoic geological history of regional significance. U/Pb zircon ages determined on 15 samples from throughout the batholith indicate at least 5 temporally distinct intrusions within two broad magmatic episodes between 63 and 57 Ma and 43 and 40 Ma. The magmatic gap between 57 and 43 Ma is thought to be real rather than simply a lack of sampling. Two additional unsampled magmatic pulses at ca. 37 and 32 Ma are cryptically recorded by $^{40}\text{Ar}/^{39}\text{Ar}$ mica and K-feldspar thermochronology results.

The Twin Lakes batholith is part of the poorly understood Colorado Mineral Belt (CMB), a northeast trending linear belt of mainly 80 to 40 Ma plutons that transects major Cretaceous and Tertiary structures in Colorado. The multiple intrusions and magmatic gap identified at Twin Lakes help advance the idea that flat-slab subduction related to the Laramide Orogeny generated widespread melts that were subsequently focused along pre-existing northeast-striking Proterozoic shear zones. This hypothesis contrasts with the idea that an eastward advancing point source of magmas were derived from the leading edge of the Farallon slab.

The TLB is located along the intersection of the CMB and Rio Grande Rift (RGR) and underlies the highest elevations of the Rocky Mountains, and thus its exhumation history has important tectonic implications. Pulsed and geographically differential exhumation began at ca. 70 Ma, when approximately 8 km of combined Phanerozoic sedimentary

and Proterozoic basement rocks were stripped between 70 and 37 Ma near the town of Buena Vista, CO. In contrast, AFT data at Twin Lakes places the present 14,003 ft summit of Huron Peak at 3 – 5 km depth at 34.5 ± 3.0 Ma. This demonstrates that the effect of combined Laramide compression and lithospheric hydration-driven buoyancy resulted in variable inversion of a deep Pennsylvanian Ancestral Rocky Mountain basin known as the Colorado Trough.

AFT and AHe age – elevation traverses describe an episodic post-25 Ma exhumation history of the TLB. At Huron Peak, AFT ages and track lengths record a pulse of cooling at 24 – 22 Ma that apparently resulted from local faulting, and is likely related to RGR extension. Both AFT and AHe data record additional pulsed exhumation between 12 and 7 Ma and AHe data indicate post-7 Ma rift flank tilting, perhaps related to RGR extension. The late Miocene to recent exhumation (~2 – 3 km) may correspond to uplift associated with the Aspen Anomaly that is a ca. 100 km deep, low seismic velocity zone that underlies the Twin Lakes region.

Combined, the exhumation history at Twin Lakes demonstrates that Laramide to recent surface uplift from sea level to current high elevations and erosion of approximately 8 km of rock was punctuated in time and space. Periods of exhumation proceeded at ca. 100 – 200 m/Ma and mechanisms evolved from early to late Laramide compression and hydration buoyancy (~70 to 35 Ma), to RGR extension and perhaps finally fairly recent effects of the Aspen Anomaly after 7 Ma.

Keywords: CREST; Thermochronology; Argon; U/Pb; Fission Track; (U-Th)/He

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This thesis is accepted on behalf of the faculty of the Institute by the following committee:

Matthew T. Heizler, Advisor

I release this document to the New Mexico Institute of Mining and Technology.

Joshua D. Feldman

Date

INTRODUCTION

This project seeks to understand the latest Cretaceous to Cenozoic plutonic and exhumation history of central Colorado during the Laramide Orogeny as well as subsequent post-Laramide denudation. This study is part of the Colorado Rockies Experiment and Seismic Transect project (CREST), which is a multi-institutional, interdisciplinary project focused on understanding the geometry of seismic velocity anomalies in the lithosphere beneath the Colorado Rocky Mountains. The primary target of the geophysical investigations is the Aspen Anomaly, a low-velocity anomaly located approximately 100 km beneath western Colorado (Dueker et al., 2001). The Aspen Anomaly, as well as other low velocity anomalies in the lithosphere beneath Colorado, could be caused by modern-day high temperatures in the mantle or chemical heterogeneity in the mantle of uncertain age contributing to density variations.

Geochronology is used to determine the time-space distribution of magmatism along the Colorado Mineral Belt (CMB), whereas thermochronology is used to interpret exhumation rates related to Laramide Orogeny compression, Rio Grande Rift (RGR) extension, and possible buoyancy associated with the Aspen Anomaly. The first pluton sampled was the Twin Lakes pluton, located ~20 km southwest of Leadville, CO (Figure 1). Complicated initial argon results required the focus to shift to characterizing the emplacement and exhumation history of this single pluton rather than studying multiple CMB plutons. Detailed findings at Twin Lakes help to understand Laramide plutonism in general. The Twin Lakes pluton is a good candidate for study of the emplacement and exhumation history of central Colorado because it is located over the Aspen Anomaly,

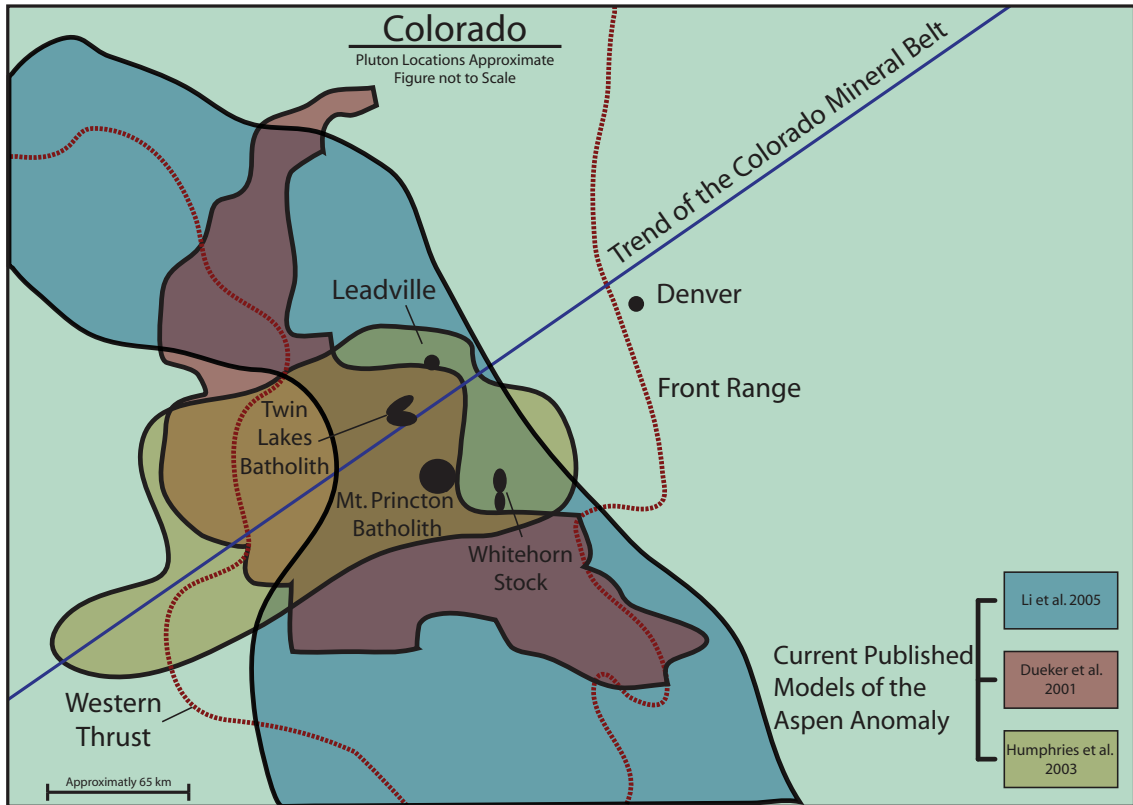


Figure 1: Aspen Anomaly geometries relative to the Front Range and Western Thrust (red dashed lines), Colorado Mineral Belt (blue solid line), and the cities of Leadville and Denver, CO (black dots). The plutons discussed in the text are marked by black ellipses which are proportional to their size.

where the CMB and RGR meet in the highest elevations in the Rocky Mountains. The geologic history of the pluton was determined using four geo and thermochronometric systems, as well as outcrop mapping, Al-in-hornblende geobarometry, and electron microprobe analysis. The data reveal a protracted and episodic magmatic history and an exhumation history that is punctuated in time and space, and have significant implications for the Cenozoic evolution of Central Colorado.

CHAPTER 1

BACKGROUND

1.1 Geologic Setting

Juvenile Proterozoic arc terrains were accreted to the Laurentian plate by north-westerly vergent subduction. Paleo-subduction zones are preserved today as northeast-striking suture zones such as the Cheyenne Belt and Jemez Lineament (Bowring and Karlstrom, 1990; Karlstrom and Humphries, 1999). Many workers (Karlstrom et al., 2001; Shaw et al., 2005) suggest that these northeast-striking shear zones in Colorado “provide a first-order control on the complex history of exhumation, deformation, sedimentation, and magmatism. . .” of Colorado during the Cenozoic (Karlstrom et al., 2001). The Proterozoic basement of the Twin Lakes region cooled to temperatures below the $^{40}\text{Ar}/^{39}\text{Ar}$ biotite closure isotherm ($\sim 350 - 300^\circ\text{C}$) by 1200 Ma (Bryant and Naeser, 1980; Shaw et al., 2005), which correlates to a depth of $\sim 12 \pm 5$ km if the geothermal gradient was between 20 and $45^\circ\text{C}/\text{km}$. The majority of Phanerozoic burial in central Colorado occurred during the Pennsylvanian by sediment shed from Ancestral Rocky Mountain uplifts (Rocky Mtn Assn of Geologists, 1972). By the late Paleozoic, two north-northwest trending highlands formed (presently exposed as the Sawatch and Front Ranges) with a structural relief of several kilometers (Bryant and Naeser, 1980). The basin between these two highlands is known as the Colorado Trough, and underwent 2 – 3 km of post-Pennsylvanian burial by the early to middle Mesozoic. The Laramide Orogeny (the event that formed the Rocky Mountains) began in the area by ~ 75 Ma (Bryant and Naeser,

1980).

The Laramide Orogeny is related to late-Cretaceous subduction of the Farallon plate beneath the North American plate; the associated subduction zone trench is ~1000 km west of the Colorado Rocky Mountains. In contrast, many subduction-related mountain ranges and arcs are only on the order of 100 km from the collisional boundary (e.g. Cascades, Andes, Himalayas). The mechanism by which stress was transmitted so far inboard of the trench has been the subject of debate, but the most commonly accepted mechanism for Laramide orogenesis in Colorado between ~75 and 25 Ma is the flat slab subduction hypothesis presented by Coney and Reynolds (1977).

Despite all of the work that has been done on the Laramide- and post-Laramide geologic history of the Colorado Rocky Mountains, details of their origin are still debated. Snyder et al. (1976) recognized a broad eastward younging of andesitic to rhyolitic composition volcanic rocks from the west coast to Colorado between ~80 and ~29 Ma, followed by a cessation of silicic magmatism and onset of basaltic volcanism; the basaltic volcanism is associated with regional extension. The magmatic pattern was only clearly apparent on a broad scale that Snyder et al. (1976) referred to as 'magmatic loci'. Their preferred model to explain the pattern was an echelon flat slab subduction of the Farallon slab, as also proposed by Lipman et al. (1971). A year later, Coney and Reynolds (1977) expanded the compilation to southwestern North America and expanded the age progression of eastward younging to between 120 Ma and 40 Ma, followed by a period of relative quiescence, and then a westward younging trend from 35 Ma to 25 Ma (Figure 1.1). These authors again invoked flat-slab subduction, but they argued for a single slab, and proposed slab steepening (removal) beginning around 40 Ma, which caused the westward-younging igneous activity. The major dating method compiled in both of these papers was K-Ar, and Coney and Reynolds acknowledge K-Ar ages as susceptible to heating effects, which makes them less useful for dating the emplacement age of a pluton

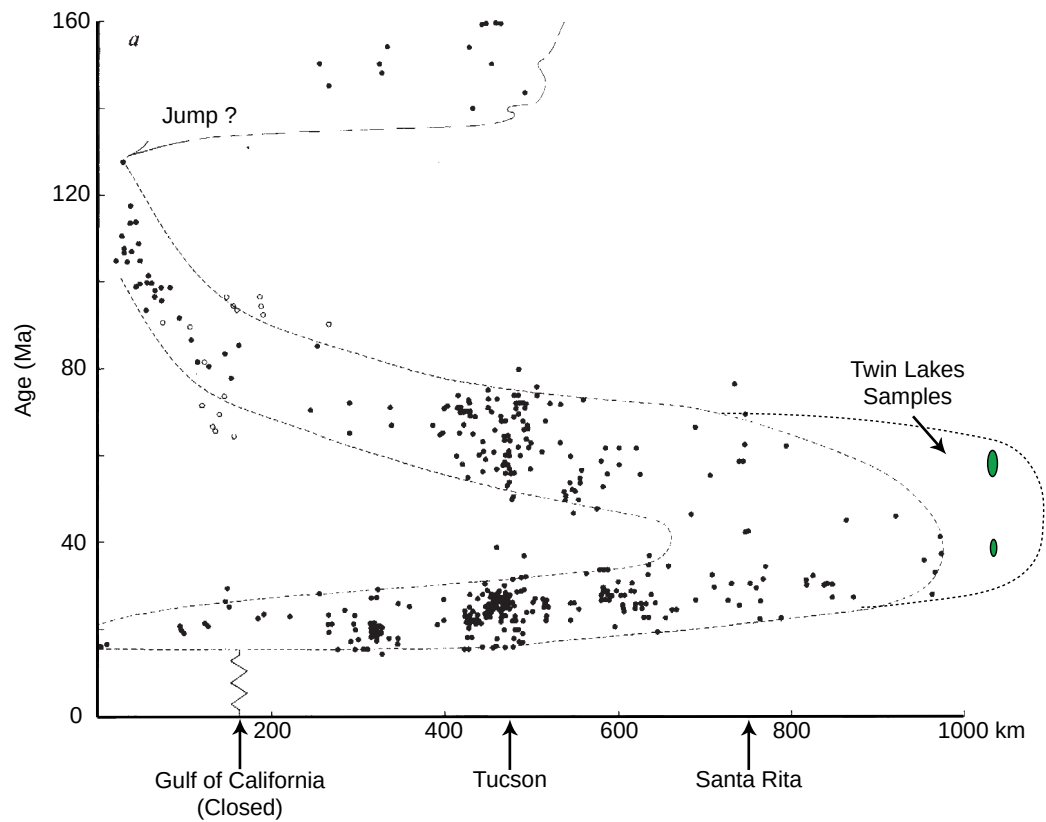


Figure 1.1: Figure from Coney and Reynolds (1977). Plot illustrates possible eastward migration of magmatism from ~120 – 55 Ma, followed by a period of magmatic quiescence, and westward migration from ~40 – 25 Ma. The compilation contains many K-Ar biotite ages, which are susceptible to reheating events and may cause artifacts in the graph. Green ovals near 1,000 km are U/Pb zircon age data (obtained in this study) from the Twin Lakes area.

unless there are multiple concordant minerals dated from the same sample. More recent authors have proposed refinements to the foundering hypothesis of the flat-slab subduction model, such as the Taco model (Humphreys et al., 2003), and piecemeal removal of the slab (Schmandt, Personal Comm., 2009), referred to here as the paint chip model, due to the resemblance to paint chips peeling off of a ceiling.

Whereas most subducting plates dip at roughly $40 - 60^\circ$, in flat-slab subduction the plate dips at $\sim 15 - 20^\circ$ due to elevated convergence velocities or anomalously low under-riding plate density (Coney and Reynolds, 1977). The shallow dip allows the subducting slab to travel laterally much further beneath the overriding plate, which can lead to arc magmatism much farther inboard of the trench than the typical ~ 100 km. The under-riding plate couples with the overriding plate, causing compression of the overriding plate and associated basement-cored uplift. In the case of the Farallon slab, basement-cored uplift and arc magmatism is ~ 1000 km inboard of where the trench was located during orogenesis. The slab isolated the North American lithosphere from the asthenosphere, causing both refrigeration and hydration of the North American plate (Humphreys et al., 2003). Eventually, around 40 Ma, the Farallon slab became unstable, possibly due to subduction of the East Pacific Rise (Coney and Reynolds, 1977) or a reduction of plate velocity. The slab foundered and was removed from the base of the North American plate, releasing the traction on North America and allowing the hot dry asthenosphere (relative to the hydrated overriding lithosphere) to come into contact with the refrigerated lithosphere, generating large volumes of magma referred to as the ignimbrite flare-up from roughly 36 to 25 Ma. The San Juan, Mogollon-Datil, and Sierra Madre Occidental volcanic fields formed during this time (Humphreys et al., 2003; Lipman et al., 1978; McIntosh et al., 1992; McDowell and Keizer, 1977).

The CMB is a N35E trending lineament that is sub-parallel to Proterozoic shear zones (Tweto and Sims, 1963) and is defined by late Mesozoic to Cenozoic magmatism

and mineralization that crosscuts regional folds, large faults, and the three major north-south present-day mountain ranges (Figure 1.2). Here the Laramide Orogeny is defined by the eastward progression of the Farallon slab with associated magmatism (~70 to 57 Ma), and post-Laramide is defined as geologic events occurring after the slab ceased moving eastwards. Specifically, post-Laramide silicic magmatism is related to the removal of the Farallon slab (~36 to 25 Ma in Colorado). Silicic magmatism within Colorado (excluding the San Juan and 39-Mile volcanic fields), both Laramide and post-Laramide, is generally confined to the CMB. Mutchler (1987) compiled the ages available at the time and concluded that no eastward younging is recorded along the CMB, but the absence of a simple temporal pattern may be an artifact of coarse geochronology sampling in the region, or incorrectly interpreting cooling ages as intrusion ages (Fridrich et al., 1998 and references therein; Cunningham et al., 1994).

The intersection of the CMB with the north-south striking RGR coincides with the highest average elevations and the Aspen Anomaly (Dueker et al., 2001) roughly between Aspen and the northern end of the Arkansas river valley. The RGR began to form by ~30 Ma, and caused thinning of the Laurentian lithosphere and associated normal faulting during this time (Chapin and Cather, 1994). The RGR caused extension in the Twin Lakes region by at least 22 Ma (Chapin and Cather, 1994).

1.2 Research Goals

Originally the Twin Lakes pluton was sampled with the intent of also sampling many other Laramide-age plutons in Colorado in order to test the hypothesis that the younging pattern observed by Snyder et al. (1976) and Coney and Reynolds (1977) across the southwestern United States could also be observed along the CMB. Early discovery that the Twin Lakes pluton is actually composed of multiple plutons necessitated a much

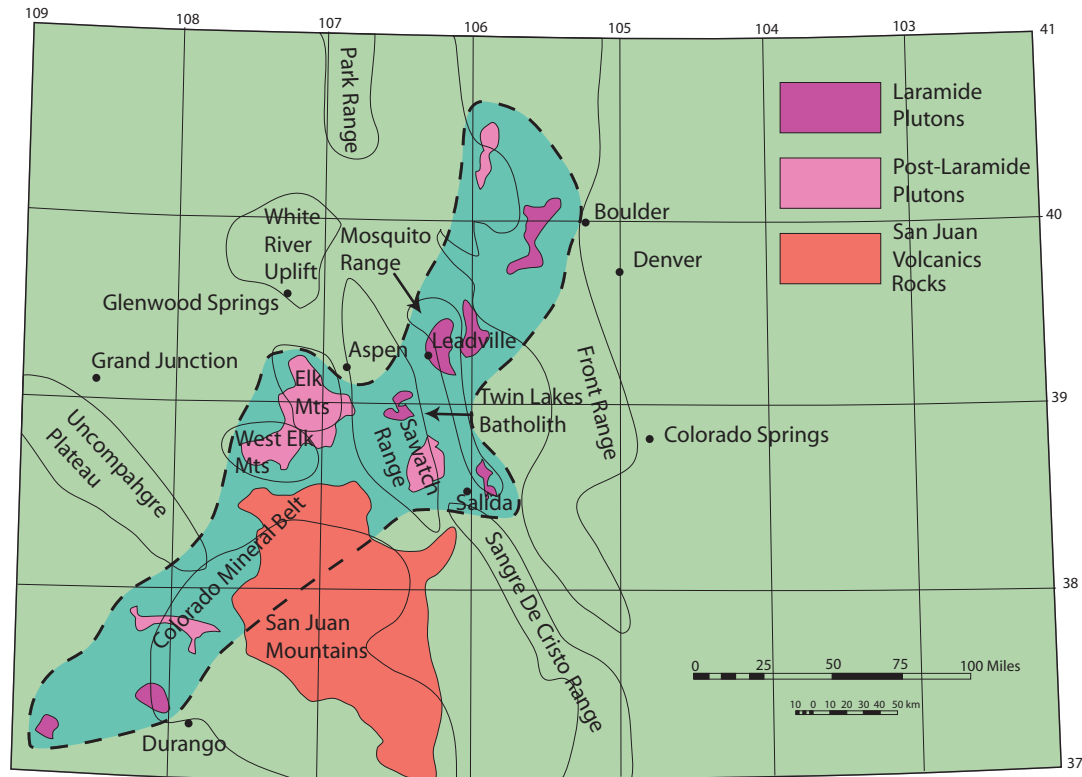


Figure 1.2: Map of Colorado with generalization of Laramide-age plutons (75 – 45 Ma, purple), post-Laramide-age plutons (36 – 25 Ma, pink), and post-Laramide volcanic units from the San Juan volcanic field. Blue-green outline represents the Colorado Mineral Belt based on Cenozoic silicic magmatism. Thin black polygons outline the major mountain ranges and topographic features. The Sawatch, Sangre De Cristo/Park/Mosquito, White River, and Front ranges make up the modern Rocky Mountains. Map after Tweto and Sims (1963) and Tweto (1979).

more local study. Although a more geographically-restricted study area, the Twin Lakes pluton is located above the Aspen Anomaly and occurs within an area containing the highest elevations of the Rocky Mountains. Additionally, the pluton is along the RGR, and therefore provides an excellent opportunity to investigate the Cenozoic evolution of central Colorado. If magmatism related to flat-slab subduction actually migrated eastwards, paused, and then migrated westward again, it might be expected to see this magmatic gap at Twin Lakes. Humphreys et al. (2003) suggest that the Farallon slab hydrated the overlying Laurentia lithosphere, which eventually lowered the melting temperature to a point where melting of lithospheric mantle began to occur. The hydration of the lithosphere is not confined to the leading edge of the subducting plate, but rather it affects a large diffuse area. In Colorado, magmatism is thought to be focused along the CMB due to inherent weakness in the crust (Karlstrom et al., 2001), and magmatism should therefore not be limited to short-lived distinct periods. Instead, long lived systems that undergo several pulses of magmatism or possibly even continuous magmatism would be expected throughout these periods. Geo and thermochronology is used to furthering the understanding of these large-scale processes. Linking the intrusion and exhumation history at Twin Lakes to the Laramide Orogeny and the CMB will provide valuable constraints on the tectonic evolution of Colorado during the Cenozoic.

1.3 Previous Work at Twin Lakes

Fridrich et al. (1998) suggested the Twin Lakes pluton is a large pluton that fractionally crystallized in the Paleocene from an intermediate hornblende – biotite – tonalite composition. Their mapping reveals seven distinct textural and chemical units that may correlate to temporal units (Figure 1.3). A $^{40}\text{Ar}/^{39}\text{Ar}$ hornblende age from near Lake Pass of 63.82 ± 1.44 Ma is reported by Fridrich et al. (1998) and provides their primary

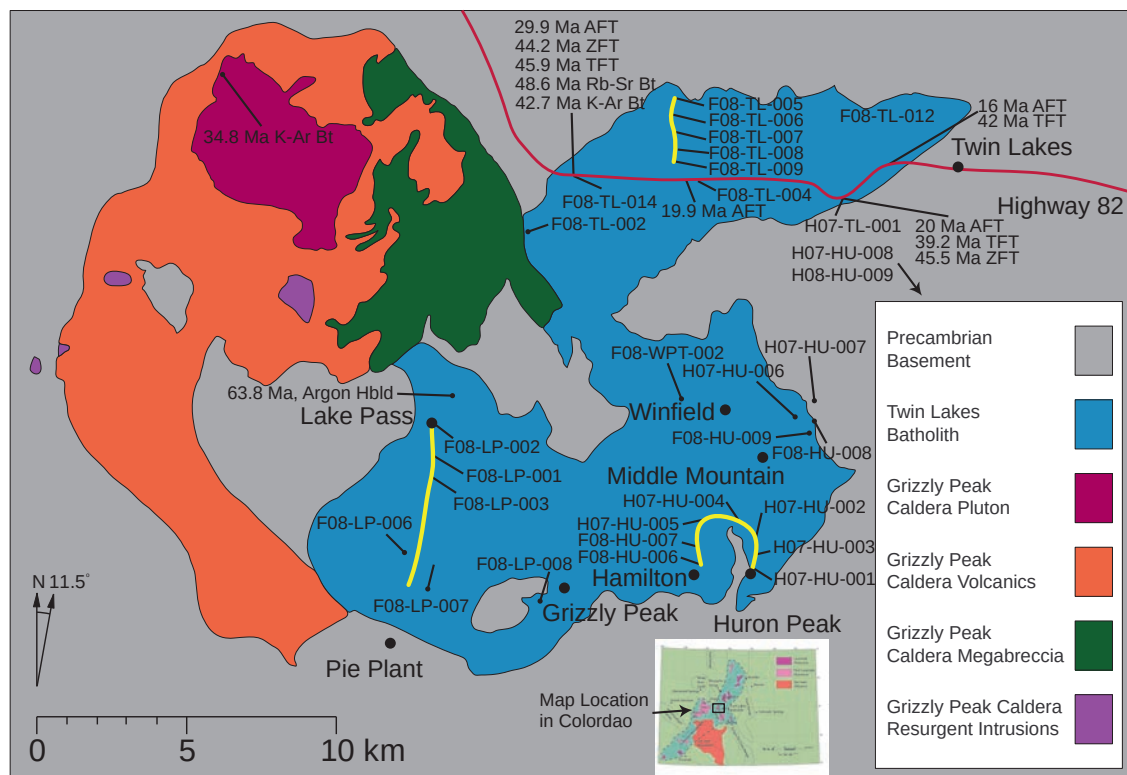


Figure 1.3: Generalized map of the Twin Lakes Batholith, Grizzly Caldera and associated intrusions and megabreccias, and surrounding Proterozoic basement. Previously published ages are included (Fridrich et al., 1998 and references therein), as are landmarks such as Huron Peak, Winfield, and Highway 82. Vertical traverses are represented by yellow lines, and locations of analyzed samples are marked. Map after Fridrich et al. (1998).

basis for the intrusion age. They suggest a simple Paleocene emplacement followed by cooling through $^{40}\text{Ar}/^{39}\text{Ar}$ biotite, and titanite, zircon, and apatite fission-track closure in the Eocene and Miocene. The Grizzly Caldera to the west of Twin Lakes is also mapped by Fridrich et al. (1991; 1998). The major volcanism and caldera formation occurred at ~34 Ma and this indicates magmatism in the study area occurred through the Eocene. From here forward the Twin Lakes pluton of Fridrich et al. (1998) is referred to as the Twin Lakes batholith (TLB) because of its size (~100 km² in diameter) and its multiple magmatic episodes spaced over a ~30 Ma timespan.

The TLB consists of three main lithologies that have been previously mapped by Fridrich et al. (1998). The most abundant phase is called the main body phase (Tt), which is a medium to coarse grained porphyritic biotite granodiorite. This phase contains common aplite dikes, areas of megacrystic K-feldspar (5 to 15 cm long) and slightly embayed quartz. The composition is geographically heterogeneous, but quartz, plagioclase, K-feldspar, biotite, apatite, zircon, and titanite are always present, and hornblende, allanite, and oxides are present only in some locations. The next most common phase is referred to as the leucocratic core by (Ttl), which is a medium-grained biotite granite. K-feldspar is present, but not as megacrysts. Aplite diking is still present, but not as commonly as in the main body phase. The unit consists of biotite, quartz, plagioclase, K-feldspar, apatite, zircon, titanite, and hornblende, allanite, and different oxides are occasionally present. The least common lithology is the mafic border phase (Ttm), which is a porphyritic hornblende gabbrodiorite. The lithology of this phase consists of plagioclase, K-feldspar, hornblende, quartz, oxides, biotite, titanite, and minor amounts of apatite and zircon. This phase is mapped in relatively small areas in the southwestern area of the batholith, but observations in this study only observed these rocks in localized areas near Grizzly Peak. Finally, there are several dike phases. The intermediate-composition porphyry dikes are hornblende-biotite tonalites that are exposed throughout the area as plugs

and small dikes concentrated around the town of Winfield. They are made up of quartz, feldspars, sericite, biotite, chlorite, epidote, titanite, and oxides. The other dike phase is made up of biotite granites and consists of K-feldspar, plagioclase, quartz, biotite, and very minor hornblende. These dikes were not observed during this study despite multiple attempts to locate them.

CHAPTER 2

METHODS

U/Pb zircon geochronology is used to decipher the intrusion history, while $^{40}\text{Ar}/^{39}\text{Ar}$ (hornblende, biotite, muscovite, and K-feldspar), apatite fission track (AFT), and apatite (U-Th)/He (AHe) dating are used to constrain the thermal history of the batholith (Table 3.1). Electron microprobe analysis was used for Al-in-hornblende geobarometry as well as determining the weight percent of Cl in apatites from two samples to aid in thermal modeling.

The geologic map by Fridrich et al. (1998) provided an invaluable base for three sampling strategies: 1) A wide distribution of samples of varying lithology were collected to constrain the magmatic history, 2) the high relief in the region provided excellent opportunities for sampling along vertical traverses (see Figure 1.3 for sample locations and vertical traverses), and 3) Proterozoic basement rock was collected to determine the regional pre-Cenozoic time-temperature path. Three vertical traverses from throughout the batholith were collected and analyzed, and these traverses allow construction of age-elevation profiles that can then be used to characterize thermal histories. All of the vertical traverses are through granitoid rocks of the TLB. The Huron Peak traverse samples 1 km of vertical relief from the top of Huron Peak (a 14,003 ft peak) to the base of the mountain near the abandoned ghost town of Hamilton. The Lake Pass traverse samples 672 m of vertical relief from Lake Pass to the Pie Plant mill site and has a 6 km horizontal component. In the northern part of the pluton, the Echo Canyon traverse samples 266 m of

vertical relief. Areas of mineralization and alteration common to the region were avoided because altered samples are not preferred for dating. Refer to appendices A – F for a detailed treatment of the age calculations, error assignments, and analytical techniques.

CHAPTER 3

RESULTS

3.1 U/Pb

All of the dating results are summarized in Table 3.1, and the U/Pb geochronology data are given in Table 3.2. Fifteen zircon samples were analyzed with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for U/Pb geochronology to determine the intrusion history of the TLB. The zircon ages range between ~39 – 43 Ma and ~56 – 63 Ma, and are displayed in Figure 3.1. Within the two broad groups of zircon ages there are statistically significant gaps at the 2-sigma level as shown by the white horizontal bars separating gray zones. MSWD calculations further attest to non-gaussian distributions of ages within the two broad groups. The MSWD's of the 63 – 57 Ma zircons ($n = 6$) and the 43 – 40 Ma zircon ages ($n = 9$) are 10.7 and 10.8, respectively. These high values indicate that the zircon ages define discrete intrusive phases within the Paleocene and Eocene groups. The Paleocene zircon ages are used to define the Lake Pass plutons, whereas the Eocene zircons are used to define the Winfield/Echo Canyon plutons (Figure 3.1).

3.2 Argon

Twenty-seven biotite (twenty-two Twin Lakes igneous and five Proterozoic basement), one muscovite (Proterozoic basement), twenty-six K-feldspar (twenty-one Twin

Table 3.1: Sample Summary Table

Sample	Elevation	Latitude	Longitude	Unit	Location	Biotite Integrated Age		Muscovite Integrated Age		(U-Th)/He		Fission Track		K-Feldspar Minimum Age		U/Pb	
						Age (Ma)	2s	Age (Ma)	2s	Age	2s	Age	2s	Min Age (Ma)	Age (Ma)	Age (Ma)	2s
F08-HU-002	3045	38.98892778	-106.4138917	Basement	Winfield	37.41	± 0.12	36.45	± 0.72	—	—	—	—	—	—	—	—
F08-HU-006	3363	38.9363426	-106.4532961	Huron Pluton	Huron Peak	39.20	± 0.08	—	—	—	—	—	—	31	—	—	—
F08-HU-007	3289	38.94506421	-106.4576973	Huron Pluton	Huron Peak	38.39	± 0.10	—	—	7.8	± 0.5	13.1	± 2	29.5	43.20	± 0.75	—
F08-HU-008	3039	38.98933775	-106.4120288	Basement	Winfield	37.68	± 0.08	—	—	—	—	—	—	—	—	—	—
F08-HU-009	3043	38.9890288	-106.412242	Winfield Pluton	Winfield	37.72	± 0.08	—	—	—	—	—	—	31	40.89	± 0.88	—
F08-LP-001	3768	38.99004813	-106.5578344	Lake Pass Pluton	Lake Pass	—	—	—	—	17.8	± 1.1	—	—	—	61.16	± 1.54	—
F08-LP-002	3711	38.9843739	-106.5583219	Lake Pass Pluton	Lake Pass	—	—	—	—	—	—	—	—	42	60.07	± 2.03	—
F08-LP-003	3890	38.99708333	-106.56145	Lake Pass Pluton	Lake Pass	64.31	± 0.12	—	—	9.9	± 0.6	—	—	38	—	—	—
F08-LP-006	3218	38.9632553	-106.5655342	Lake Pass Pluton	Pie Plant	57.11	± 0.09	—	—	17.4	± 1	—	—	34.5	62.97	± 1.31	—
F08-LP-007	3435	38.96407861	-106.5599084	Grizzly Pluton	Pie Plant	44.43	± 0.07	—	—	15.6	± 0.9	—	—	33	41.27	± 1.81	—
F08-LP-008	3175	38.92976105	-106.5200141	Grizzly Pluton	Grizzly Peak	58.01	± 0.11	—	—	8.6	± 0.5	—	—	37	57.20	± 3.09	—
F08-TL-002	3175	39.04672711	-106.5167061	Independence Pass Pluton	Independence Pass	—	—	—	—	16.5	± 1	—	—	41	—	—	—
F08-TL-004	2944	39.06952214	-106.4496202	Echo Canyon Pluton	Echo Canyon	—	—	—	—	—	—	—	—	—	—	—	—
F08-TL-005	3536	39.0866198	-106.4701108	Echo Canyon Pluton	Echo Canyon	48.08	± 0.11	—	—	—	—	—	—	—	42.66	± 1.29	—
F08-TL-006	3336	39.08038119	-106.4689408	Echo Canyon Pluton	Echo Canyon	42.62	± 0.09	—	—	—	—	—	—	40	—	—	—
F08-TL-007	3279	39.07974746	-106.4677485	Echo Canyon Pluton	Echo Canyon	42.28	± 0.10	—	—	—	—	—	—	41	—	—	—
F08-TL-008	3224	39.07660794	-106.4673367	Echo Canyon Pluton	Echo Canyon	42.34	± 0.09	—	—	—	—	—	—	40.5	—	—	—
F08-TL-009	3070	39.0704863	-106.4697529	Echo Canyon Pluton	Echo Canyon	42.25	± 0.09	—	—	—	—	—	—	39	—	—	—
F08-TL-012	3089	39.07311999	-106.4341231	Twin Lakes Pluton	Twin Lakes	—	—	—	—	—	—	—	—	—	42.90	± 0.94	—
F08-TL-014	3116	39.06716396	-106.5104048	Independence Pass Pluton	Independence Pass	57.50	± 0.11	—	—	—	—	—	—	—	56.30	± 2.45	—
F08-WPT-002	3299	38.99046044	-106.4555454	Winfield Pluton	Winfield	—	—	—	—	12.5	± 0.7	34.5	± 3	41.5	60.03	± 1.75	—
H07-HU-001	4268	38.945501	-106.438067	Huron Pluton	Huron Peak	40.44	± 0.06	—	—	—	—	—	—	—	39.45	± 1.42	—
H07-HU-002	4104	38.94851944	-106.4366361	Huron Pluton	Huron Peak	40.61	± 0.06	—	—	—	—	18.5	± 1.7	36	41.12	± 1.87	—
H07-HU-003	4120	38.99739214	-106.5618649	Huron Pluton	Huron Peak	—	—	—	—	—	—	22.8	± 6.3	35	—	—	—
H07-HU-004	3884	38.95336667	-106.4426722	Huron Pluton	Huron Peak	38.96	± 0.07	—	—	—	—	21.2	± 1.6	—	—	—	—
H07-HU-005	3506	38.95511389	-106.456	Huron Pluton	Huron Peak	38.82	± 0.11	—	—	—	—	22.8	± 2.3	34	43.14	± 0.96	—
H07-HU-006	3059	38.98955	-106.4151472	Winfield Pluton	Winfield	36.91	± 0.06	—	—	—	—	13.3	± 1.8	30.5	40.63	± 1.47	—
H07-HU-007	3053	38.99099722	-106.4132639	Basement	Winfield	55.29	± 0.78	—	—	—	—	10.2	± 1.9	—	—	—	—
H07-HU-008	2736	39.02335278	-106.2810972	Basement	U.S. Hwy. 24	837.73	± 1.12	—	—	—	—	—	—	70	—	—	—
H07-TL-001	2827	39.06471944	-106.4011167	Twin Lakes Pluton	Twin Lakes	43.81	± 0.08	—	—	—	—	—	—	35.5	—	—	—
H08-HU-009	3063	39.02875833	-106.24685	Basement	Winfield Road	120.50	± 0.23	—	—	—	—	—	—	45	—	—	—
H08-HU-010	2731	39.04337222	-106.2663889	Basement	Granite	1240.51	± 1.52	—	—	—	—	—	—	100	—	—	—

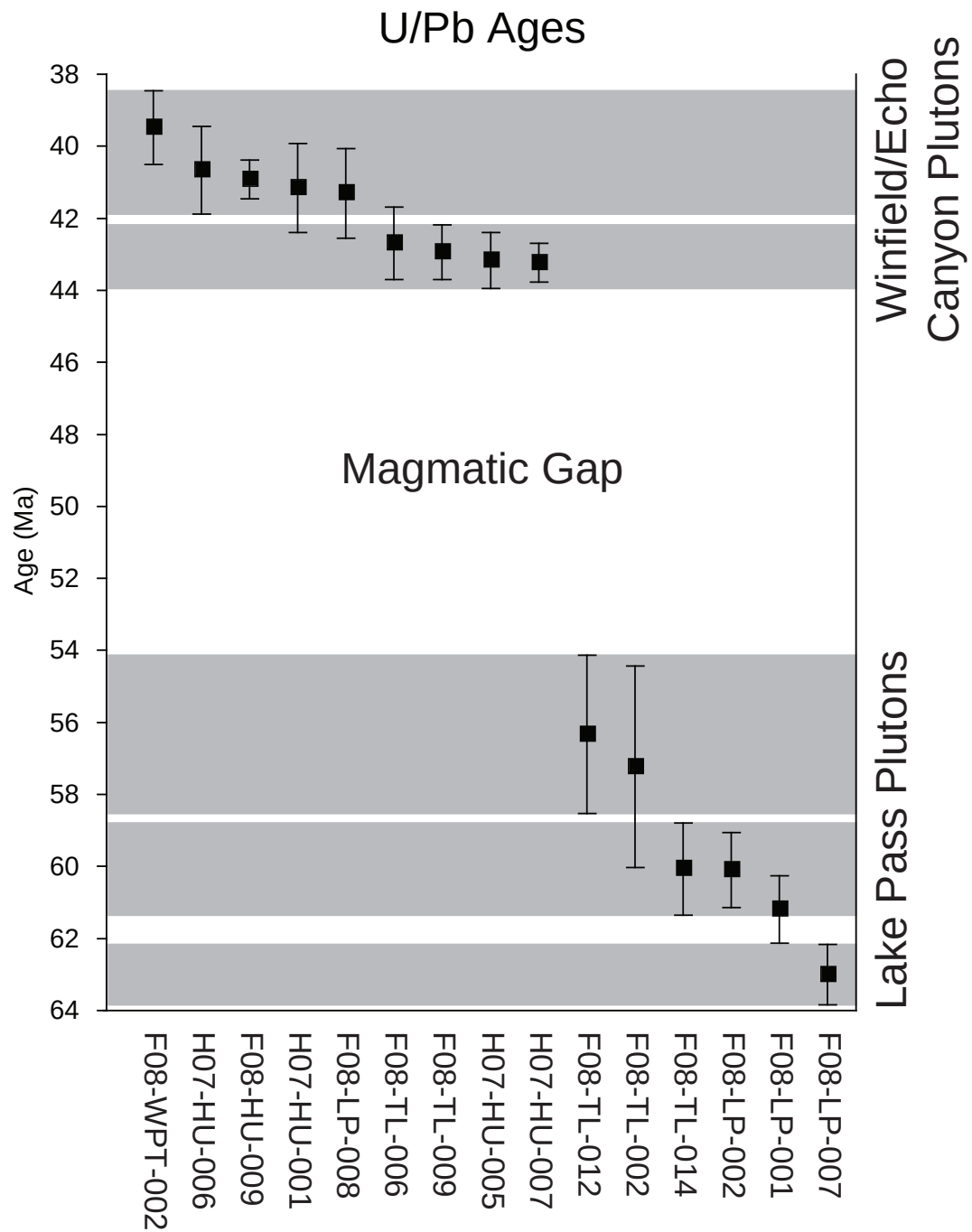


Figure 3.1: Plot of samples versus U/Pb zircon age. Errors do not include external errors, and are reported at 2-sigma. The gray bars illustrate five statistically distinguishable zircon ages, separated into two broader magmatic periods.

Table 3.2: U/Pb zircon ages reported in millions of years with errors at 2-sigma. Locations chosen by proximity to landmarks and do not necessarily imply a genetic relationship

Sample	Location	Elevation (m)	MSWD	Age (Ma)		Internal Errors	Total Errors
F08-WPT-002	Winfield West	3299	9.7	39.45	±	1.02	1.42
H07-HU-006	Winfield East	3059	2.6	40.63	±	1.22	1.47
F08-HU-009	Winfield East	3043	1.7	40.89	±	0.54	0.88
H07-HU-001	Huron Peak	4268	3.2	41.12	±	1.24	1.87
F08-LP-008	Grizzly Peak	3175	1.16	41.27	±	1.24	1.81
F08-TL-006	Echo Canyon	3336	2.7	42.66	±	1.00	1.29
F08-TL-009	Echo Canyon	3070	5.9	42.9	±	0.76	0.94
H07-HU-005	Huron Peak	3506	3.3	43.14	±	0.78	0.96
F08-HU-007	Huron Peak	3289	1.3	43.2	±	0.54	0.75
F08-TL-012	Twin Lakes	3089	23.6	56.3	±	2.20	2.45
F08-TL-002	Independence Pass	3175	3.3	57.2	±	2.80	3.09
F08-TL-014	Independence Pass	3116	3.7	60.03	±	1.28	1.75
F08-LP-002	Lake Pass	3711	1.3	60.07	±	1.04	2.03
F08-LP-001	Lake Pass	3768	4.3	61.16	±	0.94	1.54
F08-LP-007	Lake Pass	3435	1.8	62.97	±	0.84	1.31

Lakes plutonic, and five Proterozoic basement), and six hornblende samples (Twin Lakes plutonic) were step heated to determine the thermal history between 500°C and 175°C. Chloritization within hornblende and biotite was recognized with BSE imaging while analyzing four samples for Al-in-hornblende analysis, and may indicate a common occurrence for most of the Twin Lakes mineral separates. Representative age spectra are provided to demonstrate various common properties and all results are compiled in Appendix C.

3.2.1 Hornblende

The hornblende age spectra are complex, with oscillatory patterns that overall provide little information about the Twin Lakes thermal history (Figure 3.2). Spectra complexity partly correlates with K/Ca spectra complexity, and may indicate that mineral inclusions in the coarse (177 – 250 μm) separates are causing problems. BSE imaging of one hornblende shows significant biotite inclusions (Figure 3.3) that likely leads to some

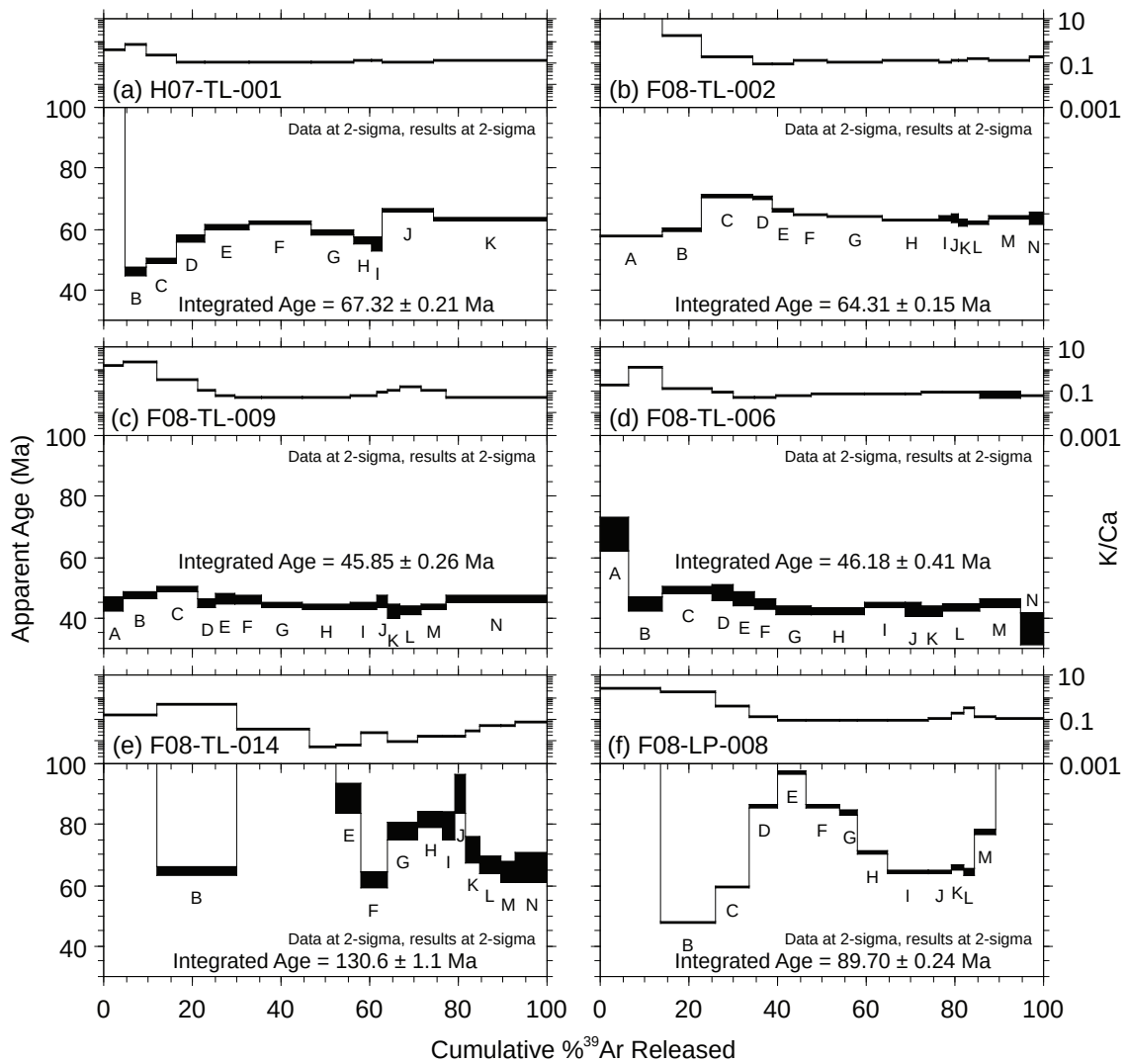


Figure 3.2: $^{40}\text{Ar}/^{39}\text{Ar}$ hornblende age spectra from the Twin Lakes batholith. The spectra are complicated and oscillate between young and old ages. Integrated ages for each sample are older than the corresponding U/Pb zircon age, suggesting contamination by extraneous argon.

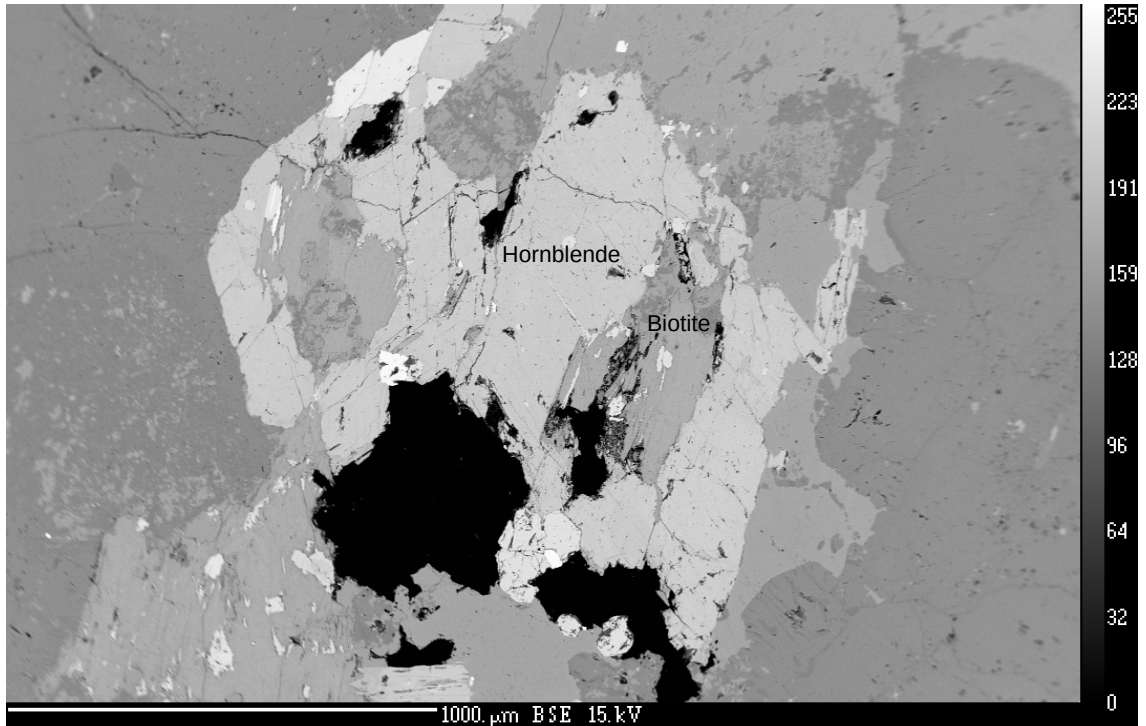


Figure 3.3: Backscatter image of a hornblende grain with biotite inclusions illustrating a possible explanation for complicated hornblende $^{40}\text{Ar}/^{39}\text{Ar}$ age spectra.

complexity, however many steps are older than the cogenetic zircon ages. This observation implies that extraneous ^{40}Ar is contaminating the samples. Extraneous ^{40}Ar may be involved either as xenocrystic hornblende from the Proterozoic basement or simply excess ^{40}Ar . In either case, the hornblendes will not be considered further in this study.

3.2.2 Biotite/Muscovite

In general biotite age spectra from the Twin Lakes granitoids are characterized by a hump-shaped pattern with initial steps and final steps giving younger ages compared to the intermediate steps (Figure 3.4). Age spectra rarely yield plateaus, and when they

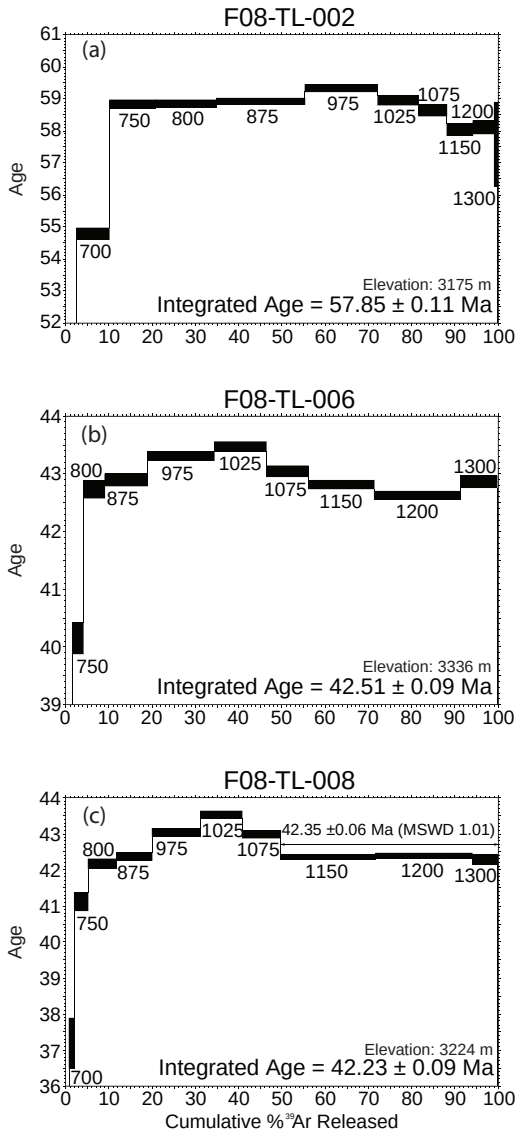


Figure 3.4: Representative biotite age spectra for Twin Lakes batholith samples. All age spectra display a characteristic hump shape pattern and especially F08-TL-006 has a pattern equal to those described by Lo and Onstott (1989). a) is a typical biotite age spectrum from Twin Lakes. b) is a common-looking hump-shaped age spectrum similar to the shape Lo and Onstott (1989) described. c) has a plateau segment that is within error of the integrated age; plateaus from Twin Lakes biotites commonly occur when the final three or four steps happen to contain >50% of the gas. Plateau ages are very similar to integrated ages, and as described in the text the integrated ages are used as the preferred age.

do, the plateau segment is comprised of few steps with barely 50% of the total ^{39}Ar . The first two or three steps of each sample also have low radiogenic yields, low K/Ca ratios, and high errors. These early steps generally contain less than 10% of the total ^{39}Ar . The remaining steps are sub-equal in ^{39}Ar concentration and have characteristic relatively old ages near the 50% cumulative part of the spectra. In several cases this single step in the middle of the spectra prevents formation of a plateau, as the majority of the other steps yield concordant ages. This humped shape has been interpreted to be due to recoil of ^{39}Ar into chlorite (cf. Lo and Onstott, 1989), however the integrated age is believed to be accurate. The plateau age, when present, is always the same as the integrated age within error, and therefore the choice of one age over the other does not interfere with geologic interpretation. For consistency, the integrated age is adopted for all biotite samples.

The integrated ages are reported in Table 3.3. Biotite ages range from 36.81 ± 0.12 to 64.14 ± 0.24 Ma. Except for F08-LP-008, the biotite ages are compatible with coexisting zircon crystallization ages in that they are concordant or younger, and correlate to cooling below ca. 300°C. F08-LP-008 biotite is older than the coexisting zircon and indicates excess argon, and is not considered further.

Along the three vertical traverses, the biotite ages young with decreasing elevation, and there appears to be a broad pattern of younging to the east. In general, the Paleocene Lake Pass plutons yield Paleocene biotite ages with the notable exception of H07-TL-001 that is only 43.7 Ma. Ages significantly younger than the inferred intrusion age likely record argon loss related to local reheating by younger intrusions. Biotites from the Winfield/Echo Canyon plutons range from zircon crystallization ages to 3 Ma younger. Integrated biotite ages from Proterozoic basement range from 1323 to 36.6 Ma and correlate to distance from the TLB (Figure 3.5). Phanerozoic-age biotites from basement samples that are older than U/Pb zircon ages from the TLB are only partially degassed (e.g. H08-HU-009; Figure 3.5). A single Proterozoic muscovite from within 5 m of the batholith contact was run and yields an age of 37.23 ± 0.72 Ma (Figure 3.6).

Table 3.3: Biotite ages reported in Ma with errors at 2-sigma. Locations chosen by proximity to landmarks and do not necessarily imply a genetic relationship.

Sample	Location	Latitude	Longitude	Elevation (m)	Age (Ma)	Internal Errors	External Errors
H07-HU-006	Winfield	38.98955	-106.4151472	3059	36.81	±	1.45
F08-HU-002†	Winfield	38.98892778	-106.4138917	3045	37.31	±	1.48
F08-HU-008	Winfield	38.98933775	-106.4120288	3039	37.58	±	1.48
F08-HU-009	Winfield	38.9890288	-106.412242	3043	37.62	±	1.48
F08-HU-007	Huron Peak	38.94506421	-106.4576973	3289	38.29	±	1.51
H07-HU-005	Huron Peak	38.95511389	-106.456	3506	38.72	±	1.53
H07-HU-004	Huron Peak	38.95356667	-106.4426722	3884	38.86	±	1.53
F08-HU-006	Huron Peak	38.9363426	-106.4532961	3363	39.10	±	1.54
H07-HU-001	Huron Peak	38.945501	-106.438067	4268	40.33	±	1.59
H07-HU-002	Huron Peak	38.94851944	-106.4366361	4104	40.50	±	1.59
F08-TL-009	Echo Canyon	39.0704863	-106.4697529	3070	42.14	±	1.66
F08-TL-007	Echo Canyon	39.07974746	-106.4677485	3279	42.17	±	1.66
F08-TL-008	Echo Canyon	39.07660794	-106.4673367	3224	42.23	±	1.67
F08-TL-006	Echo Canyon	39.08038119	-106.4689408	3336	42.51	±	1.68
H07-TL-001	Twin Lakes	39.06471944	-106.4011167	2827	43.69	±	1.72
F08-LP-008	Grizzley Peak	38.92976105	-106.5200141	3175	44.32	±	1.74
F08-TL-005‡	Echo Canyon	39.0866198	-106.4701108	3536	47.96	±	1.89
H07-HU-007†	Winfield	38.99099722	-106.4132639	3053	55.15	±	2.67
F08-LP-007	Lake Pass	38.96407861	-106.5599084	3435	56.96	±	2.24
F08-TL-014	Independence Pass	39.06716396	-106.5104048	3116	57.35	±	2.26
F08-TL-002	Independence Pass	39.04672711	-106.5167061	3175	57.85	±	2.28
F08-LP-003	Lake Pass	38.99708333	-106.56145	3890	64.14	±	2.53
H08-HU-009†	Winfield Road	39.02875833	-106.24685	3063	120	±	4.73
H07-HU-008†	Hwy 285	39.02335278	-106.2810972	2736	838	±	32.93
H08-HU-010†	Granite	39.04337222	-106.2663889	2731	1243	±	48.82
H08-285-1†	Hwy 285	38.81457778	-106.0880111	2443	1321	±	—
H08-285-2†	Hwy 285	38.81937222	-106.0698361	2488	1324	±	—

†= basement sample

‡= may not have been collected in place and may be basement

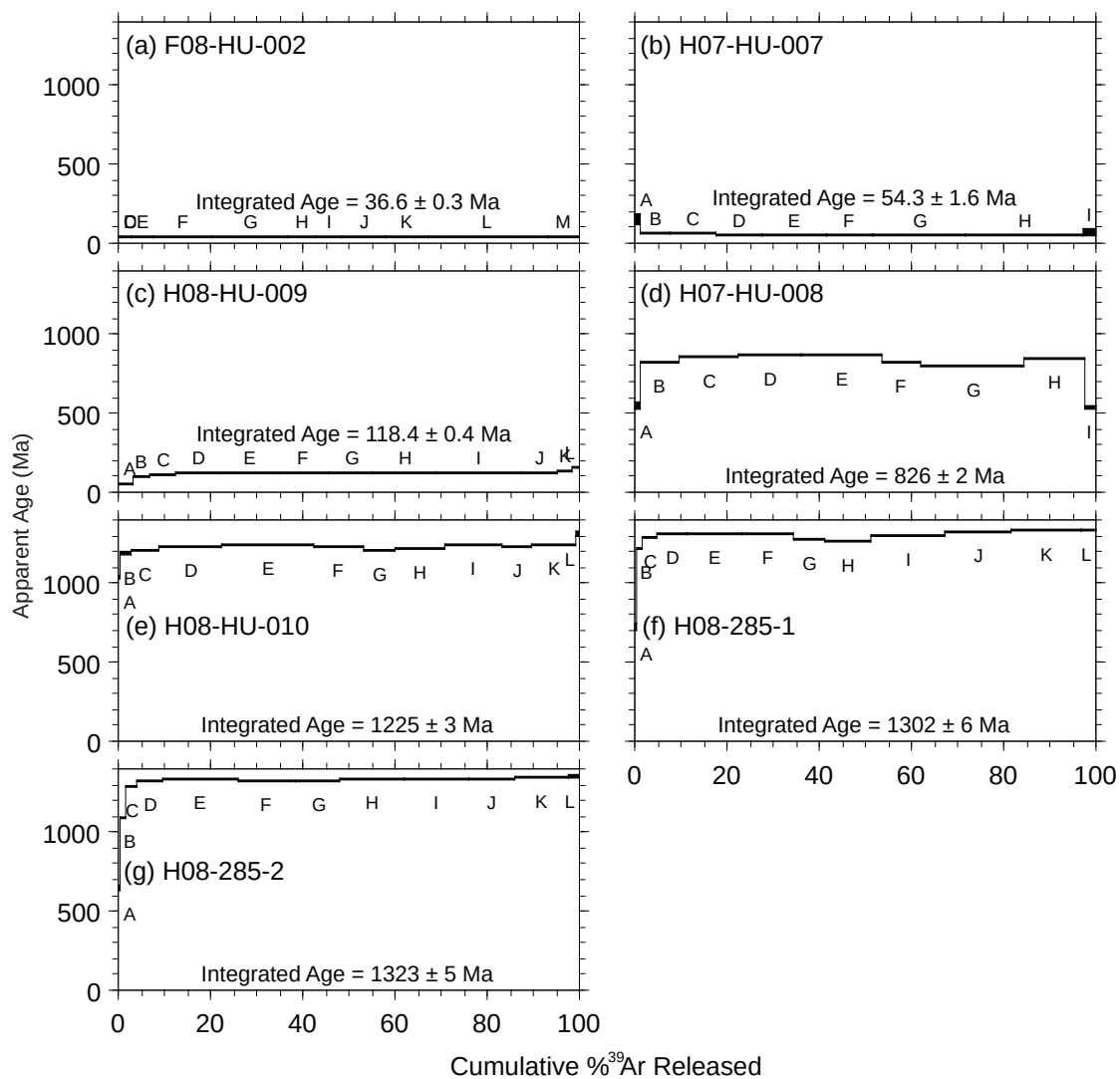


Figure 3.5: Proterozoic biotite age spectra. Hump-shaped spectra imply recoil of ³⁹Ar as discussed in the text. Young ages correspond to close proximity to batholith contacts.

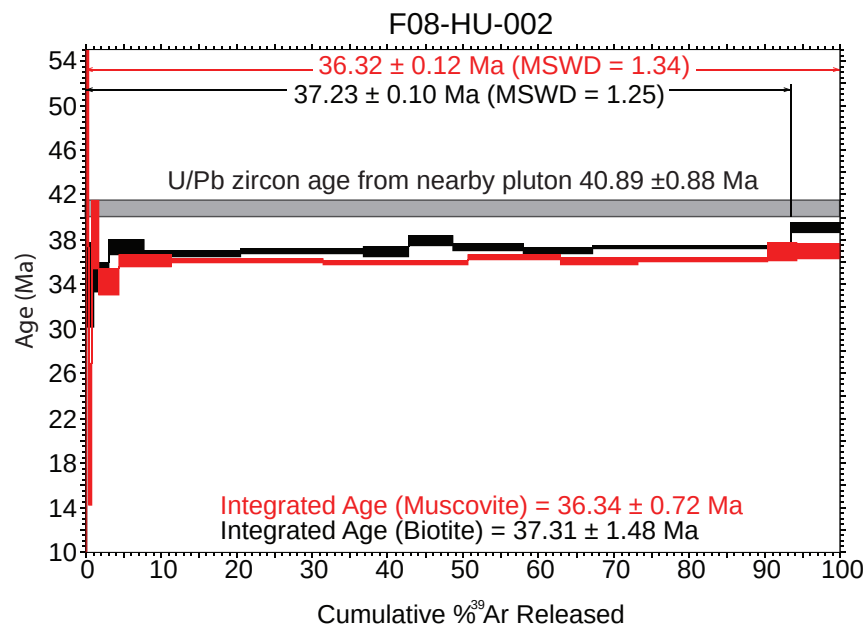


Figure 3.6: $^{40}\text{Ar}/^{39}\text{Ar}$ age spectra for biotite and muscovite from sample F08-HU-002, a Proterozoic sample from the eastern contact of the Eocene Winfield pluton. Note the integrated age is used at the preferred cooling age and the errors include external errors. The plateau age errors are analytical precision only.

3.2.3 K-Feldspar

Twenty-two K-feldspars were examined from TLB rocks and an additional five were analyzed from Proterozoic rock. The typical Twin Lakes K-feldspar age spectrum shape exhibits a gradient of ages that begin low and rise to a terminal age. The age spectra rarely develop a plateau and are typical of K-feldspar spectra that represent protracted or complex thermal histories. The degree of age gradient development varies between samples and in many cases K-feldspar ages are older than coexisting biotite and U/Pb zircon ages (Figure 3.7). The range of ages recorded by K-feldspar is understood in the context of variable closure temperatures relative to variable diffusion length scales within the K-feldspar crystals. This is described by the multiple diffusion domain (MDD) model of Lovera et al. (1989), where typically the youngest early gas release steps record cooling between $\sim 175^{\circ}\text{C}$ and the oldest late release steps record cooling below about 300°C . Figure 3.7 (a) shows a K-feldspar with an expected pattern of ages relative to coexisting biotite and U/Pb ages. Because K-feldspar has a lower argon closure temperature (i.e. $\sim 175 - 300^{\circ}\text{C}$) compared to biotite ($\sim 300 - 350^{\circ}\text{C}$) this system should record younger apparent ages and should also be younger than the zircon age that likely records the age of the rock. Figure 3.7 (b) is an example where K-feldspar records apparent ages older than the biotite and zircon ages, and are thought to reflect excess argon. Inverse isochron analysis is generally not useful in evaluating excess ^{40}Ar in K-feldspar age spectra because individual diffusion domains have age gradients and this will not yield isochronous behavior. Foster et al. (1990) suggest that excess argon occurs in large diffusion domains, and this explanation is adopted here to explain some of the K-feldspar behavior. Foster et al. (1990) also showed that the young ages for initial steps typically record accurate age information, and therefore the minimum ages for K-feldspars are interpreted to reliably record the time of cooling below $\sim 175^{\circ}\text{C}$. Table 3.4 lists the estimated minimum ages;

Table 3.4: K-feldspar ages reported in Ma. Minimum age values are estimated using the approximated y-axis intercept of the model age spectrum when available, and when not available by estimating where the model would likely predict a y-axis intercept. Locations chosen by proximity to landmarks and do not necessarily imply a genetic relationship.

Sample	Latitude	Longitude	Elevation	Location	Min Age (Ma)
F08-HU-007	38.94506421	-106.4576973	3289	Huron Peak	29.5
H07-HU-006	38.98955	-106.4151472	3059	Winfield	30.5
F08-HU-006	38.9363426	-106.4532961	3363	Huron Peak	31
F08-HU-009	38.9890288	-106.412242	3043	Winfield	31
H07-HU-005	38.95511389	-106.456	3506	Huron Peak	31.5
F08-LP-007	38.96407861	-106.5599084	3435	Lake Pass	33
H07-HU-004	38.95356667	-106.4426722	3884	Huron Peak	34
F08-LP-006	38.9632553	-106.5655342	3218	Lake Pass	34.5
H07-HU-002	38.94851944	-106.4366361	4104	Huron Peak	35
H07-TL-001	39.06471944	-106.4011167	2827	Twin Lakes	35.5
H07-HU-001	38.945501	-106.438067	4268	Huron Peak	36
F08-LP-008	38.92976105	-106.5200141	3175	Grizzley Peak	37
F08-TL-004	39.06952214	-106.4496202	2944	Independence Pass	37
F08-LP-003	38.99708333	-106.56145	3890	Lake Pass	38
F08-TL-009	39.0704863	-106.4697529	3070	Echo Canyon	39
F08-TL-006	39.08038119	-106.4689408	3336	Echo Canyon	40
F08-TL-008	39.07660794	-106.4673367	3224	Echo Canyon	40.5
F08-TL-002	39.04672711	-106.5167061	3175	Independence Pass	41
F08-TL-007	39.07974746	-106.4677485	3279	Echo Canyon	41
F08-TL-014	39.06716396	-106.5104048	3116	Independence Pass	41.5
F08-LP-002	38.9843739	-106.5583219	3711	Lake Pass	42
H08-HU-009‡	39.02875833	-106.24685	3063	Winfield Road	45
H07-HU-008‡	39.02335278	-106.2810972	2736	Winfield Road	70
H08-HU-010‡	39.04337222	-106.2663889	2731	Granite	80
H08-285-1†	38.81457778	-106.0880111	2443	Hwy 285	70
H08-285-2†	38.81937222	-106.0698361	2488	Hwy 285	70

† = Proterozoic basement

‡ = Proterozoic basement samples affected by local reheating

these ages should be regarded as the maximum age that the smallest domains passed through $\sim 175^{\circ}\text{C}$.

MDD modeling was conducted on all K-feldspars (Appendix C). The Lovera et al. (1989) method was used to calculate diffusion coefficients that are plotted against laboratory heating temperatures to generate Arrhenius plots by calculating the ^{39}Ar fractional loss during age spectrum analysis. These diffusion coefficients are modeled within the context of multiple diffusion lengths to arrive at the distribution of domains with the assumption of an activation energy (E) of 46 kcal/mol (cf. Lovera et al., 1997).

The age spectrum is forward modeled by imposing thermal histories onto the domain distribution. Thermal histories that are constrained to cooling only, as well as those that allow reheating, are calculated. Inaccurate MDD thermal history models may be determined for samples with excess ^{40}Ar , and these are dealt with on a case-by-case basis. Additional information about MDD solutions for data collected at New Mexico Tech are provided in Sanders et al. (2006).

The minimum ages for the TLB and basement samples located near its contact range from $\sim 30 - 42$ Ma (Table 3.4). The oldest ages occur in the northwestern part of the batholith and decrease to about 36 Ma towards the east along US Highway 82. The youngest ages occur in the Winfield/Huron Peak area and also correlate with elevation.

The K-feldspars from Proterozoic basement that are outside TLB-related temperature aureoles have minimum ages between ~ 70 and 100 Ma (Table 3.4; Appendix C). Their spectra climb rapidly from ~ 70 to ~ 1000 Ma with the majority of the spectra recording Proterozoic apparent ages.

3.3 Apatite Fission-Track

Fission-track analysis was conducted on eight samples from the Twin Lakes batholith, and results are summarized in Table 3.5. The ages ranged from 13.1 ± 1.5 Ma at the base

Table 3.5: Apatite ages reported in Ma with errors at 2-sigma. Locations chosen by proximity to landmarks and do not necessarily imply a genetic relationship.

Sample	Location	Latitude	Longitude	Elevation	No. Grains Counted	Ni	Ns	Area	Age	Errors	Avg Lengths	Errors
H07-HU-001	Huron Peak	38.945501	-106.438067	4268	20	2519	188	6.40E-05	34.5	± 3.0	12.5	± 2.78
H07-HU-002	Huron Peak	38.94851944	-106.4366361	4104	20	3930	158	6.40E-05	18.5	± 1.7	—	± —
H07-HU-003	Huron Peak	38.99739214	-106.5618649	4120	10	281	14	6.40E-05	22.8	± 6.3	—	± —
H07-HU-004	Huron Peak	38.95356667	-106.4426722	3884	20	5636	263	6.40E-05	21.2	± 1.6	—	± —
H07-HU-005	Huron Peak	38.95511389	-106.456	3506	20	2496	126	6.40E-05	22.8	± 2.3	13.04	± 2.59
F08-HU-007	Huron Peak	38.94506421	-106.4576973	3289	20	1597	110	6.40E-05	13.1	± 2	—	± —
H07-HU-006	Winfield	38.98955	-106.4151472	3059	20	2059	61	6.40E-05	13.3	± 1.8	—	± —
H07-HU-007	Winfield	38.99099722	-106.4132639	3053	5	1948	31	6.40E-05	10.2	± 1.9	—	± —

of the traverse to 34.1 ± 3.0 Ma at the top of Huron Peak. This difference in ages is due to the higher elevation samples cooling through their closure temperature earlier than the lower elevation samples. The cooling rate can be controlled by two general processes: movement of the mineral toward the surface by erosion and uplift relative to the isotherms, and a change in the geothermal gradient over time. The recorded ages were significantly younger than the emplacement ages of the rock, and the age differential between the AFT and $^{40}\text{Ar}/^{39}\text{Ar}$ age increases with decreasing elevation. Two characteristics of apatite fission-tracks are used to interpret AFT data: the spontaneous track density, and the spontaneous track length profiles (Figure 3.8; Table 3.5). Gleadow et al. (1986) quantified the mean track length and standard deviations for three classifications of cooling histories: rapid cooling, basement terrains, and mixed or complex histories. Mean track lengths for a rapidly cooled sample such as a volcanic or shallow intrusive phase range from 14.5 to 15 μm on average, with a standard deviation of around 1 μm . Granitic basement terrains that cool rapidly tend to be negatively skewed, and have mean lengths of 12 to 13 μm , and standard deviations of 1.2 – 2 μm . The mean track lengths for the Huron Peak samples (H07-HU-001 and H07-HU-005) are 12.5 and 13.0 μm (respectively), with standard deviations of 2.8 and 2.6 μm and negatively skewed curves, and as expected for a plutonic sample are indicative of cooling through the closure temperature at depth. Note that the frequency of short tracks tends to be systematically lower than that of long tracks because short tracks intersect etchant pathways less often than long tracks do. This fact should

Table 3.6: (U-Th)/He apatite ages reported in Ma with errors at 2-sigma. Locations chosen by proximity to landmarks and do not necessarily imply a genetic relationship.

Sample	Location	Latitude	Longitude	Elevation	Age	Errors
H07-HU-001	Huron Peak	38.945501	-106.438067	4268	12.5	± 0.7
F08-LP-008	Grizzley Peak	38.92976105	-106.5200141	3175	8.6	± 0.5
F08-HU-007	Huron Peak	38.94506421	-106.4576973	3289	7.8	± 0.5
F08-LP-001	Lake Pass	38.99004813	-106.5578344	3768	17.8	± 1.1
F08-LP-002	Lake Pass	38.9843739	-106.5583219	3711	17.4	± 1.0
F08-TL-002	Independence Pass	39.04672711	-106.5167061	3175	16.5	± 1.0
F08-LP-007	Lake Pass	38.96407861	-106.5599084	3435	15.6	± 0.9
F08-LP-003	Lake Pass	38.99708333	-106.56145	3890	9.9	± 0.6

be kept in mind when interpreting track length frequency diagrams because 4 or 5 very short tracks may be indicative of a larger unsampled population. The chlorine weight percentages of samples H07-HU-001 and H07-HU-005 are 0.08 and 0.02 wt% respectively, based on electron microprobe quantitative analysis. These values indicate the apatites are fluoroapatites with a closure temperature of 110°C (Donelick et al., 2005).

3.4 Apatite (U-Th)/He

Eight samples were analyzed for apatite (U-Th)/He thermochronology (closure temperature is ~70°C) and are summarized in Table 3.6. Two samples are from the Huron Peak vertical traverse, four are from the Lake Pass vertical traverse, one was from near the northwestern margin of the batholith near Highway 82, and one was from Grizzley Peak, which is between the Lake Pass and Huron Peak vertical traverses (Figure 1.3). The highest Huron Peak sample is 12.5 ±0.7 Ma and the low elevation sample is 7.8 ±0.5 Ma, the Lake Pass samples range from 17.8 ±1.1 Ma to 9.9 ±0.6 Ma and do not correlate to a sample age-elevation position. The Grizzly Peak age is 8.6 ±0.5 Ma, and the Independence Pass age is 17.4 ±1.0 Ma. The mean uranium, thorium, and samarium concentrations for all of the samples are 1.6, 2.6, and 9.4 ppm, respectively. For the

vertical traverses the AHe ages commonly decrease with decreasing elevation and are younger than AFT ages determined from the same samples. AHe ages will be addressed in detail in the discussion section.

3.5 Al-in-Hornblende Geobarometry

Two samples were analyzed for aluminum content for Al-in-hornblende geobarometry, however only one sample from the northeastern Lake Pass pluton near the town of Twin Lakes (H07-TL-001) had the proper mineral assemblage (Table 3.7; cf. Hammerstrom and Zen, 1986; Hollister et al., 1987). Four models are used to evaluate the pressure/depth at which the batholith was emplaced: the Schmidt model (1992) records a pressure of 4.43 ± 0.6 kbar, which is considered unreasonably high based on the thermochronology. The Johnson and Rutherford model (1989) applies to volcanic mineral assemblages, and cannot be used for plutonic rocks. Hollister et al. (1987) improved on the Hammerstrom and Zen (1986) model and brought the errors from ± 3 kbars to ± 1 kbar by analyzing neighboring plagioclase crystals and is the preferred geobarometry model for Twin Lakes. The low-elevation sample from the Echo Canyon traverse (F08-TL-009) yielded enough hornblende to perform the geobarometry, but was deficient in quartz, and cannot be assumed to be in equilibrium at the time of formation (cf. Hammerstrom and Zen, 1986; Hollister et al., 1987). The Al-in-hornblende method assumes the pressure-sensitive substitution is the tschermakite component (Hollister et al., 1987). The equation that governs this reactions is:



The lack of quartz therefore becomes a limiting reagent, and the pressure calculated from the concentration of Al-in-hornblende will be incorrect.

Sample	Run Number	Hammarstrom and Zen	Johnson and Rutherford	Hollister et al.	Schmidt
H07-TL-001	13	2.24	2.15	1.72	2.82
Grain 1	14	3.73	3.82	2.98	4.23
	15	3.92	4.03	3.13	4.41
	16	1.16	0.94	0.82	1.80
	17	4.64	4.84	3.74	5.09
	19	3.57	3.64	2.84	4.08
	20	3.71	3.80	2.96	4.22
	21	3.98	4.10	3.18	4.46
	22	5.17	5.44	4.19	5.60
	23	4.35	4.51	3.50	4.82
	24	3.54	3.61	2.82	4.05
	25	4.45	4.63	3.58	4.91
	26	3.96	4.07	3.16	4.44
	27	4.14	4.28	3.32	4.62
	28	4.30	4.46	3.45	4.77
Avg		3.79	3.89	3.03	4.29
Std Dev		0.97	1.09	0.82	0.92

Sample	Run Number	Hammarstrom and Zen	Johnson and Rutherford	Hollister et al.	Schmidt
H07-TL-001	42	4.19	4.33	3.36	4.66
Grain 3	43	3.58	3.65	2.85	4.09
	44	2.82	2.80	2.21	3.37
	45	4.36	4.53	3.51	4.83
	46	4.53	4.71	3.64	4.98
	47	4.56	4.75	3.67	5.01
	48	3.98	4.10	3.18	4.46
Avg		4.00	4.12	3.20	4.49
Std Dev		0.62	0.70	0.52	0.59

Avg of Avgs	4.09	4.06	3.15	4.43
Avg of St Devs	0.90	0.73	0.54	0.61

Sample	Run Number	Hammarstrom and Zen	Johnson and Rutherford	Hollister et al.	Schmidt
H07-TL-001	33	3.45	3.61	2.81	4.05
Grain 2	34	3.96	4.08	3.17	4.45
	35	3.38	3.43	2.68	3.90
	36	6.67	3.75	2.92	4.14
	38	4.21	4.35	3.37	4.68
Avg		4.33	3.84	2.99	4.24
Std Dev		1.35	0.37	0.28	0.32

Sample	Run Number	Hammarstrom and Zen	Johnson and Rutherford	Hollister et al.	Schmidt
H07-TL-001	53	3.76	3.85	3.00	4.26
Grain 4	54	4.34	4.50	3.49	4.81
	55	4.58	4.77	3.69	5.03
	56	5.32	5.60	4.31	5.74
	57	3.85	3.95	3.07	4.34
	58	3.53	3.59	2.81	4.04
Avg		4.23	4.38	3.40	4.70
Std Dev		0.66	0.74	0.55	0.63

Table 3.7: Al-in-hornblende geobarometry. Four hornblende grains were analyzed from sample H07-TL-001 near the town of Twin Lakes, a sample from the Twin Lakes pluton. The Hollister et al. (1987) model gives the preferred pressure of 3.15 ± 1 kbar.

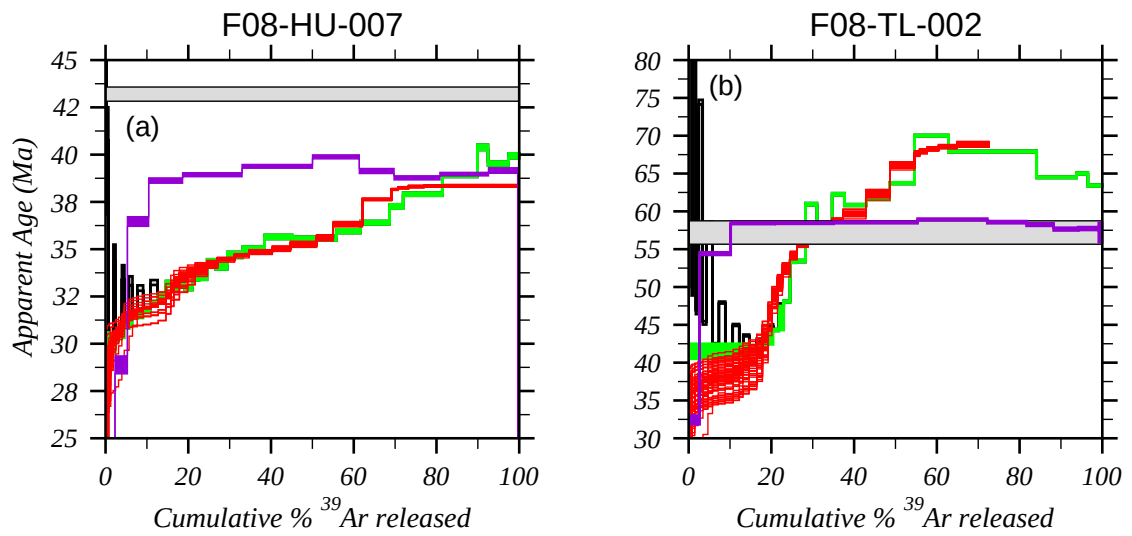


Figure 3.7: $^{40}\text{Ar}/^{39}\text{Ar}$ K-feldspar age spectra and associated MDD models. Black spectra are K-feldspar analyses, red spectra are models, green spectra are measured spectra corrected for excess argon, purple spectra are coexisting biotites, and gray bars are U/Pb zircon ages. a) is a sample where the biotite is the same age (or older) than the oldest part of the K-feldspar spectra as would be expected. b) is a sample that contains excess argon in the oldest parts of the K-feldspar spectra that makes it several Ma older than the biotite and U/Pb zircon ages.

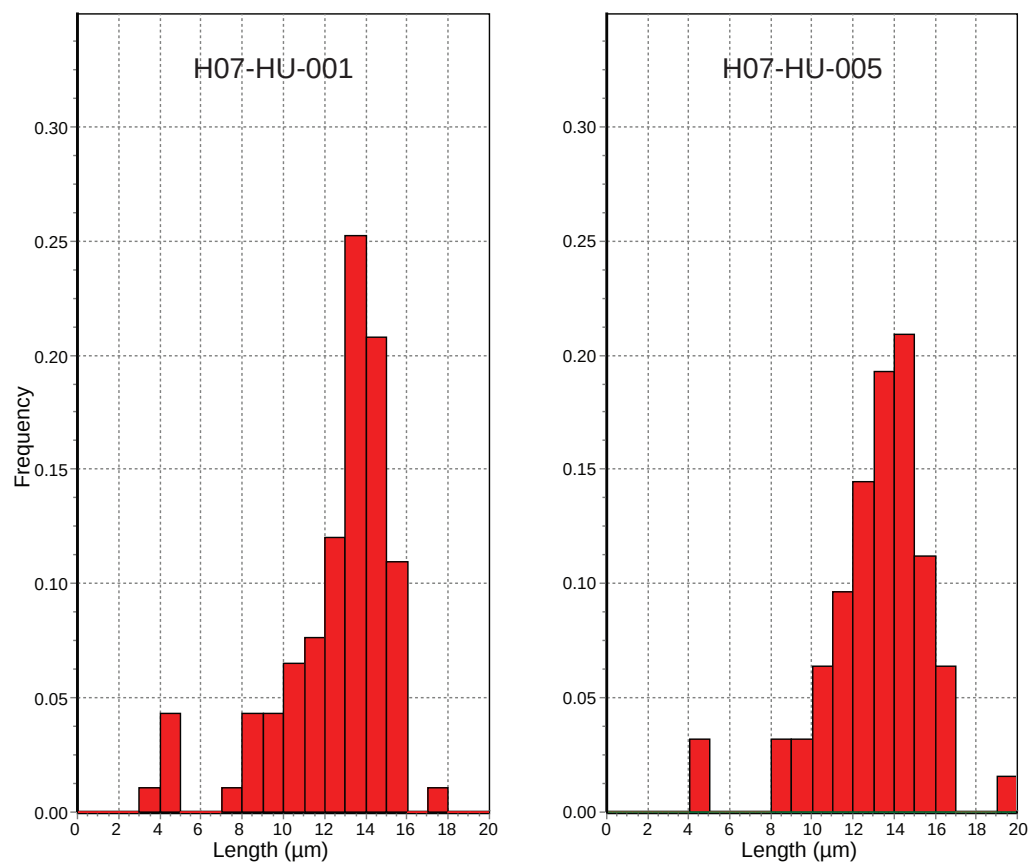


Figure 3.8: Apatite fission track-length histograms. Mean track lengths are 12.5 and 13 μm , respectively.

CHAPTER 4

DISCUSSION

U/Pb zircon; $^{40}\text{Ar}/^{39}\text{Ar}$ hornblende, muscovite, biotite, and K-feldspar; apatite fission track, and apatite (U-Th)/He geo and thermochronology are used to deduce the intrusion and subsequent exhumation history of the TLB. Results from these findings help constrain the Cenozoic geologic history of the region and are used to explore the origin and mechanisms of the Laramide Orogeny. The data also bear on the Phanerozoic burial history of the region and the late Cretaceous-to-recent exhumation history.

4.1 Emplacement History

Fifteen new U/Pb zircon ages reveal a much more extensive intrusion history for the TLB than was previously recognized by Fridrich et al. (1998; and references therein). Five chronologically distinct intrusions are defined by the zircon age data (Figure 3.1) and their distribution requires a substantial modification of the Fridrich et al. (1998) map (Figure 4.1). The zircon ages are used to define two plutonic suites within the TLB. The Lake Pass plutons are defined by Paleocene ages between 63 and 57 Ma and the Winfield/Echo Canyon plutons have Eocene ages between 43 and 40 Ma. Statistically distinct intrusions occur in both the Lake Pass and Winfield/Echo Canyon plutons, and in some cases correlate to lithologies mapped by Fridrich et al. (1998). For instance, in the south Lake Pass plutons, a zircon age of 62.97 ± 0.84 Ma is obtained from a sample of the map unit Ttl and 60.07 ± 1.04 Ma from nearby Tt (Figure 4.1). Near Huron Peak the 43.20 ± 0.54 age

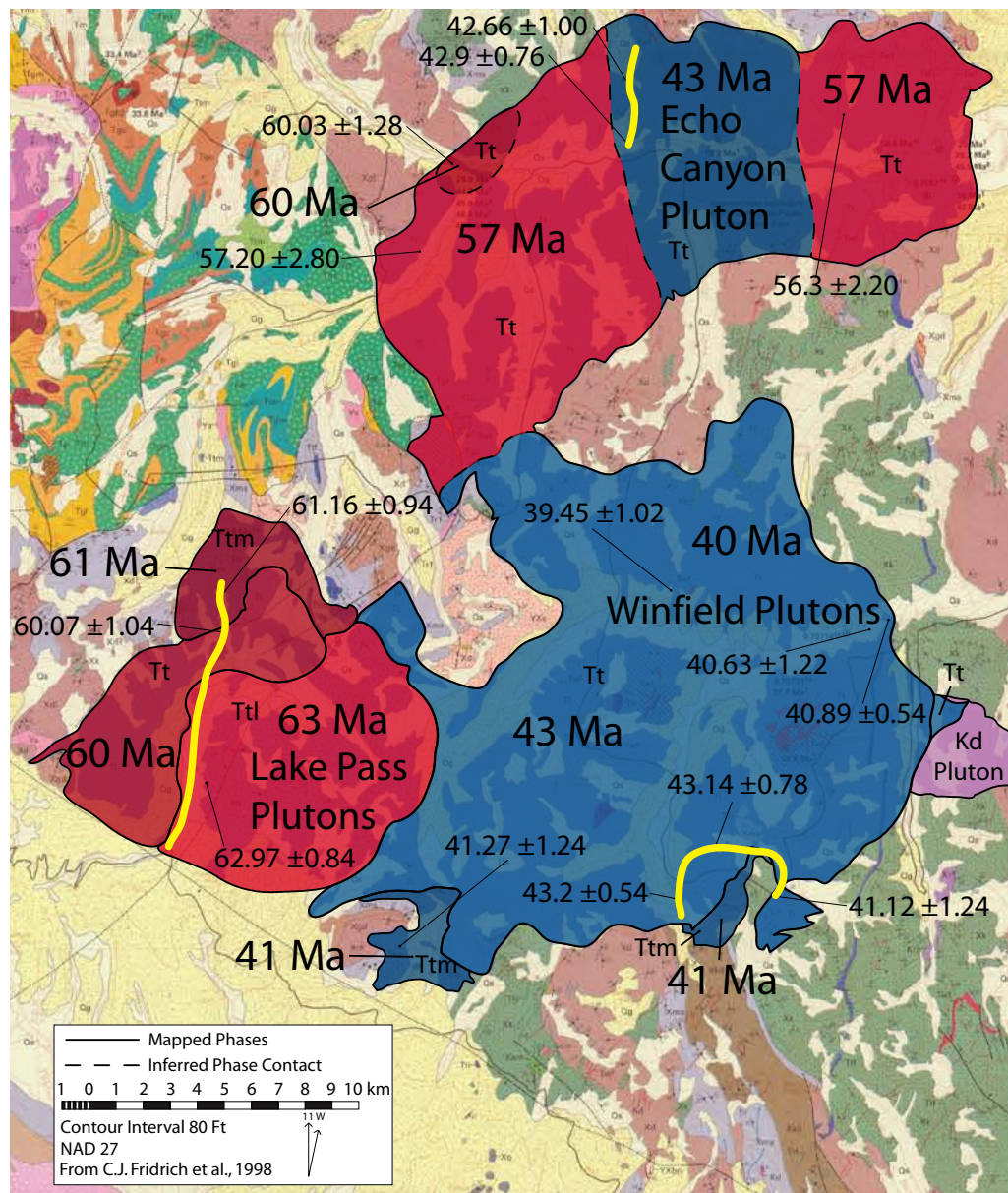


Figure 4.1: Pluton extent and location map of the Twin Lakes batholith. The geologic base map is from Fridrich et al (1998), and the color pluton overlays are mapped based on previous phase mapping, U/Pb zircon analysis, field relations, and best-guess interpolation between data points. Dashed lines represent inferred pluton contacts. Yellow lines are vertical traverses, and are named based on the plutons they sample. Lake Pass plutons (in red) were emplaced during the 63 – 57 Ma period, and Winfield/Echo Canyon plutons (in blue) were intruded between 43 and 40 Ma. Plutons are named based on proximity to prominent landmarks. Note the Independence Pass pluton is one pluton that has been intruded by a later 43 Ma pluton.

from Tt is distinct from 41.27 ± 1.24 from Ttm near Grizzly Peak. Contacts and changes in mineralogy between these discrete intrusions have been observed in the field, and are consistent with the incremental emplacement models where multiple plutons are intruded during a several Ma magmatic episode (e.g. Glazner et al., 2004; Coleman et al., 2004).

In some cases, map units of Fridrich et al. (1998) do not correlate with a single age. For instance, the northern lobe of the TLB (mapped entirely at Tt) contains 60, 57, and 43 Ma plutons. Geochronology sampling shows that the 60 Ma pluton contains abundant quartz and megacrystic K-feldspar, the 57 Ma pluton contains hornblende and abundant quartz, and the 43 Ma pluton contains hornblende and megacrystic K-feldspar, but is quartz-poor. A field transect along US Highway 82 was conducted to identify contacts between the three plutons using these mineralogical criteria, however no discernible contacts were found due to heavy vegetation. Mineralogical differences are gradational and not diagnostic of discrete intrusions, which underscores the utility of detailed geochronology when deciphering a complex magmatic history. The designation of plutonic complexes within the TLB are described by both rock type as well as age in Figure 4.1. Solid lines define the mapped phases of Fridrich et al. (1998) and dashed lines approximate contacts based on age patterns. Two additional younger plutons are cryptically identified by thermochronologic methods. In order to demonstrate this, detailed discussion of some of the thermochronology is required.

$^{40}\text{Ar}/^{39}\text{Ar}$, AFT, and AHe are all susceptible to resetting by thermal pulses to varying degrees, and can be used to identify unsampled younger plutons. Previous workers have used K-Ar and zircon fission-track data (Cunningham et al., 1994; Fridrich et al., 1998) from throughout the CMB to estimate the emplacement age of plutons. In areas experiencing multiple magmatic events separated by tens of Ma it is possible for younger plutons to reheat, and thus reset, the argon and zircon/titanite fission track ages of older plutons to varying degrees, thereby making some $^{40}\text{Ar}/^{39}\text{Ar}$, K-Ar, and zircon/titanite

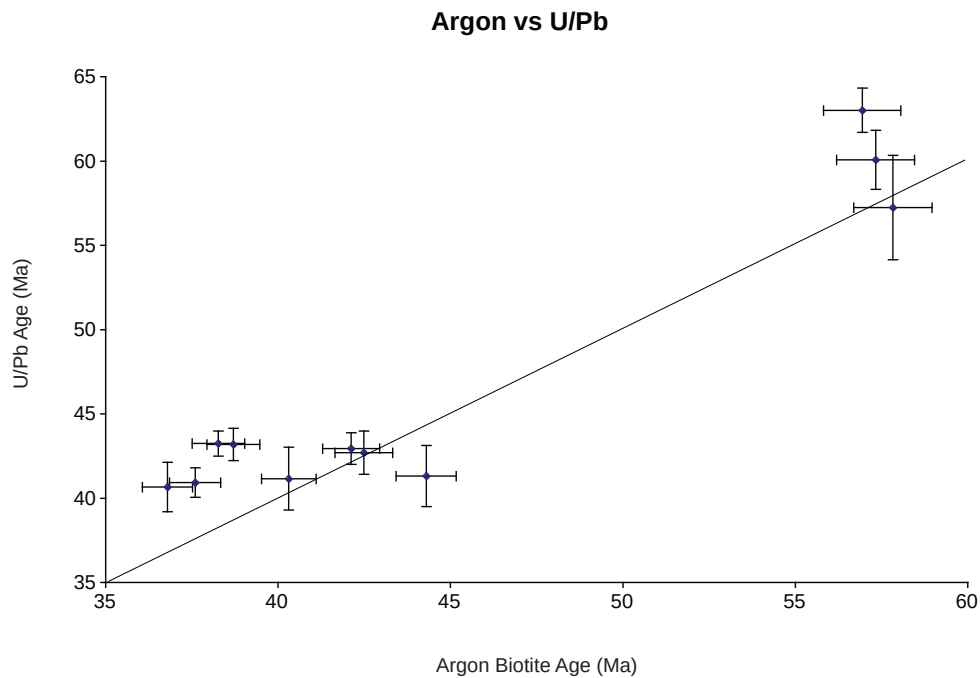


Figure 4.2: $^{40}\text{Ar}/^{39}\text{Ar}$ biotite vs U/Pb zircon plot from magmatic samples. Errors include external errors and are reported at 2-sigma. Samples above the 1:1 line have been partially to completely reset by younger heating events that have not been sampled and/or dated by zircon geochronology. The one sample that falls below the 1:1 line is likely caused by excess argon in the biotite.

fission-track dates inaccurate relative to intrusion age. This is clearly the case at Twin Lakes where magmatism occurred in many places over ~30 Ma. $^{40}\text{Ar}/^{39}\text{Ar}$ biotite ages from the TLB range from 63 to 37 Ma (Table 3.3). Figure 4.2 is a plot of cogenetic zircon age versus biotite age. Four samples have concordant biotite and U/Pb ages and thus fall on the one-to-one line. Six samples have biotite ages younger than the corresponding zircon ages; for instance sample F08-LP-007 (north of the Pie Plant mill site) has a 63 Ma zircon and a biotite 57 Ma biotite and sample F08-TL-014 (at the western pluton/basement contact along US Highway 82) has a 60 Ma zircon and a 57 Ma biotite.

Two possible explanations are that the area did not cool below biotite argon closure until about 57 Ma, or that an intrusion of 57 Ma magmas sufficiently heated the biotites in the older rocks and reset the $^{40}\text{Ar}/^{39}\text{Ar}$ system. In the context of a single old intrusion, biotite ages may represent variable and protracted cooling, but because most biotite ages here have equivalent zircon ages, young biotites (relative to coexisting zircons) likely record the timing of reheating events, and place the level of intrusions structurally shallow at temperatures below biotite closure.

Further evidence that the ambient temperature of the Twin Lakes region was below the biotite argon closure temperature during emplacement comes from basement sample thermochronology. Biotite from H08-HU-010 from near the town of Granite, ~14 km east of the margin of the TLB, has an integrated age of ~1.2 Ga and indicates that the ambient temperature in the Twin Lakes region has been below ~300°C since this time. In addition, the K-feldspar from this sample does not record any ages younger than ~80 Ma, placing the current surface exposed at Twin Lakes structurally above the ~200 – 250°C isotherm at this time. Therefore, if ambient temperatures at the depth and time of TLB emplacement were at or below ~200°C, biotites would be expected to record ages that are within 1 – 2 Ma of zircon ages. This strongly supports reheating events rather than protracted cooling to explain the six biotite ages that do not fall on the one-to-one concordance line on Figure 4.2.

Several biotites from near Winfield are significantly younger than coexisting zircons. Biotites from the low elevation samples of Huron Peak are as young as 38 Ma, which also cannot be explained by protracted cooling following 40 Ma magmatism. Furthermore, a sample from a Proterozoic rock near Winfield (F08-HU-002) yields a muscovite age of 36.34 ± 0.14 Ma and a biotite age of 37.31 ± 0.12 Ma (Figure 3.6). This sample is within 10 meters of the contact of an intrusion that has a zircon age of 40.89

± 0.88 Ma (sample F08-HU-009). The closure temperature of muscovite is $\sim 400^{\circ}\text{C}$ (Harrison et al., 2009), and it is very unlikely that the area stayed above this temperature for ca. 4 Ma. More likely, the mica ages that are younger than the youngest U/Pb zircon age record a magmatic pulse at ca. 38 – 36 Ma that either completely or partially reset mica ages in the Huron Peak/Winfield area. The magmatic event that is not sampled by U/Pb geochronology will be referred to as the 37 Ma Middle Mountain pluton (Figure 4.5). Interestingly, the 37 Ma Wall Mountain Tuff, an ignimbrite of wide geographic distribution (McIntosh and Chapin, 1992), has not been attributed to a source, and this pluton may be a good candidate based on the size of the thermal aureole and location.

In addition to the biotite ages, 15 K-feldspar minimum ages and corresponding MDD unconstrained thermal models support post-40 Ma magmatic events. A plot of K-feldspar minimum age vs U/Pb zircon age (Figure 4.3) shows a similar scenario as that demonstrated by the biotite age versus U/Pb zircon age plot (Figure 4.2). Despite K-feldspar minimum ages representing argon closure at only $\sim 175^{\circ}\text{C}$, several minimum ages are concordant with the magmatic events documented by U/Pb zircon ages (Table 3.1). This is especially true in the northwestern part of the TLB where K-feldspars from Paleocene (60 – 57 Ma) and Eocene (43 Ma) plutons have minimum ages of typically $\sim 41 \pm 2$ Ma, indicating partial resetting of older rocks by the 43 Ma Winfield/Echo Canyon plutons or rapid cooling of the 43 Ma rocks themselves. Traversing from west to east along the northern plutons, K-feldspar minimum ages young to 36 Ma (i.e., H07-TL-001) and strongly suggest that this area, like the Winfield area, has been heated by the 37 Ma Middle Mountain pluton that appears to have affected the eastern side of the northern Lake Pass pluton.

In the southern part of the batholith, the intensity of post 40 Ma reheating appears much greater compared to the north. Vertical sampling traverses in the Lake Pass and

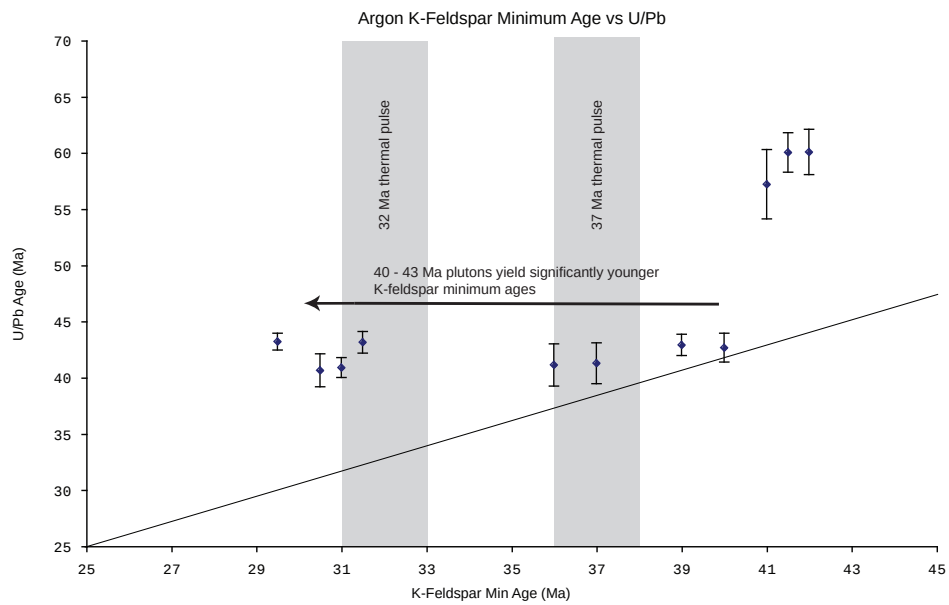


Figure 4.3: $^{40}\text{Ar}/^{39}\text{Ar}$ K-feldspar age vs U/Pb zircon age plot. U/Pb errors include external errors and are reported at 2-sigma. K-feldspar minimum ages are estimated by extrapolation of the age spectrum gradient to the y-axis. No rigorous error estimation is associated with the K-feldspar minimum age, however it is estimated at ~ 1 Ma. Samples that do not fall on the 1:1 line have experienced resetting by younger magmatic events.

Huron Peak areas were primarily intended to examine the exhumation history of the region, but instead appear to provide evidence of unsampled younger intrusions. At Huron Peak, both biotite and K-feldspar ages decrease with decreasing elevation, however the large range of apparent ages (biotites 40 to 38 Ma; K-feldspar minimum 36 to 30 Ma) relative to a vertical separation of only 1 km, cannot be explained by simple exhumation cooling of a deeply intruded 40 Ma pluton. If the region cooled slowly due to exhumation through the closure isotherms, biotite ages require emplacement at or near the 300°C isotherm, followed by protracted exhumation of ~500 m/Ma between 40 and 38 Ma, and K-feldspar ages require similar, but slower exhumation between 36 and 30 Ma. This apparent protracted cooling is not compatible with other data where several zircon/biotite age pairs in the area are concordant. Also, individual MDD thermal histories that consider cooling only for Huron Peak K-feldspars require rapid cooling of ~100°C/Ma at discrete times that is not internally consistent with an age-elevation distribution explained solely by slow exhumation (Figure 4.4). The K-feldspar unconstrained MDD models allow high temperature/short duration thermal pulses at times much younger than any reported U/Pb zircon age (Figure 4.4). These thermal pulses cause the age-elevation discordance of biotites and K-feldspars, and are used to argue for a 37 Ma Middle Mountain pluton and a 32 Ma intrusion named here as the Virginia Peak pluton.

A fairly well defined lateral distribution of K-feldspars that appear to have experienced argon loss associated with one or both of the 37 and 32 Ma events is located in and around the Winfield area (Figure 4.5). Between Lake Pass and Huron Peak the K-feldspar minimum ages increase from ~30 – 36 Ma away from a central axis. This suggests both of the post 40 Ma intrusions occur in the Winfield area.

The Middle Mountain and Virginia Peak intrusions may presently be beneath the currently exposed surface, or could have been above the currently exposed surface and subsequently eroded away. Alternatively, several undated igneous rocks have been

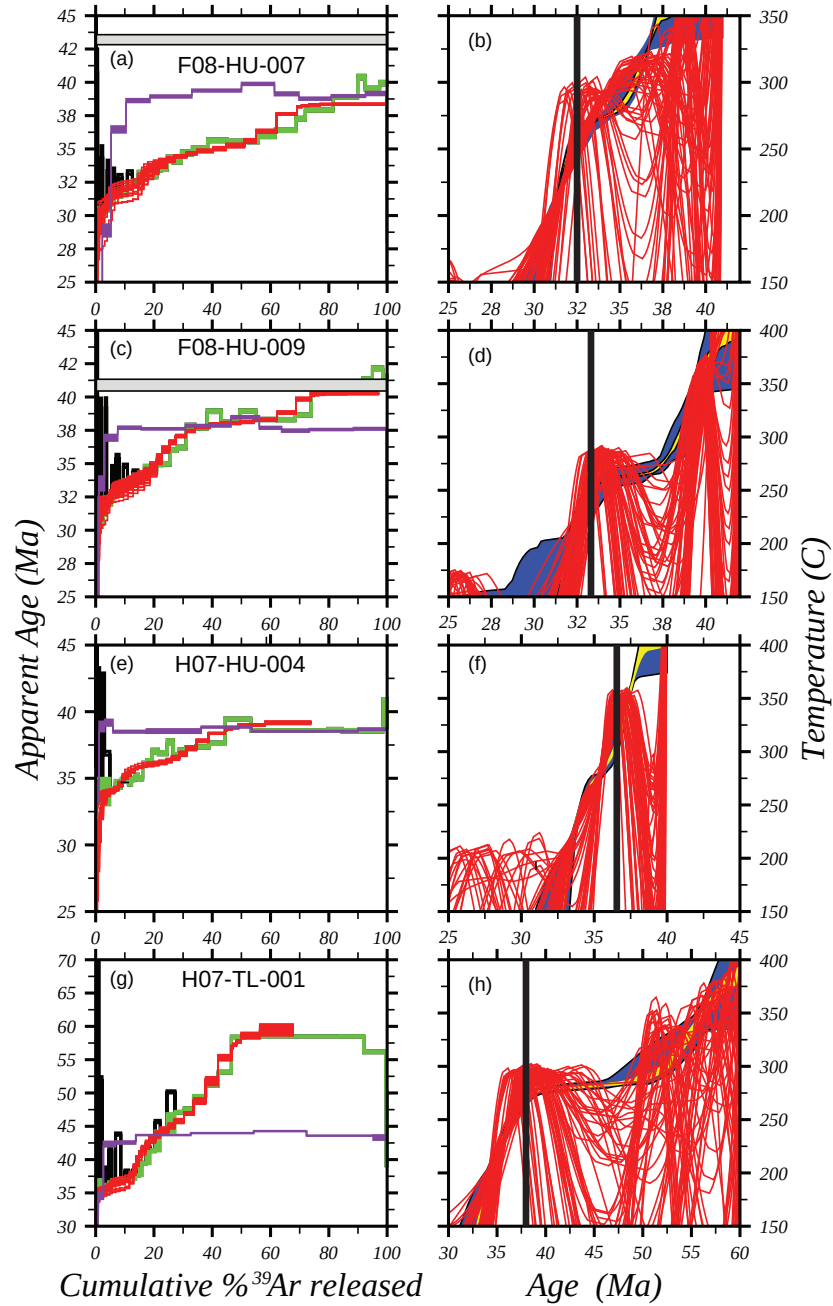


Figure 4.4: $^{40}\text{Ar}/^{39}\text{Ar}$ K-feldspar age spectra and associated MDD modeling. Black spectra are K-feldspar analyses, red spectra are models, green spectra are measured spectra corrected for excess ^{40}Ar , purple spectra are coexisting biotites, and gray bars are U/Pb emplacement ages. The red lines on the thermal histories are unconstrained thermal history models. These unconstrained models demonstrate that the measured spectra can be explained by relatively short duration heating pulses at ~ 37 and 32 Ma. Blue-yellow bars are cooling only thermal histories.

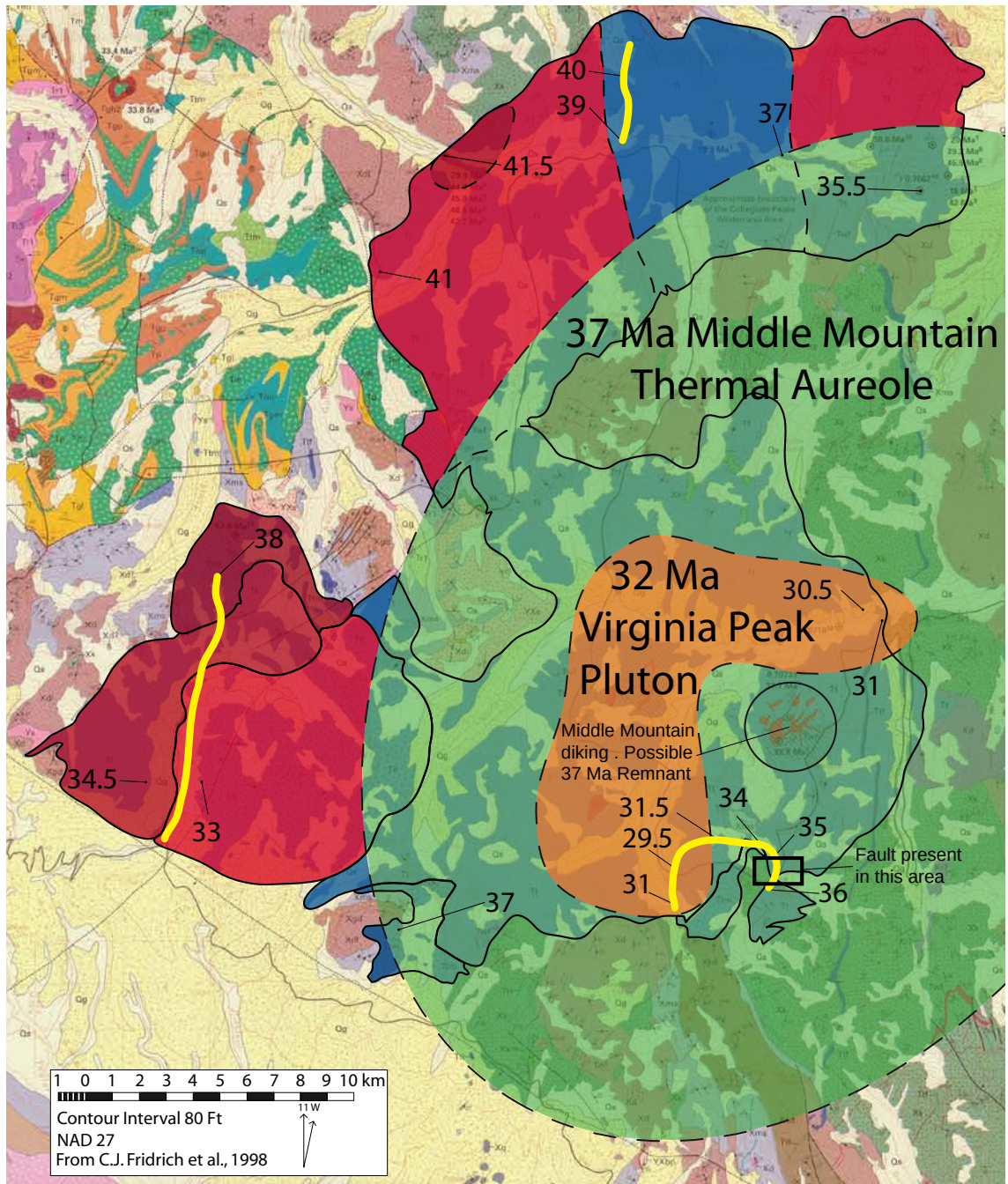


Figure 4.5: Pluton extent and location map of the Twin Lakes batholith with 32 and 37 Ma inferred plutons included. The map is from Figure 4.1, and K-feldspar minimum ages are reported here and used to infer the location and possible shape of the post-40 Ma plutons. The green dotted ellipse is the thermal aureole of the 37 Ma pluton, and does not necessarily represent the full extent of the magma body itself.

mapped by Fridrich et al. (1998). Notably, an intermediate-composition porphyry dike unit (Tti; Figure 4.1) is concentrated around Middle Mountain and Winfield Peak just south of Winfield that was subjected to significant mineralization (shown on the Fridrich et al. 1998 map and seen in the field). Other candidate plutons mapped as Cretaceous calc-alkalic diorites (Kd; Figure 4.1; Brock and Barker, 1972) occur in the area, especially one in contact with the east side of the Huron Peak pluton that may be at least one of the unsampled post-40 Ma plutons. Figure 4.5 illustrates other possible locations for the two unsampled plutons based on the spatial distribution of biotite and K-feldspar data.

In summary, the Twin Lakes batholith was assembled during multiple plutonic events that are discrete in both time and space. Episodic Paleocene and Eocene magmatism is separated by a magmatic lull (magmatic gap) between 57 and 43 Ma. This magmatic gap is considered real rather than an artifact of sampling. Both the Lake Pass and Winfield/Echo Canyon plutonic suites were constructed incrementally over approximate durations of 6 and 3 Ma, respectively. Biotite and K-feldspar ages between 38 and 30 Ma define heating effects of a 37 Ma pluton (Middle Mountain) and 32 Ma pluton (Virginia Peak) that are presently undated by U/Pb geochronology.

4.2 Exhumation History

Understanding the pre-Laramide geological and thermal history is essential for understanding the Laramide to recent exhumation history at Twin Lakes. Shaw et al. (2005) reported hundreds of K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ mica ages from Colorado and New Mexico that are typically older than 1.20 Ga. They conclude that major metamorphism associated with 1.45 – 1.35 Ga magmatism occurred under mid-crustal conditions and that variation in mica cooling ages was caused by long-term crustal residence near the biotite argon

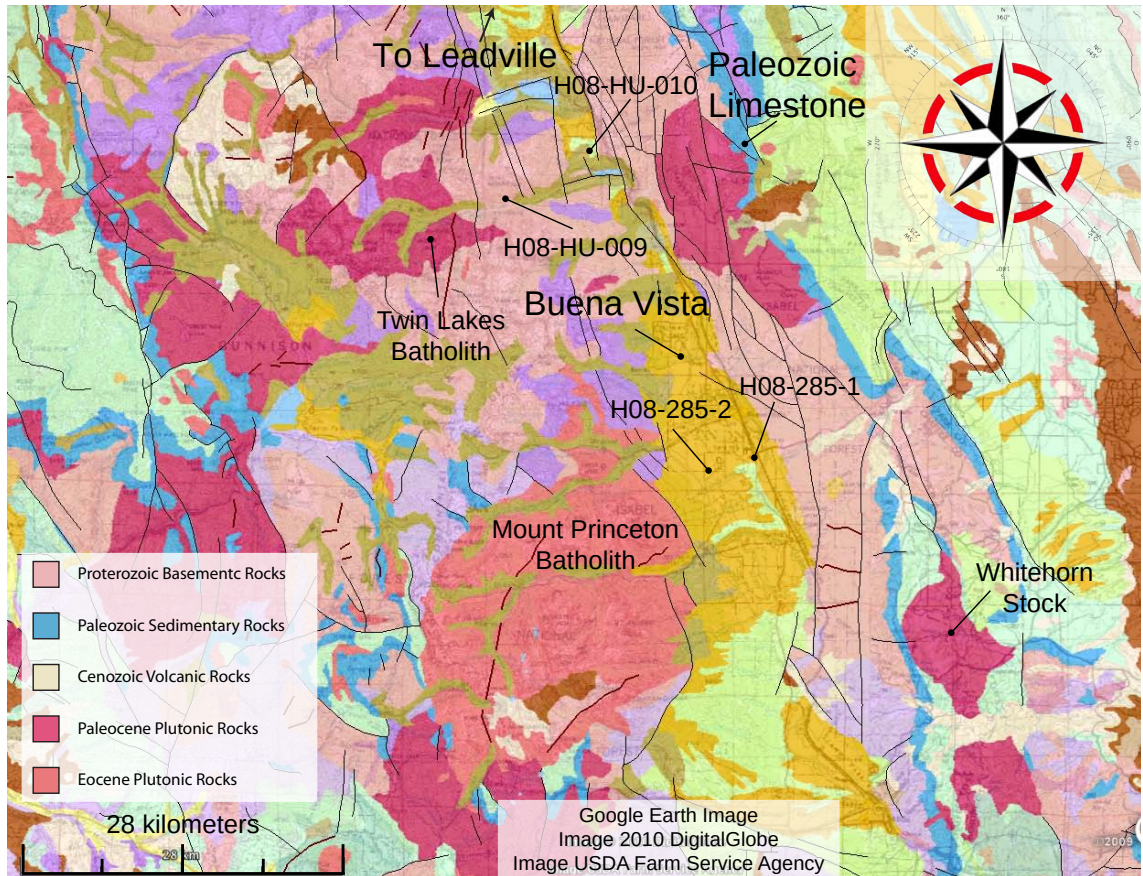


Figure 4.6: Geologic map of central Colorado. Blue north-south trending rock type that passes just to the west of the Whitehorn stock is Paleozoic and implies the basement overlain by sedimentary rocks have not undergone erosion since the Paleozoic. Base map from Google Earth.

closure temperature ($300 - 350^{\circ}\text{C}$) between 1.35 and 1.0 Ga. Proterozoic basement in the central Colorado Trough at the southern end of the Front Range, in southwestern Colorado near Leadville, was at the surface by the Cambrian as shown by preservation of Cambrian sediments nearby (Tweto, 1979; Figure 4.6). The total thickness of the Paleozoic and Mesozoic section can be estimated from isopach reconstructions that suggest Proterozoic basement burial in the central Colorado Trough of at least ~ 6.5 km by the late Cretaceous, with $\sim 4 - 5$ km of Pennsylvanian strata, and 1.6 km of Mesozoic sediments (Stark et al., 1949; DeVoto et al., 1971; Workman, 1997). Samples H08-285-1 and 2 from

Buena Vista K-Feldspar MDD Analyses

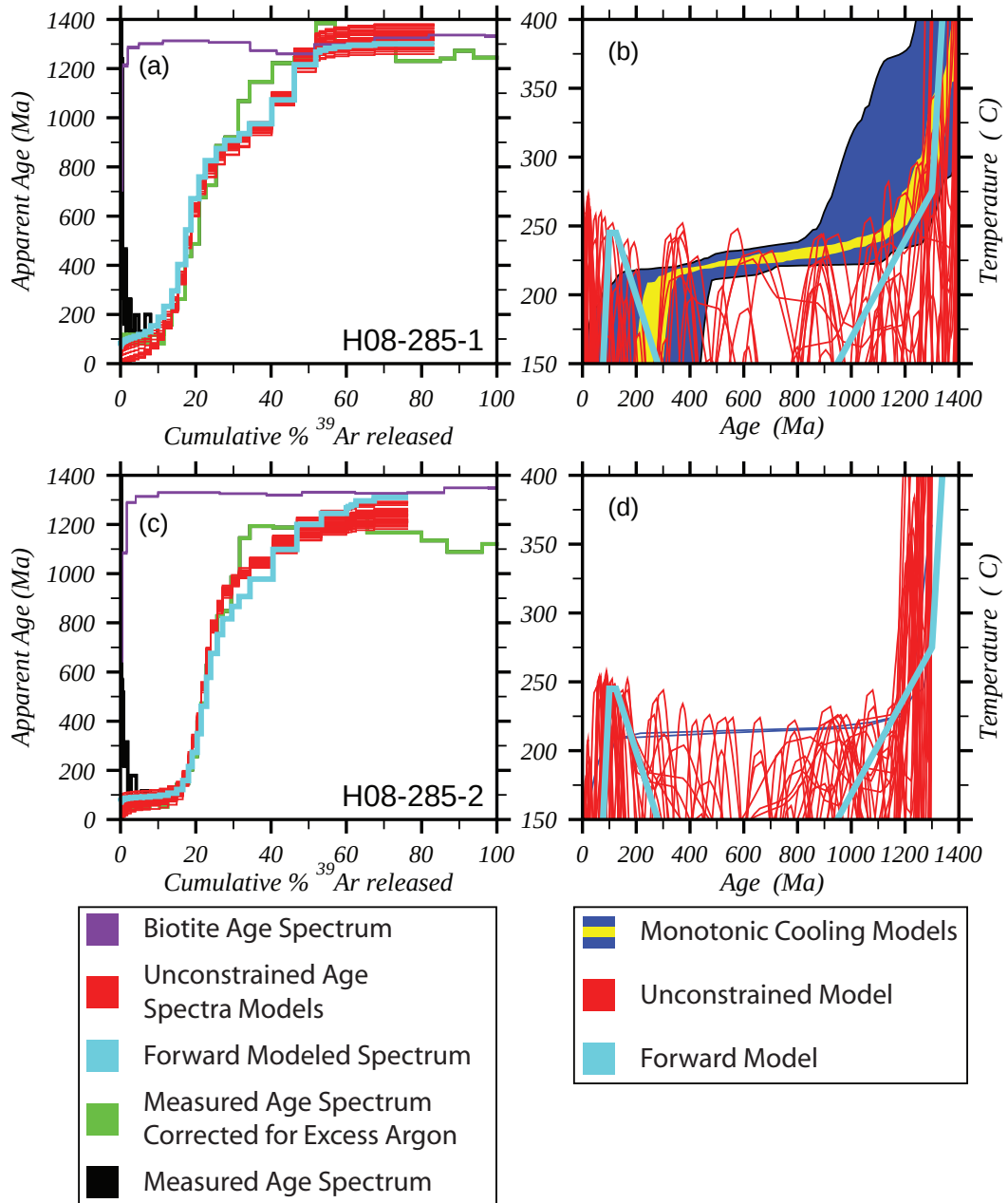


Figure 4.7: $^{40}\text{Ar}/^{39}\text{Ar}$ age spectra and MDD thermal models for Proterozoic basement samples near Buena Vista, CO.

near Buena Vista (Figure 4.6) are Proterozoic basement and their K-feldspar and biotite $^{40}\text{Ar}/^{39}\text{Ar}$ dates are presented on Figure 4.7. Like the Proterozoic sample near Granite (H08-HU-010) the biotites here are Mesoproterozoic with cooling ages around 1.35 Ga (Figure 4.7). The K-feldspar age spectra climb from 80 – 100 Ma to approximately 1.2 Ga. The biotite ages indicate that the area around Buena Vista has remained below $\sim 300^\circ\text{C}$ since the Mesoproterozoic, and the K-feldspar minimum ages indicate basement heating to $\sim 200^\circ\text{C}$ between 80 and 100 Ma (Figure 4.7). The heating recorded by the K-feldspar MDD modeling represents the effects of regional burial, as the closest Laramide pluton (the Whitehorn Stock) is more than 10 km to the south. If heating was solely related to sediment cover, the average geothermal gradient in the late Cretaceous would be $\sim 30^\circ\text{C}/\text{km}$ (e.g. 6 km of sedimentary rocks, per 200°C), however if significant basement has been removed along with Paleozoic and Mesozoic sediments in the Cenozoic the gradient would be less. Additional evidence that the present basement exposure was at significant depth at the onset of the Laramide comes from the Whitehorn stock contact metamorphic mineral assemblage (Workman, 1997) located 55 km southeast of the TLB (Figure 4.6). The metamorphic minerals near the 70 Ma Whitehorn stock suggest a pressure of 3.5 ± 0.5 kbars and indicate an ~ 8 -10 km intrusion depth. Workman (1997) accounted for this depth with ~ 6 km of Phanerozoic sediments plus 2.5 km of Whitehorn plutonic rocks. He acknowledged the possibility of pre-Whitehorn-age thrusting in the region to attain this significant depth, but preferred an explanation that did not require structural thickening.

Several lines of evidence suggest that the basement underlying the Colorado Trough in the region of Twin Lakes was near 8 km between 60 and 100 Ma. These include: 1) isopach sediment thickness of at least 6 km, 2) MDD K-feldspar thermochronology from basement samples require $\sim 200^\circ\text{C}$ (i.e., 6 – 10 km depending upon the geothermal gradient), 3) contact metamorphic minerals associated with the Whitehorn stock suggesting

~9 km of overburden, and 4) Al-in-hornblende geobarometry (3.1 ± 1 kbar; $\sim 8 \pm 3$ km) from the 57 Ma sample H07-TL-001 collected near the town of Twin Lakes. Removal of this rock section occurred between ~70 and 37 Ma near the U.S. Highway 285 K-feldspar samples east of Buena Vista. This assertion is constrained by the presence of large paleovalleys that cut the basement and Whitehorn stock that are partially filled with the 37 Ma Wall Mountain Tuff (Chapin and Lowell, 1989). The details of the overall exhumation history and the precise timing of paleovalley cutting are not constrained by the existing data, but it is clear that major erosion between 80 – 100 and 37 Ma was caused by Laramide uplift and inversion of the Colorado Trough.

In the Twin Lakes area it is difficult to extract the exhumation history between 63 and 40 Ma because thermochronometers that might track this history have experienced resetting events associated with post-63 Ma magmatism. Al-in-hornblende geobarometry indicates that the northern TLB was at 3.1 ± 1 kbar at 57 Ma, which is similar to estimates from the Whitehorn stock. Also, K-feldspar H08-HU-010 near Granite (Figure 4.6) is consistent with the U.S. Highway 285 K-feldspars that place the Granite area at $>200^{\circ}\text{C}$ around 70 Ma. Thus, only minor exhumation (~2 km) occurred between 70 and 57 Ma. Using the experimentally determined pressure and assuming an average rock density of 2.7 g/cm^3 , the area was exhumed from ~9.5 km to ~8.4 km between 70 and 57 Ma, which requires an average exhumation rate of ~75 m/Ma.

Details of exhumation between 56 and 43 Ma are unknown, however the Huron Peak vertical traverse provides a comprehensive thermochronological history of the southern TLB between 43 Ma and the present. Figure 4.8 is an age vs elevation plot from the Huron Peak vertical traverse that summarizes the following age patterns. The Huron Peak traverse crosses both a 43 and 41 Ma pluton, and the younger pluton reset thermochronometers from the older pluton as shown by biotite ages no older than 40 Ma

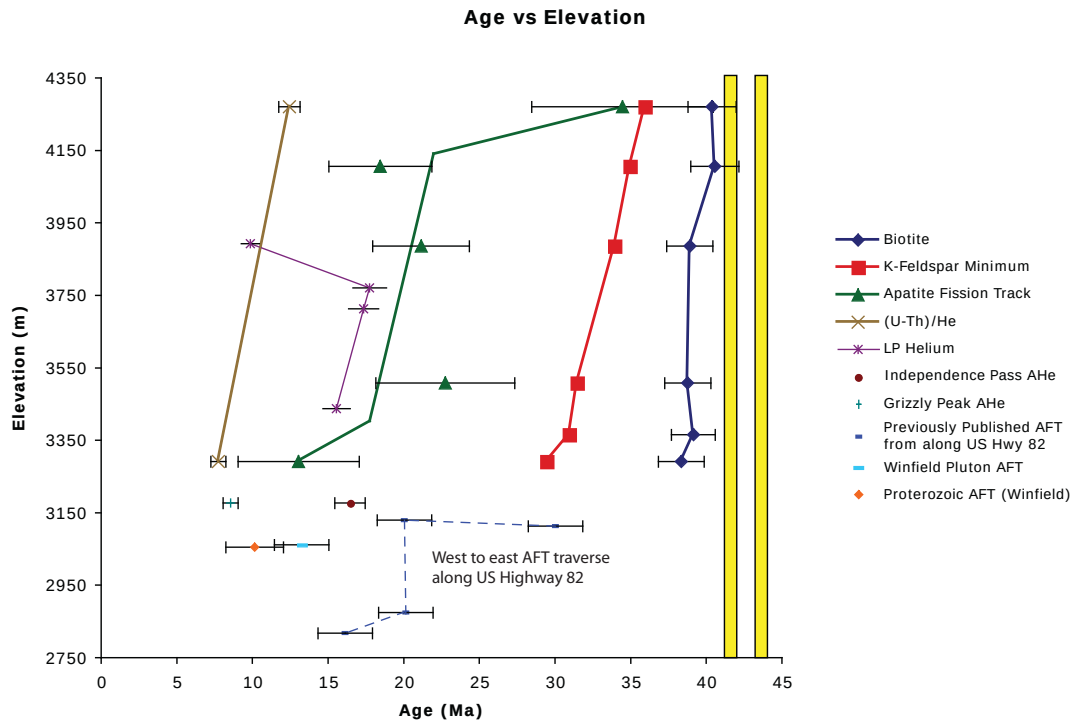


Figure 4.8: Age vs elevatoin plot. Yellow bar represents U/Pb zircon ages of the Huron Peak vertical traverse. Each line represents a different thermochronometer from the Huron Peak vertical traverse except for the purple and blue lines. Older apparent ages generally correlate to both higher closure temperatures and higher elevations. For direct compar-ison, the purple line is the AHe data from the Lake Pass vertical traverse, and single samples are other samples from the TLB. The dashed blue line connects previously pub-lished AFT ages from a traverse along US Highway 82. These ages young to the east. Error bars are plotted at 2-sigma.

along the traverse (Figure 4.8). As discussed previously, biotite ages decrease with elevation due to heating by the Middle Mountain intrusion at 37 Ma; K-feldspar minimum ages are younger than biotite ages and also decrease with decreasing elevation. It appears as though all samples were heated sufficiently at 37 Ma to reset the small diffusion K-feldspar domains, with the low elevation samples experiencing the additional effects of the 32 Ma Virginia Peak pluton (Figure 4.8).

Apatite-fission track ages range from 34 to 13 Ma from the top of the traverse to the bottom, but do not vary in a systematic fashion (Figure 4.8). The samples in the middle of the traverse are ~22 Ma, which results in two changes in the slope of the line on the age vs elevation graph. Typically, age-elevation profiles that capture two changes in slope are interpreted to represent the partial annealing zone (PAZ), however the track length data do not support this interpretation. First of all, the changes in slope are not typical of a PAZ. Second, track length measurements from the entire traverse yield relatively long values (~12.5 μm), which preclude the samples from having resided near annealing temperatures for an extended period of time. This means the high-elevation sample could not have cooled below 110°C at 34 Ma and remained structurally just above the 110°C isotherm for 12 Ma before the next lowest sample closed at 22 Ma as Figure 4.8 suggests. The geothermal gradient could have been high enough that the high-elevation sample was at ~70°C while the next sample down (164 m) was warmer than 110°C, however Decker et al. (1988) suggests that the maximum possible geothermal gradient at this time was 45°C/km. A more plausible explanation for the large difference in age between samples of similar elevation and preservation of long track lengths is structural juxtaposition of samples. Faulting is further supported by the two low-elevation samples of the Huron Peak traverse, where like the top two samples it is difficult to reconcile long track lengths (i.e. rapid cooling) with significant difference in AFT age (i.e. slow cooling) from vertically adjacent samples. Published AFT data along US Highway 82 also vary over small

elevation differences (Figure 4.8). A sample near the town of Twin Lakes is ~16 Ma, and one from the western contact of the batholith is 29.9 Ma (Bryant and Naeser, 1980). AFT ages between these two samples are ~20 Ma and may indicate an overall younging from west to east. These data, when combined with the new AFT results, demonstrate that no simple relationship between age and elevation exists for the TLB; further attesting to complicated cooling patterns across the area.

Although the AFT ages cannot describe regional patterns of Twin Lakes cooling (i.e. exhumation) in a simple manner, thermal modeling of individual samples provide valuable details of cooling paths. Figure 4.9 shows thermal histories derived from geologic constraints and various thermochronologic data (K-feldspar, AFT age and track length distributions, and AHe ages from samples H07-HU-001 (top of Huron Peak, 4268 m) and H07-HU-005 (3506 m sample near the bottom of Huron Peak)). Thermal modeling of the high-elevation sample predicts rapid cooling from 34 – 32 Ma followed by nearly isothermal behavior (70 – 60°C) from ~30 Ma to 13 Ma. This isothermal segment is indicative of extremely slow or no exhumation during 30 – 13 Ma. H07-HU-005 from near the bottom of the Huron Peak traverse suggests slow cooling between 30 and 24 Ma, at which point the rate increases until 22 Ma, and decreases to essentially isothermal (100 – 90°C) until 13 Ma. The pulse of cooling between 24 and 22 Ma recorded by this track length model may also explain concordant AFT ages of ~22 Ma for the three middle-elevation samples along the Huron Peak traverse (Figure 4.8). The two track length thermal models demonstrate compatibility for similar time periods, especially post-24 Ma (Figure 4.9). That is, if the three middle-elevation samples are on the same structural block they could have all passed through 110°C at ~22 Ma. Both samples indicate protracted cooling between ~22 – 13 Ma, at which point they record accelerated cooling. This may indicate that samples from the Huron Peak traverse share parts of their thermal histories, with the low-elevation samples remaining slightly hotter.

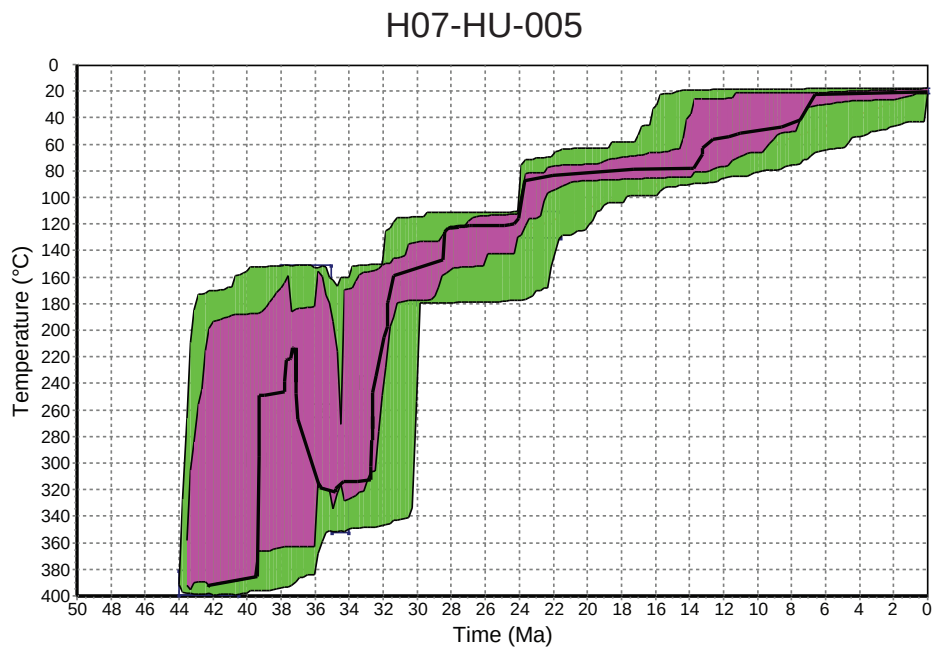
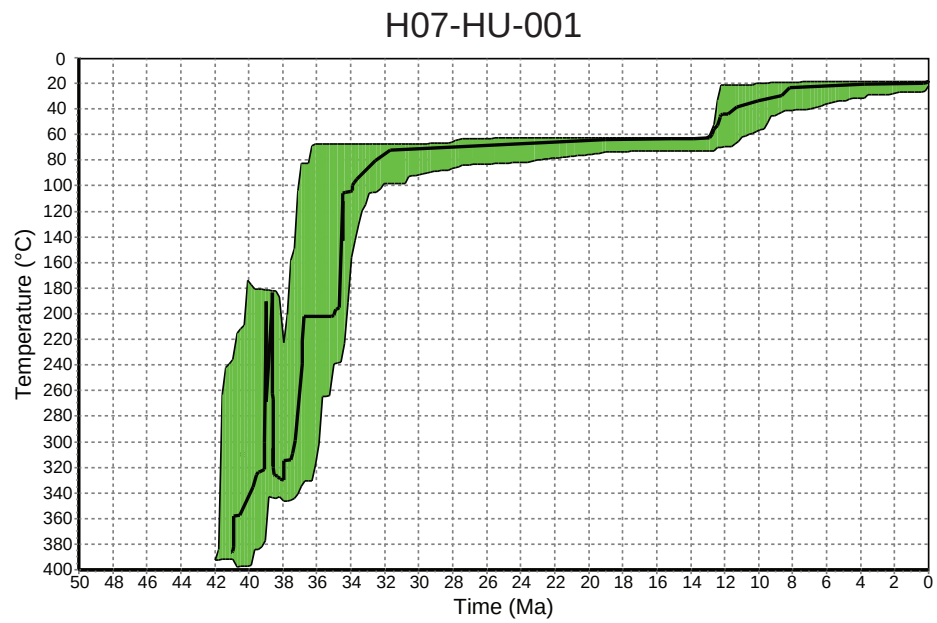


Figure 4.9: AFT thermal histories determined from track length distributions using HeFTy (Ketcham, 2007). Periods of essentially isothermal conditions are punctuated by several cooling pulses.

The AHe data range from 17.8 Ma to 7.8 Ma over two vertical traverses that are 10 km apart. The Lake Pass traverse is complicated by the fact that the highest-elevation sample is the youngest at 9 Ma (perhaps affected by lightening), with lower-elevation samples showing a systematically decreasing age-elevation pattern (17.8 – 15.6 Ma). Like the AFT data, this pattern appears to require structural complexity. Structures are further indicated by similar elevation samples along the Huron Peak and Lake Pass traverses having discordant ages (Figure 4.8). Ignoring the high-elevation Lake Pass sample, the discordance between the two vertical traverses seems to require post-7 Ma. Inferred fault juxtaposition brought the deeper Huron Peak samples to a similar structural position with the shallowest Lake Pass samples at or after 7 Ma. This can be explained by down-to-the west tilting, and may have been accommodated by a rifting-related tilted rift flank structure.

The Huron Peak vertical traverse AHe dates are no older than 12.5 Ma, and the 200 m/Ma exhumation rate calculated from the age-elevation pattern is compatible with increased exhumation from 13 to 8 Ma (Figure 4.9). The Grizzly Peak and Independence Pass areas have the lowest elevation AHe samples, and yield 8.6 and 16 Ma ages, respectively (Figure 4.8). Like the Lake Pass samples, the Independence Pass sample resides on the western part of the batholith and their overall compatibility may place them on the same structural block. Despite complexity, the youngest AHe ages place part of the batholith between 3.5 and 1.5 km below the surface at 7 Ma if the geothermal gradient was between 30 to 45°C/km.

Figure 4.10 summarizes possible exhumation paths for the TLB and Figure 4.11 diagrammatically depicts the combined intrusion and exhumation history. Pressure estimates of the Whitehorn stock and isopach reconstruction require paleodepths of ~8 – 10 km that are exhumed by 37 Ma, as constrained by the Wall Mountain Tuff unconformity (Chapin and Lowell, 1989). The exhumation history at the TLB is apparently much more

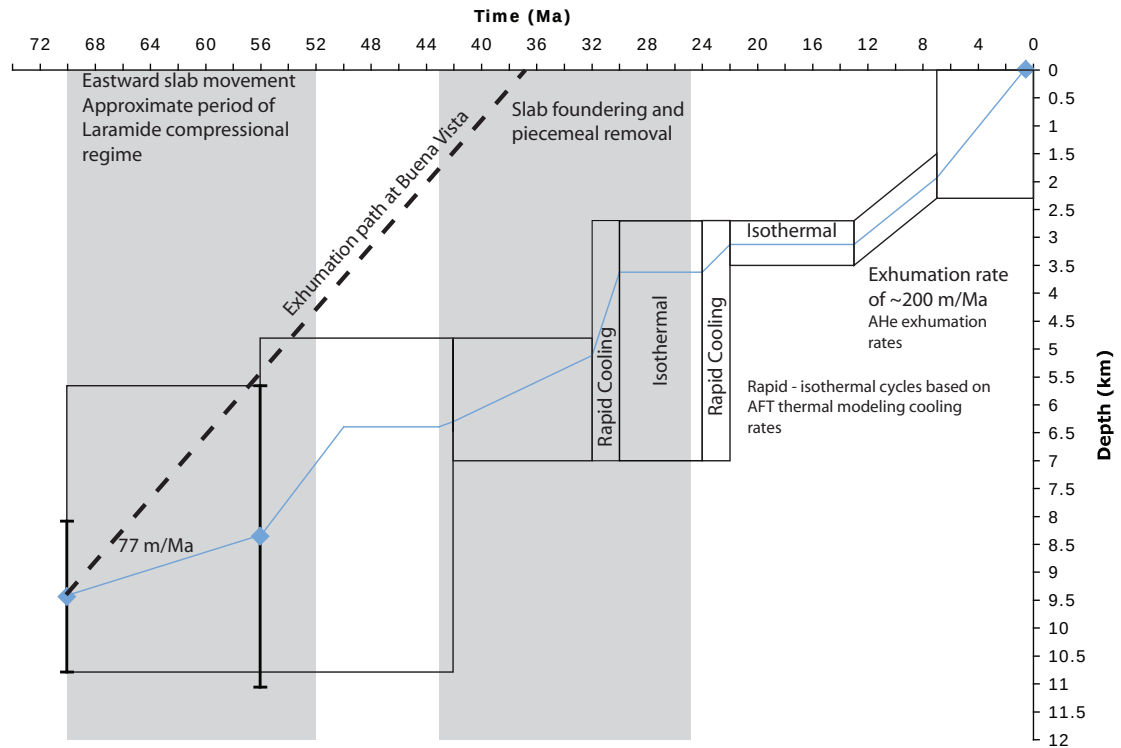


Figure 4.10: Summary of the exhumation path as determined by U/Pb, $^{40}\text{Ar}/^{39}\text{Ar}$ (muscovite, biotite, and K-feldspar), AFT, AHe, and Al-in-hornblende geobarometry. The Buena Vista area (dashed line) was differentially exhumed relative to the TLB (blue line). Boxes encompass the possible paths that include errors in geobarometry and geothermal gradients.

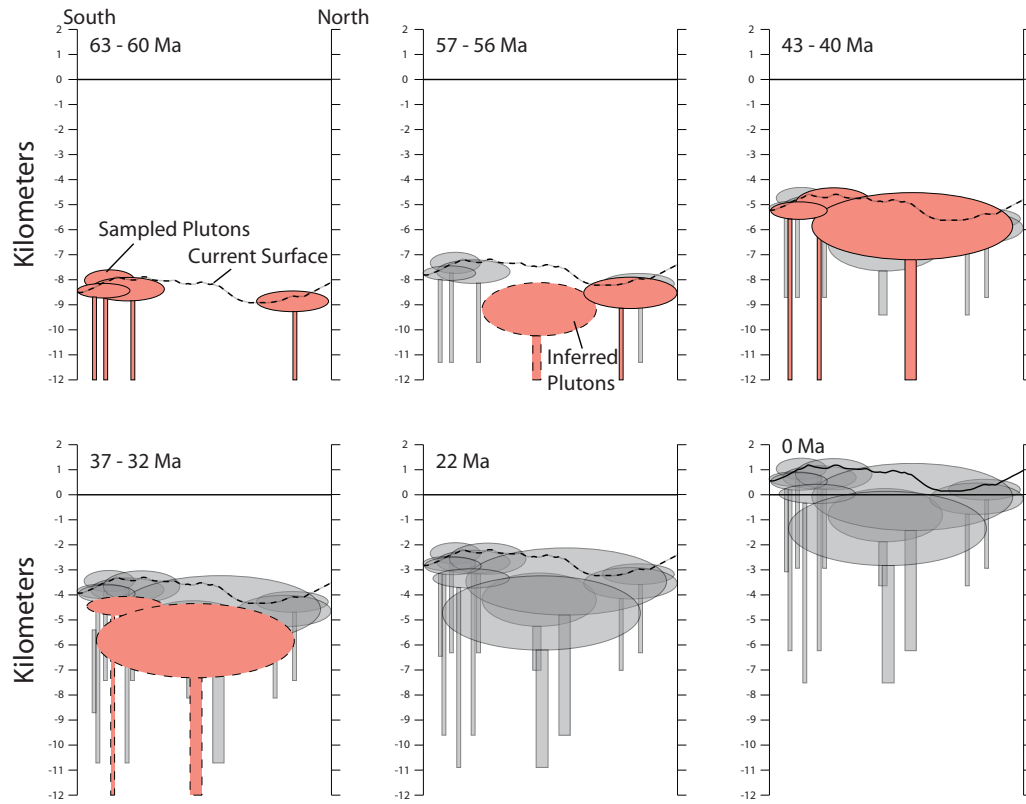


Figure 4.11: Cross section cartoon depicting the emplacement and exhumation over time to accompany Figure 4.10. Dashed line represents incipient modern topography. Red polygons represent plutons emplaced during the time denoted at the top of each cross section. Gray polygons are plutons that have been emplaced prior to denoted time represented by each cross section.

complicated and protracted. The TLB was incrementally emplaced between 63 and 57 Ma at 8.4 ± 3 km (3 ± 1 kbar). If the paleodepth at 70 Ma was similar to the Whitehorn stock, the Twin Lakes area likely experienced only moderate exhumation between 70 and 57 Ma. The exhumation during the next 16 Ma is unclear, but it is important to note that the exhumation during this time may very well have been variable as the Farallon slab slowed its eastward progression, became unstable, and began to founder. At 34 Ma, the Grizzly Caldera formed, and megabreccias contact the TLB in two places (Fridrich et al., 1998; Figure 1.3). Fridrich et al. (1991) report that caldera-related surface deposits (tuffs and megabreccias) are 4 km thick, and even if several kilometers of surface deposits have been removed over time, this puts the depth of the Twin Lakes area no deeper than 6 km by 34 Ma. After 34 Ma, the exhumation is very complicated in space and time, as indicated by variable AFT and AHe ages from throughout the batholith. Broadly, the cooling was pulsed with periods of isotherm relaxation at ca. 34 – 32 Ma, and exhumation at 24 – 22 Ma, and 13 – 0 Ma. Periods of accelerated exhumation are apparently separated by intervals of stability.

4.3 Implications for the Laramide Orogeny and post-Laramide uplift

The emplacement and exhumation histories of the TLB provide insight into the mechanisms of the Laramide Orogeny and may have implications for the nature of the Aspen Anomaly as well. Magmatism was concentrated into two relatively long-lived periods separated by a hiatus between 57 and 43 Ma. These periods are suggestive of, but not required by, a magmatic gap due to the Farallon plate slowing to a stop and eventually foundering (Lipman et al., 1971; Armstrong, 1974). The 57 – 43 Ma magmatic gap at Twin Lakes could be representative of the CMB in general. A query of the NAVDAT geochemical database yields no $^{40}\text{Ar}/^{39}\text{Ar}$, K-Ar, fission track, or U/Pb ages between 40

and 60 Ma in Colorado, and other plutons in the region near the study area are older and younger than the 57 – 43 Ma gap (i.e. the 70 Ma Whitehorn stock (Workman, 1997), and the 35 – 36 Ma Mount Princeton Batholith (Zimmerer et al., in prep.), further supporting the hypothesis that the magmatic gap at Twin Lakes is representative of the CMB. This observation implies magmatism along the CMB is not simply recording the position of the leading edge of the Farallon slab. Humphreys et al. (2003) suggest that long-lived magmatic activity and uplift of the Rocky Mountains during the Laramide cannot be accounted for by invoking only a compressional regime, and they propose de-watering of the Farallon slab during flat-subduction to de-densify the North American plate and prime the lithosphere for Laramide-age magmatism. Lithospheric hydration necessarily takes place over a broad geographic region, and the surface manifestation would not be confined to a thin (20 km long) band indicative of the edge of the slab; rather, magmatism would develop several million years after the leading edge of the slab moved east of the area in question as water slowly accumulated in the North American lithosphere. Magmatism triggered by this hydration lasted only as long as the lithosphere was hydrated enough for melting to occur at such low temperatures, and this seems to account for the magmatic gap. The magmatism during this time was geographically focused by pre-existing shear zones that coincide with the CMB.

Another important aspect of the magmatic record along the CMB is the timing of oldest magmatism. In Colorado, plutons that are widely separated record similar ages. In southwestern Colorado, the La Plata area has ~70 Ma K-Ar ages (Mutchler, 1987), in central Colorado the Whitehorn stock is 70 Ma and new $^{40}\text{Ar}/^{39}\text{Ar}$ data (Heizler, 2009) reveal that the Albion stock west of Boulder, CO is at least 68 Ma. Thus along the entire CMB, magmatism was occurring at ~70 Ma, thereby negating a simple eastward propagation of magmas derived from an advancing tip of the Farallon slab.

Eventually the Farallon slab became unstable, and was removed from the base of

the North American plate. The upper plate was still hydrous compared to typical lithosphere, but not enough for melting without a catalyst or trigger. As the slab was removed, the warm asthenosphere moved in and raised the temperature at the base of the lithosphere, triggering voluminous melting until enough of the hydrous phases were gone and melting stopped. This melting occurred more quickly and was more voluminous than Laramide-related melting, and is expected to have migrated spatially and temporally in the direction of progressing removal. Several workers have suggested magma migration during the ignimbrite flare-up (Coney and Reynolds, 1977; Humphreys, 1995, C. Henry, personal comm., 2010). The geometry of Farallon plate removal will become more clear as more data are collected, but for now the TLB supports slab removal between 43 and 32 Ma in the area under central Colorado.

The Twin Lakes area was exhumed to the surface from ~70 Ma to the present in pulses that are variable in time and space (Figure 4.10). The first pulse of exhumation between about 70 and 37 Ma is well recorded in the Buena Vista area, where ~8 km of section was removed. The Twin Lakes region also experienced a portion of this exhumation history, but thermochronology data do not allow complete exhumation until well into the late Miocene. This 70 – 40 Ma exhumation may be attributed to the eastward progression of the Farallon slab that hydrated and de-densified the North American plate (Humphreys et al., 2003). This hydration at the base of the lithosphere provided buoyancy and caused surface uplift and ultimately denudation. Coupling of the Farallon slab to the North American slab also transmitted stress ~1000 km inboard of the trench, causing characteristic Laramide-age thrusting in Colorado (Bird, 1988). Compression resulted in the inversion of the basins (Bird, 1988), and is an additional mechanism to explain the stripping of pre-Cenozoic strata between ~70 and 40 Ma.

A second period of cooling in the Twin Lakes region occurred between ~34 – 12 Ma, and records both exhumation and relaxation of elevated isotherms caused by

Eocene magmatism. Fission-track length distributions and their associated thermal models demonstrate complex and pulsed cooling during this interval (Figure 4.9). Two samples have AFT ages between 34 and 30 Ma and show that at least part of the TLB resided at a shallow paleodepth (3 – 5 km, depending upon the geothermal gradient). Other AFT results record a 24 – 22 Ma pulse of cooling, and still others document a pulse between 14 and 12 Ma. In the upper Arkansas River valley, the Dry Union Formation, a rift fill sediment, contains volcanic material as young as 22 Ma (Chapin and Cather, 1994). Rift extension was likely the primary mechanism for pulsed denudation between ~25 and 12 Ma.

The AHe data record the final pulse of exhumation that partially overlaps with the AFT data, but also extends the history to at least the latest Miocene. Although complicated in detail, some rocks in the Twin Lakes region cooled below ~70°C by 18 Ma, whereas others did not until ~8 Ma. This middle Miocene complexity appears to further demonstrate that RGR extension played a key role in the area during this time. The 7 Ma AHe ages indicate that since this time, <2 km of stripping has occurred. This final stage of denudation may record the influence of the Aspen Anomaly. Regionally, surface uplift and associated river downcutting (e.g. Colorado River knickpoints and formation of the Grand Canyon) started at ~6 Ma and is tied to the Aspen Anomaly (Karlstrom, in prep.). Regional basaltic magmatism with mantle-signature Nd isotopes began at ~10 Ma and continues through the present (Karlstrom, in prep.). This activity may indicate that the Aspen Anomaly as a fairly young feature. Unpublished modeling by the CREST working group shows that upwelling asthenosphere following partial delamination of the upper mantle (mantle drip) could drive regional surface uplift that is partially recorded by the young AHe data at Twin Lakes.

CONCLUSION

Geo and thermochronological studies of the Twin Lakes batholith and nearby country rock provide significant insight into the Cenozoic evolution of central Colorado. The TLB was constructed by a minimum of seven pluton emplacement events between 63 – 57 and 43 – 32 Ma. The early period of activity resulted from Farallon slab-driven hydration and subsequent melting of the lithosphere during the Laramide Orogeny. The younger period records slab foundering that allowed asthenosphere to trigger melting at the base of the lithosphere. The magmatic gap between 57 and 43 Ma at Twin Lakes appears representative of magmatic quiescence along the entire CMB. New geochronology, coupled with existing data, indicate that ~70 Ma magmatism occurred simultaneously along the length of the CMB. These two observations indicate that magmatism along the CMB is not related to simple propagation of a magmatic point source derived from the leading edge of the Farallon slab.

Exhumation at Twin Lakes was pulsed in time and variable in space. In the Buena Vista, CO area, ~8 km of rock removal and inversion of the central Colorado Trough occurred between ~70 and 37 Ma. This exhumation was caused by Laramide compression and lithospheric hydration-driven buoyancy as the Farallon slab was migrating eastwards under the North American plate. At Twin Lakes, at least 5 km was denuded between ~75 and 34 Ma, but the present surface wasn't exposed until at least after 7 Ma. Low temperature thermochronology reveals a complicated pattern of cooling with multiple blocks of the TLB moving differentially. Between 34 and 12 Ma, pulsed cooling occurred at ~34, 24 – 22, and 12 Ma, and is likely related to relaxation of elevated isotherms and RGR

extension. The post-12 Ma cooling probably records combined effects of RGR extension and Aspen Anomaly thermal buoyancy uplift. The ~2 km of exhumation that occurred since 7 Ma at Twin Lakes, coupled with the present high average surface elevation, may indicate that the Aspen Anomaly is a relatively young (ca. 10 Ma) feature that formed by asthenospheric upwelling to near the base of the lithosphere.

APPENDIX A

MINERAL SEPARATION

A.1 Methods

Similar techniques were used to separate minerals for each of the dating methods. First, thin section billets were cut from whole rocks and made into uncovered polished thin sections for petrography and microprobe work for 12 samples. Samples were crushed and pulverized in a jaw crusher and disk mill, respectively. The samples were then sieved to concentrate pieces larger than 600 μm . The >600 μm fraction was passed over a Wilfley table to concentrate apatite and zircon. The samples were washed in deionized water in an ultrasonic cleaner, and both fractions (the apatite/zircon concentrate and the rest) were sieved to appropriate sizes (between 60 and 600 μm depending on what mineral was being separated) and were magnetically separated with a frantz. Heavy liquids were used to further separate by density, and then apatite, zircon, biotite, hornblende, and K-feldspar separates were hand picked.

APPENDIX B

U/PB

B.1 Methods

U/Pb geochronology of zircons was conducted by laser ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICPMS) at the Arizona Laser-Chron Center on two separate trips. 60 zircons are placed in 6x10 grids surrounding Sri-Lankan zircon standards (564 ± 4 Ma), and are ablated with a New Wave/Lambda Physik DUV193 Excimer laser (operating at a wavelength of 193 nm) using a spot diameter of 25 - 35 μm . The ablated material is carried with helium gas into the plasma source of a GV Instruments Isoprobe, which is equipped with a flight tube of sufficient width that U, Th, and Pb isotopes are measured simultaneously. All measurements are made in static mode, using Faraday detectors for ^{238}U and ^{232}Th , an ion-counting channel for ^{204}Pb , and either faraday collectors or ion counting channels for $^{208-206}\text{Pb}$. Ion yields are 1 mv per ppm. Each analysis consists of one 12-second integration on peaks with the laser off (for backgrounds), 12 one-second integrations with the laser firing, and a 30 second delay to purge the previous sample and prepare for the next analysis. The ablation pit is 12 microns in depth.

For each analysis, the errors in determining $^{206}\text{Pb}/^{238}\text{U}$ and $^{206}\text{Pb}/^{204}\text{Pb}$ result in a measurement error of $\sim 1\%$ (at 2-sigma level) in the $^{206}\text{Pb}/^{238}\text{U}$ age. The errors in measurement of $^{206}\text{Pb}/^{207}\text{Pb}$ and $^{206}\text{Pb}/^{204}\text{Pb}$ also result in $\sim 1\%$ (2-sigma) uncertainty in age for grains that are > 1.0 Ga, but are substantially larger for younger grains due to low intensity of the ^{207}Pb signal. For most analyses, the cross-over in precision of $^{206}\text{Pb}/^{238}\text{U}$

and $^{206}\text{Pb}/^{207}\text{Pb}$ ages occurs at ~ 1.0 Ga.

Common Pb correction is accomplished by using the measured ^{204}Pb and assuming an initial Pb composition from Stacey and Kramers (1975) (with uncertainties of 1.0 for $^{206}\text{Pb}/^{204}\text{Pb}$ and 0.3 for $^{207}\text{Pb}/^{204}\text{Pb}$). Our measurement of ^{204}Pb is unaffected by the presence of ^{204}Hg because backgrounds are measured on peaks (thereby subtracting any background ^{204}Hg and ^{204}Pb), and because very little Hg is present in the argon gas.

Inter-element fractionation of Pb/U is generally $\sim 20\%$, whereas apparent fractionation of Pb isotopes is generally $< 2\%$. In-run analysis of fragments of a large zircon crystal (generally every fifth measurement) with known age of 564 ± 4 Ma (2-sigma error) is used to correct for this fractionation. The uncertainty resulting from the calibration correction is generally $\sim 1\%$ (2-sigma) for both $^{206}\text{Pb}/^{207}\text{Pb}$ and $^{206}\text{Pb}/^{238}\text{U}$ ages.

Typically 35 ± 10 zircons were analyzed from each rock sample. Anomalously old ages result from ablation of inherited zircon cores and are omitted from age calculations. The reported ages are calculated from the weighted mean of single grain ages using the method of Ludwig (2003). Two uncertainties (at 2-sigma) are reported for the zircon ages. Internal errors that include analytical errors such as measurement of isotopes can be used when comparing data within the U/Pb system. External errors include contributions from the uranium decay constants, age of the calibration standard, standard calibration, and the composition of common lead, and is typically $\sim 3 - 4\%$ at 2-sigma.

Table B.1: U/Pb in Zircon analytical data

Analysis	U (ppm)	206Pb 204Pb	U/Th	206Pb 207Pb	± (%)	207Pb 235U	Isotope ratios				206Pb 238U	± (Ma)	Apparent ages (Ma)				Best age (Ma)	± (Ma)	Conc (%)	
							206Pb (%)	error corr.	207Pb 235U	± (Ma)			207Pb 235U	± (Ma)	206Pb 207Pb	± (Ma)				
F08-HU-007																				
F08-HU-007-28	827	3427	0.7	18.9291	22.3	0.0456	22.6	0.0063	3.5	0.15	40.2	1.4	45.3	10.0	321.5	512.5	40.2	±	1.4	12.5
F08-HU-007-34	1029	7517	1.2	22.1209	12.2	0.0404	12.3	0.0065	1.5	0.12	41.7	0.6	40.2	4.8	-44.5	297.4	41.7	±	0.6	-93.6
F08-HU-007-23	563	5684	4.0	22.9400	16.8	0.0392	16.9	0.0065	2.4	0.14	41.9	1.0	39.0	6.5	-133.7	417.0	41.9	±	1.0	-31.3
F08-HU-007-9	456	5076	3.6	22.5136	28.6	0.0401	28.6	0.0065	2.1	0.07	42.1	0.9	39.9	11.2	-87.5	712.5	42.1	±	0.9	-48.1
F08-HU-007-11	862	16549	2.7	24.8776	30.9	0.0364	30.9	0.0066	1.8	0.06	42.2	0.8	36.3	11.0	-338.3	811.7	42.2	±	0.8	-12.5
F08-HU-007-24	660	11884	1.8	21.6166	26.2	0.0420	26.4	0.0066	3.1	0.12	42.3	1.3	41.8	10.8	11.2	640.1	42.3	±	1.3	376.1
F08-HU-007-29	726	10505	2.9	21.5650	27.2	0.0421	27.4	0.0066	3.1	0.11	42.3	1.3	41.9	11.2	17.0	664.9	42.3	±	1.3	249.7
F08-HU-007-19	479	4810	1.6	18.9212	17.2	0.0480	18.2	0.0066	5.9	0.33	42.4	2.5	47.6	8.5	322.4	393.6	42.4	±	2.5	13.1
F08-HU-007-25	517	6923	4.0	21.0484	21.0	0.0434	21.2	0.0066	2.5	0.12	42.5	1.0	43.1	8.9	74.9	504.9	42.5	±	1.0	56.8
F08-HU-007-4	501	15149	4.3	22.4131	42.0	0.0408	42.1	0.0066	2.7	0.06	42.6	1.1	40.6	16.8	-76.5	1069.2	42.6	±	1.1	-55.7
F08-HU-007-16	751	13720	2.3	22.1557	22.8	0.0413	23.0	0.0066	2.6	0.11	42.6	1.1	41.1	9.2	-48.3	561.1	42.6	±	1.1	-88.2
F08-HU-007-31	553	15343	3.3	26.3132	22.0	0.0348	22.2	0.0066	2.9	0.13	42.7	1.2	34.8	7.6	-484.9	590.5	42.7	±	1.2	-8.8
F08-HU-007-5	551	4471	4.3	19.1988	14.2	0.0478	14.5	0.0067	3.0	0.21	42.8	1.3	47.4	6.7	289.2	325.4	42.8	±	1.3	14.8
F08-HU-007-22	413	4100	3.7	20.6298	42.7	0.0446	42.7	0.0067	0.7	0.02	42.8	0.3	44.3	18.5	122.4	1048.4	42.8	±	0.3	35.0
F08-HU-007-3	584	8046	3.4	19.6603	15.4	0.0468	15.7	0.0067	3.0	0.19	42.9	1.3	46.4	7.1	234.7	357.3	42.9	±	1.3	18.3
F08-HU-007-18	647	9313	2.8	21.3950	17.9	0.0430	18.2	0.0067	3.5	0.19	42.9	1.5	42.8	7.6	35.9	431.3	42.9	±	1.5	119.4
F08-HU-007-8	889	11218	2.9	20.8849	9.0	0.0442	9.0	0.0067	0.8	0.08	43.0	0.3	43.9	3.9	93.4	213.7	43.0	±	0.3	46.1
F08-HU-007-27	813	15505	2.6	20.9285	15.8	0.0441	16.0	0.0067	2.1	0.13	43.1	0.9	43.9	6.9	88.5	377.5	43.1	±	0.9	48.6
F08-HU-007-35	559	16758	3.1	19.1551	29.1	0.0482	29.1	0.0067	2.1	0.07	43.1	0.9	47.8	13.6	294.4	676.1	43.1	±	0.9	14.6
F08-HU-007-32	549	9673	3.3	18.2589	18.4	0.0506	18.4	0.0067	0.7	0.04	43.1	0.3	50.1	9.0	402.7	415.6	43.1	±	0.3	10.7
F08-HU-007-10	483	5832	3.2	22.4241	18.7	0.0415	18.8	0.0067	1.4	0.08	43.3	0.6	41.3	7.6	-77.7	461.7	43.3	±	0.6	-55.7
F08-HU-007-14	754	3442	0.6	18.6859	25.4	0.0499	25.4	0.0068	1.6	0.06	43.4	0.7	49.4	12.3	350.7	582.1	43.4	±	0.7	12.4
F08-HU-007-33	249	3445	1.1	27.2437	66.6	0.0343	66.7	0.0068	2.5	0.04	43.5	1.1	34.2	22.4	-578.1	2015.3	43.5	±	1.1	-7.5
F08-HU-007-15	527	9356	4.0	20.4144	21.2	0.0458	21.3	0.0068	1.2	0.06	43.6	0.5	45.5	9.5	147.1	502.7	43.6	±	0.5	29.6
F08-HU-007-30	376	4028	4.1	17.7086	28.7	0.0531	29.3	0.0068	5.6	0.19	43.8	2.4	52.6	15.0	470.9	647.8	43.8	±	2.4	9.3
F08-HU-007-12	619	13892	3.1	23.7909	30.3	0.0396	30.3	0.0068	1.4	0.04	43.9	0.6	39.5	11.7	-224.5	776.9	43.9	±	0.6	-19.6
F08-HU-007-2	633	7967	3.3	24.0858	25.8	0.0393	25.8	0.0069	1.1	0.04	44.1	0.5	39.1	9.9	-255.7	662.4	44.1	±	0.5	-17.3
F08-HU-007-7	1282	2369	4.7	13.4388	29.4	0.0707	29.5	0.0069	1.8	0.06	44.2	0.8	69.3	19.8	1052.7	605.9	44.2	±	0.8	4.2
F08-HU-007-21	752	10109	2.8	20.6234	17.0	0.0461	17.0	0.0069	1.1	0.06	44.3	0.5	45.7	7.6	123.2	402.7	44.3	±	0.5	36.0
F08-HU-007-26	665	7697	2.7	23.2702	13.7	0.0409	13.8	0.0069	1.3	0.09	44.3	0.6	40.7	5.5	-169.1	342.5	44.3	±	0.6	-26.2
F08-HU-007-1	328	3938	2.0	28.4493	42.9	0.0337	43.0	0.0070	2.9	0.07	44.7	1.3	33.7	14.2	-696.7	1236.9	44.7	±	1.3	-6.4
F08-HU-007-13	413	9173	3.9	21.9655	22.8	0.0437	22.9	0.0070	2.0	0.09	44.7	0.9	43.4	9.7	-27.4	557.8	44.7	±	0.9	-163.3
F08-HU-007-20	944	25952	2.9	20.8796	17.5	0.0473	17.5	0.0072	1.1	0.06	46.0	0.5	47.0	8.0	94.0	416.2	46.0	±	0.5	49.0
F08-HU-007-17	285	8669	2.7	22.7786	36.6	0.0447	36.7	0.0074	3.8	0.10	47.4	1.8	44.4	16.0	-116.2	927.8	47.4	±	1.8	-40.8
F08-HU-007-6	428	96912	3.6	9.8166	0.8	3.9084	2.3	0.2783	2.1	0.93	1582.6	29.5	1615.4	18.2	1658.4	15.0	1658.4	±	15.0	95.4
F08-HU-009																				
F08-HU-009-28	814	15877	3.1	20.1094	19.5	0.0417	19.7	0.0061	3.0	0.15	39.1	1.2	41.5	8.0	182.3	457.8	39.1	±	1.2	21.4
F08-HU-009-25	568	5413	2.9	21.6616	25.6	0.0388	25.7	0.0061	2.6	0.10	39.2	1.0	38.7	9.8	6.2	625.6	39.2	±	1.0	632.3
F08-HU-009-14	505	5733	2.2	18.5101	22.1	0.0457	22.2	0.0061	2.4	0.11	39.5	1.0	45.4	9.9	372.0	503.2	39.5	±	1.0	10.6
F08-HU-009-20	669	7909	2.8	24.4808	51.2	0.0348	51.3	0.0062	2.2	0.04	39.7	0.9	34.7	17.5	-297.0	1390.2	39.7	±	0.9	-13.4
F08-HU-009-15	631	9325	2.8	19.8791	20.0	0.0430	20.3	0.0062	3.4	0.17	39.9	1.4	42.8	8.5	209.1	468.6	39.9	±	1.4	19.1
F08-HU-009-26	682	7753	3.8	22.5100	17.8	0.0380	17.9	0.0062	2.0	0.11	39.9	0.8	37.9	6.7	-87.1	439.4	39.9	±	0.8	-45.8
F08-HU-009-16	845	11279	2.3	24.1646	28.0	0.0355	28.0	0.0062	1.3	0.04	40.0	0.5	35.4	9.7	-263.9	721.8	40.0	±	0.5	-15.1
F08-HU-009-13	811	9887	3.0	21.9305	12.9	0.0392	13.0	0.0062	1.9	0.15	40.0	0.8	39.0	5.0	-23.5	312.6	40.0	±	0.8	-170.0
F08-HU-009-10	342	3506	3.7	21.0491	38.9	0.0409	38.9	0.0062	1.3	0.03	40.1	0.5	40.7	15.5	74.8	957.2	40.1	±	0.5	53.6
F08-HU-009-27	438	4040	3.3	24.5665	29.7	0.0352	29.8	0.0063	2.8	0.09	40.3	1.1	35.1	10.3	-306.0	773.3	40.3	±	1.1	-13.2
F08-HU-009-1	1215	5179	2.3	20.1191	9.2	0.0430	9.2	0.0063	0.9	0.10	40.4	0.4	42.8	3.9	181.2	214.9	40.4	±	0.4	22.3
F08-HU-009-17	869	7153	3.6	22.3237	13.6	0.0388	13.9	0.0063	3.0	0.21	40.4	1.2	38.7	5.3	-66.7	333.9	40.4	±	1.2	-60.6
F08-HU-009-4	1136	15140	1.5	25.0103	17.7	0.0347	17.8	0.0063	1.2	0.07	40.4	0.5	34.6	6.0	-352.0	460.8	40.4	±	0.5	-11.5
F08-HU-009-21	778	13069	2.6	24.5670	16.4	0.0354	16.6	0.0063	2.4	0.14	40.5	1.0	35.3	5.7	-306.0	421.5	40.5	±	1.0	-13.2
F08-HU-009-30	869	7761	3.3	20.8456	14.8	0.0417	14.8	0.0063	0.9	0.06	40.5	0.4	41.5	6.0	97.9	352.1	40.5	±	0.4	41.4
F08-HU-009-2	1336	10265	2.5	21.2745	13.1	0.0409	13.1	0.0063	1.0	0.08	40.6	0.4	40.7	5.2	49.5	313.5	40.6	±	0.4	82.0
F08-HU-009-8	1025	8350	1.2	21.4842	16.3	0.0406	16.3	0.0063	0.9	0.05	40.6	0.4	40.4	6.5	26.0	393.5	40.6	±	0.4	156.2
F08-HU-009-12	694	8046	3.4	23.9209	28.0	0.0368	28.0	0.0064	1.2	0.04	41.1	0.5	36.7	10.1	-238.3	718.7	41.1	±	0.5	-17.2
F08-HU-009-19	741	10366	2.5	19.3601	9.6	0.0456	9.9	0.0064	2.0	0.20	41.1	0.8	45.2	4.4	270.0	221.7	41.1	±	0.8	15.2
F08-HU-009-5	1292	11298	3.3	20.6277	5.7	0.0429	6.2	0.0064	2.3	0.37	41.2	0.9	42.6							

Analysis	U (ppm)	206Pb 204Pb	U/Th	Isotope ratios							Apparent ages (Ma)							Best age (Ma)	± (Ma)	Conc (%)
				206Pb 207Pb	± (%)	207Pb 235U	± (%)	206Pb 238U	± (%)	error corr.	206Pb 238U	± (Ma)	207Pb 235U	± (Ma)	206Pb 207Pb	± (Ma)				
F08-LP-001																				
F08-LP-001-18	400	19548	5.9	12.9326	22.5	-0.1610	22.5	-0.0151	0.5	0.02	-98.1	-0.5	-178.2	-43.9	1129.6	453.8	-98.1	±	-0.5	-8.7
F08-LP-001-55	1322	3378	3.9	21.8401	3.6	0.0577	5.3	0.0091	3.9	0.73	58.7	2.3	57.0	2.9	-13.5	87.4	58.7	±	2.3	-433.3
F08-LP-001-57	273	844	2.2	27.0512	23.5	0.0472	23.7	0.0093	2.6	0.11	59.5	1.5	46.9	10.8	-558.9	640.9	59.5	±	1.5	-10.6
F08-LP-001-51	501	1144	4.8	22.6161	8.0	0.0566	8.0	0.0093	0.5	0.06	59.6	0.3	55.9	4.3	-98.6	196.0	59.6	±	0.3	-60.4
F08-LP-001-7	228	599	3.6	30.6120	33.6	0.0419	33.6	0.0093	1.2	0.03	59.7	0.7	41.7	13.7	-904.6	996.8	59.7	±	0.7	-6.6
F08-LP-001-30	421	1256	3.7	22.7685	8.0	0.0564	8.0	0.0093	0.9	0.11	59.8	0.5	55.7	4.4	-115.1	197.1	59.8	±	0.5	-51.9
F08-LP-001-17	1110	2917	9.3	22.0673	4.1	0.0583	4.4	0.0093	1.6	0.36	59.9	1.0	57.5	2.5	-38.6	99.1	59.9	±	1.0	-155.1
F08-LP-001-12	1251	1686	8.3	21.8881	4.9	0.0589	4.9	0.0093	0.5	0.10	59.9	0.3	58.1	2.8	-18.8	117.6	59.9	±	0.3	-318.0
F08-LP-001-33	1109	3916	10.9	21.7086	4.1	0.0596	4.3	0.0094	1.3	0.31	60.2	0.8	58.7	2.5	1.0	99.0	60.2	±	0.8	5922.5
F08-LP-001-36	675	1693	3.6	22.2243	5.5	0.0583	6.0	0.0094	2.3	0.38	60.2	1.4	57.5	3.3	-55.9	133.9	60.2	±	1.4	-107.9
F08-LP-001-39	315	1021	11.8	24.8430	16.5	0.0523	16.9	0.0094	3.5	0.21	60.4	2.1	51.7	8.5	-334.7	427.2	60.4	±	2.1	-18.0
F08-LP-001-4	286	720	3.8	27.4069	24.0	0.0474	24.1	0.0094	2.3	0.09	60.5	1.4	47.0	11.1	-594.3	659.4	60.5	±	1.4	-10.2
F08-LP-001-40	483	1277	2.9	23.2000	9.9	0.0560	10.1	0.0094	1.9	0.19	60.5	1.2	55.3	5.4	-161.6	246.6	60.5	±	1.2	-37.4
F08-LP-001-6	751	1941	7.2	22.3905	6.1	0.0581	6.3	0.0094	1.7	0.27	60.5	1.0	57.4	3.5	-74.0	149.1	60.5	±	1.0	-81.8
F08-LP-001-43	454	1233	4.8	23.6585	10.8	0.0552	10.9	0.0095	1.5	0.13	60.8	0.9	54.5	5.8	-210.5	272.3	60.8	±	0.9	-28.9
F08-LP-001-20	510	1081	2.9	23.5864	12.9	0.0555	13.0	0.0095	1.7	0.13	60.9	1.0	54.8	6.9	-202.9	323.3	60.9	±	1.0	-30.0
F08-LP-001-46	440	1115	2.9	22.5589	7.3	0.0580	7.4	0.0095	1.5	0.20	60.9	0.9	57.3	4.1	-92.4	178.5	60.9	±	0.9	-65.9
F08-LP-001-22	635	2140	9.1	23.1337	9.0	0.0569	9.1	0.0095	1.5	0.16	61.3	0.9	56.2	5.0	-154.5	223.7	61.3	±	0.9	-39.7
F08-LP-001-38	528	1828	5.4	22.2502	7.1	0.0593	7.3	0.0096	1.5	0.21	61.4	0.9	58.5	4.1	-58.7	173.2	61.4	±	0.9	-104.6
F08-LP-001-19	670	1987	8.7	22.3147	5.4	0.0593	5.4	0.0096	0.6	0.11	61.5	0.4	58.5	3.1	-65.8	131.3	61.5	±	0.4	-93.6
F08-LP-001-45	675	2116	10.5	22.2411	5.8	0.0595	5.8	0.0096	0.8	0.14	61.6	0.5	58.7	3.3	-57.7	140.8	61.6	±	0.5	-106.7
F08-LP-001-49	1258	4075	8.0	21.7335	3.5	0.0614	3.7	0.0097	1.4	0.38	62.1	0.9	60.5	2.2	-1.7	83.2	62.1	±	0.9	-3569.0
F08-LP-001-35	567	1448	3.3	22.1460	5.6	0.0604	5.6	0.0097	0.6	0.11	62.3	0.4	59.6	3.2	-47.3	135.1	62.3	±	0.4	-131.7
F08-LP-001-52	826	2915	9.5	22.1372	6.0	0.0605	6.1	0.0097	0.6	0.09	62.3	0.4	59.6	3.5	-46.3	147.1	62.3	±	0.4	-134.5
F08-LP-001-47	351	1448	12.4	23.7461	13.1	0.0565	13.3	0.0097	2.4	0.18	62.4	1.5	55.8	7.2	-219.8	331.3	62.4	±	1.5	-28.4
F08-LP-001-23	752	1201	7.4	22.9828	9.8	0.0584	10.2	0.0097	2.6	0.26	62.4	1.6	57.6	5.7	-138.3	243.7	62.4	±	1.6	-45.1
F08-LP-001-8	403	1406	75.6	22.9656	8.2	0.0588	8.2	0.0098	0.7	0.08	62.8	0.4	58.0	4.6	-136.4	202.1	62.8	±	0.4	-46.0
F08-LP-001-48	961	3121	8.6	21.6862	3.3	0.0623	3.4	0.0098	0.6	0.19	62.9	0.4	61.4	2.0	3.5	79.7	62.9	±	0.4	1803.4
F08-LP-001-32	534	1820	5.5	22.5001	6.1	0.0601	6.3	0.0098	1.4	0.22	62.9	0.9	59.2	3.6	-86.0	150.3	62.9	±	0.9	-73.1
F08-LP-001-26	511	1513	5.3	22.1257	5.7	0.0612	7.2	0.0098	4.5	0.62	63.0	2.8	60.3	4.2	-45.0	137.7	63.0	±	2.8	-140.0
F08-LP-001-3	693	1854	3.1	22.4035	5.9	0.0610	6.8	0.0099	3.3	0.49	63.5	2.1	60.1	4.0	-75.5	145.6	63.5	±	2.1	-84.2
F08-LP-001-29	357	1128	2.7	23.5294	12.4	0.0583	12.4	0.0099	0.7	0.06	63.8	0.5	57.5	6.9	-196.8	310.5	63.8	±	0.5	-32.4
F08-LP-001-2	954	4506	6.3	14.6202	2.2	0.1329	7.6	0.0141	7.3	0.96	90.2	6.5	126.7	9.1	880.6	45.8	90.2	±	6.5	10.2
F08-LP-001-56	903	5492	8.6	13.9997	4.7	0.1618	5.0	0.0164	1.8	0.35	105.0	1.8	152.3	7.1	969.8	95.4	105.0	±	1.8	10.8
F08-LP-001-16	309	4292	4.4	12.6992	2.5	0.3307	8.5	0.0305	8.1	0.96	193.4	15.5	290.1	21.4	1165.7	49.5	193.4	±	15.5	16.6
F08-LP-001-21	805	14749	8.2	12.2141	1.9	0.4780	2.4	0.0423	1.5	0.63	267.4	4.0	396.7	7.9	1242.5	36.4	267.4	±	4.0	21.5
F08-LP-001-53	322	8305	5.3	11.7746	2.1	0.6652	2.8	0.0568	1.9	0.67	356.2	6.6	517.8	11.6	1313.9	41.2	356.2	±	6.6	27.1
F08-LP-001-37	946	28702	13.6	11.1666	1.7	0.9904	5.8	0.0802	5.5	0.96	497.4	26.5	698.9	29.2	1416.0	32.6	497.4	±	26.5	35.1
F08-LP-001-41	208	13663	2.9	11.6210	2.9	1.8635	8.9	0.1571	8.5	0.95	940.4	73.9	1068.2	59.1	1339.3	56.2	1339.3	±	56.2	70.2
F08-LP-001-11	837	47170	25.1	10.9234	1.2	2.8966	1.6	0.2295	1.1	0.66	1331.8	12.8	1381.0	12.1	1458.0	23.0	1458.0	±	23.0	91.3
F08-LP-001-5	949	32134	11.5	10.6347	1.0	1.1188	3.2	0.0863	3.1	0.95	533.6	15.7	762.4	17.4	1508.7	19.7	1508.7	±	19.7	35.4
F08-LP-001-1	1302	60047	7.9	10.1722	1.2	3.2920	1.3	0.2429	0.6	0.44	1401.6	7.1	1479.2	10.0	1592.2	21.5	1592.2	±	21.5	88.0
F08-LP-001-60	258	16897	8.4	10.1350	1.9	2.8306	4.4	0.2081	4.0	0.91	1218.5	44.6	1363.7	33.3	1599.1	34.9	1599.1	±	34.9	76.2
F08-LP-001-42	496	55028	10.2	9.7530	2.8	4.2602	3.0	0.3013	1.0	0.34	1698.0	15.1	1685.7	24.6	1670.5	52.0	1670.5	±	52.0	101.6
F08-LP-001-28	199	15821	2.2	9.7212	0.9	4.1376	2.0	0.2917	1.8	0.90	1650.1	26.5	1661.8	16.5	1676.5	16.1	1676.5	±	16.1	98.4
F08-LP-001-54	922	29481	10.4	9.4878	1.6	3.7662	2.2	0.2592	1.5	0.67	1485.6	19.5	1585.6	17.5	1721.3	29.6	1721.3	±	29.6	86.3
F08-LP-001-9	426	24405	2.3	9.3637	1.4	3.9431	1.6	0.2678	0.8	0.47	1529.6	10.2	1622.6	12.8	1745.4	25.5	1745.4	±	25.5	87.6
F08-LP-001-10	1317	48015	3.7	9.3455	1.4	4.1127	2.0	0.2788	1.4	0.69	1585.1	19.0	1656.8	16.1	1749.0	26.2	1749.0	±	26.2	90.6
F08-LP-001-58	184	11987	2.7	9.3349	1.8	4.1405	2.2	0.2803	1.3	0.58	1593.0	17.6	1662.3	17.7	1751.1	32.3	1751.1	±	32.3	91.0
F08-LP-001-24	683	35042	14.2	9.3334	1.4	3.8090	3.2	0.2578	2.9	0.90	1478.8	38.6	1594.6	26.1	1751.3	26.0	1751.3	±	26.0	84.4
F08-LP-002A																				
F08-LP-002A-25	2755	66858	4.2	19.1773	6.3	0.0522	10.2	0.0073	8.0	0.78	46.7	3.7	51.7	5.1	291.8	144.8	46.7	±	3.7	16.0
F08-LP-002A-8	4141	4605	2.0	16.9266	12.8	0.0695	15.0	0.0085	7.9	0.52	54.8	4.3	68.3	9.9	570.0	279.9	54.8	±	4.3	9.6
F08-LP-002A-10	395	5392	4.6	18.9390	12.9	0.0652	13.2	0.0090	2.4	0.18	57.5	1.4								

Analysis	U (ppm)	206Pb 204Pb	U/Th	206Pb 207Pb	± (%)	Isotope ratios					Apparent ages (Ma)					Best age (Ma)	± (Ma)	Conc (%)	
						207Pb 235U	± (%)	206Pb 238U	± (%)	error corr.	206Pb 238U	± (Ma)	207Pb 235U	± (Ma)	206Pb 207Pb				± (Ma)
F08-LP-002B																			
F08-LP-002B-9	1197	7623	4.8	21.3828	2.3	0.0556	3.0	0.0086	1.9	0.63	55.3	1.0	54.9	1.6	37.3	55.4	55.3	± 1.0	148.4
F08-LP-002B-5	1104	9842	10.1	21.4443	3.7	0.0555	4.3	0.0086	2.1	0.49	55.4	1.1	54.8	2.3	30.4	89.5	55.4	± 1.1	181.9
F08-LP-002B-12	1121	9314	8.8	21.0683	9.9	0.0569	10.2	0.0087	2.8	0.27	55.8	1.5	56.1	5.6	72.7	234.7	55.8	± 1.5	76.7
F08-LP-002B-10	889	8985	8.5	21.3627	10.0	0.0562	10.1	0.0087	1.2	0.12	55.9	0.7	55.5	5.4	39.6	239.4	55.9	± 0.7	141.2
F08-LP-002B-3	722	5318	6.7	21.1970	6.7	0.0581	7.1	0.0089	2.3	0.33	57.3	1.3	57.3	3.9	58.1	159.7	57.3	± 1.3	98.5
F08-LP-002B-7	892	6338	6.4	21.0327	3.9	0.0593	4.7	0.0090	2.7	0.56	58.1	1.5	58.5	2.7	76.7	93.2	58.1	± 1.5	75.8
F08-LP-002B-1	1228	8580	9.1	21.0692	2.8	0.0598	3.1	0.0091	1.2	0.40	58.6	0.7	59.0	1.8	72.6	67.4	58.6	± 0.7	80.8
F08-LP-002B-11	164	1140	2.0	21.9176	14.0	0.0590	14.2	0.0094	2.3	0.16	60.2	1.3	58.2	8.0	-22.1	341.1	60.2	± 1.3	-272.3
F08-LP-002B-13	773	5924	4.5	20.5015	8.1	0.0632	8.3	0.0094	2.0	0.24	60.3	1.2	62.2	5.0	137.1	189.5	60.3	± 1.2	43.9
F08-LP-002B-4	771	41542	9.9	9.9894	1.2	3.1568	2.8	0.2287	2.6	0.91	1327.7	30.8	1446.7	21.7	1626.0	21.4	1626.0	± 21.4	81.7
F08-LP-007																			
F08-LP-007-23	2947	7862	9.9	21.3402	1.7	0.0598	2.4	0.0093	1.8	0.72	59.4	1.0	59.0	1.4	42.1	40.0	59.4	± 1.0	141.2
F08-LP-007-16	1576	5139	5.4	21.6498	4.0	0.0598	4.6	0.0094	2.4	0.52	60.2	1.4	58.9	2.7	7.5	95.3	60.2	± 1.4	798.6
F08-LP-007-4	1246	2733	8.7	21.6968	3.4	0.0599	3.7	0.0094	1.5	0.39	60.4	0.9	59.0	2.1	2.3	83.0	60.4	± 0.9	2636.9
F08-LP-007-25	2323	6752	7.4	21.2984	1.7	0.0618	2.4	0.0095	1.8	0.73	61.2	1.1	60.8	1.4	46.8	40.2	61.2	± 1.1	130.8
F08-LP-007-20	1249	3116	7.1	21.7342	4.1	0.0608	4.3	0.0096	1.2	0.28	61.5	0.7	59.9	2.5	-1.8	99.1	61.5	± 0.7	-3386.8
F08-LP-007-38	1804	6179	10.4	21.5131	1.8	0.0614	2.2	0.0096	1.3	0.60	61.5	0.8	60.5	1.3	22.7	42.1	61.5	± 0.8	270.4
F08-LP-007-9	230	705	3.0	26.5514	21.6	0.0501	21.6	0.0096	1.5	0.07	61.9	0.9	49.6	10.5	-508.9	580.5	61.9	± 0.9	-12.2
F08-LP-007-6	1662	4785	7.0	21.5839	2.4	0.0620	2.5	0.0097	0.8	0.32	62.3	0.5	61.1	1.5	14.9	57.5	62.3	± 0.5	418.9
F08-LP-007-43	1122	2257	7.4	21.9119	5.3	0.0613	5.5	0.0097	1.2	0.22	62.5	0.8	60.4	3.2	-21.5	129.3	62.5	± 0.8	-291.1
F08-LP-007-42	2357	7787	8.0	21.3476	1.7	0.0630	2.7	0.0098	2.1	0.77	62.6	1.3	62.0	1.6	41.3	41.3	62.6	± 1.3	151.6
F08-LP-007-27	1927	4252	7.9	21.2120	1.8	0.0634	2.5	0.0098	1.7	0.69	62.6	1.1	62.5	1.5	56.5	43.4	62.6	± 1.1	110.8
F08-LP-007-33	2077	5963	9.4	21.9449	4.0	0.0613	4.2	0.0098	1.4	0.32	62.6	0.8	60.5	2.5	-25.1	95.8	62.6	± 0.8	-249.2
F08-LP-007-41	691	2516	4.4	22.1994	5.5	0.0607	6.4	0.0098	3.3	0.51	62.7	2.0	59.8	3.7	-53.1	134.1	62.7	± 2.0	-118.0
F08-LP-007-24	2577	6684	12.0	21.4831	1.7	0.0629	2.8	0.0098	2.2	0.78	62.9	1.4	61.9	1.7	26.1	41.9	62.9	± 1.4	240.8
F08-LP-007-40	1160	3566	8.8	21.1988	2.3	0.0638	2.5	0.0098	0.8	0.32	62.9	0.5	62.8	1.5	57.9	55.6	62.9	± 0.5	108.5
F08-LP-007-14	1770	3289	6.2	21.5707	2.2	0.0627	2.4	0.0098	0.8	0.34	62.9	0.5	61.8	1.4	16.3	53.5	62.9	± 0.5	385.2
F08-LP-007-3RIM	2039	4187	8.6	21.4521	2.4	0.0633	4.3	0.0098	3.6	0.84	63.1	2.3	62.3	2.6	29.6	56.7	63.1	± 2.3	213.3
F08-LP-007-15	2084	6390	10.2	21.3478	3.0	0.0639	3.1	0.0099	0.7	0.21	63.4	0.4	62.9	1.9	41.3	71.6	63.4	± 0.4	153.7
F08-LP-007-44	270	1008	1.3	25.9583	19.6	0.0526	19.7	0.0099	1.6	0.08	63.5	1.0	52.0	10.0	-449.0	521.1	63.5	± 1.0	-14.1
F08-LP-007-39	2090	5853	11.2	21.5373	2.9	0.0634	3.3	0.0099	1.6	0.47	63.5	1.0	62.4	2.0	20.0	70.3	63.5	± 1.0	316.7
F08-LP-007-34	1712	4840	9.5	21.4218	1.7	0.0639	2.5	0.0099	1.9	0.75	63.7	1.2	62.9	1.5	32.9	40.0	63.7	± 1.2	193.3
F08-LP-007-26	745	3483	6.9	21.9684	5.3	0.0627	5.4	0.0100	0.7	0.13	64.1	0.4	61.7	3.2	-27.7	129.7	64.1	± 0.4	-231.0
F08-LP-007-8	1668	4575	11.2	21.6040	2.3	0.0638	2.6	0.0100	1.3	0.49	64.1	0.8	62.8	1.6	12.6	55.0	64.1	± 0.8	508.4
F08-LP-007-2	1883	5117	6.9	21.7517	3.0	0.0634	3.3	0.0100	1.3	0.40	64.2	0.8	62.4	2.0	-3.8	72.4	64.2	± 0.8	-1708.5
F08-LP-007-45	1353	3920	10.0	21.5428	3.1	0.0641	3.4	0.0100	1.3	0.38	64.2	0.8	63.0	2.1	19.5	75.3	64.2	± 0.8	329.9
F08-LP-007-35	1488	4796	4.8	21.5253	2.2	0.0643	2.6	0.0100	1.2	0.48	64.4	0.8	63.3	1.6	21.4	53.7	64.4	± 0.8	300.8
F08-LP-007-7	2181	6197	4.8	21.2194	1.6	0.0664	1.9	0.0102	1.1	0.54	65.5	0.7	65.3	1.2	55.7	38.6	65.5	± 0.7	117.7
F08-LP-007-37	1429	6894	8.7	14.6902	7.4	0.1481	7.9	0.0158	3.0	0.38	100.9	3.0	140.2	10.4	870.8	152.8	100.9	± 3.0	11.6
F08-LP-007-21	1362	9590	9.3	12.1348	6.7	0.2553	11.5	0.0225	9.4	0.82	143.2	13.3	230.8	23.8	1255.2	130.2	143.2	± 13.3	11.4
F08-LP-007-19	793	14825	7.6	11.0519	1.6	0.5201	6.3	0.0417	6.1	0.96	263.3	15.7	425.2	21.9	1435.7	31.5	263.3	± 15.7	18.3
F08-LP-007-28	884	90893	100.0	10.8336	0.9	2.7623	1.5	0.2170	1.2	0.79	1266.2	13.2	1345.4	10.8	1473.7	16.9	1473.7	± 16.9	85.9
F08-LP-007-1	315	18939	6.3	9.7043	1.5	4.0109	1.7	0.2823	0.8	0.49	1602.9	11.6	1636.4	13.6	1679.7	27.0	1679.7	± 27.0	95.4
F08-LP-007-30	231	19272	6.6	9.5783	1.2	3.4995	11.1	0.2431	11.0	0.99	1402.8	138.9	1527.1	87.8	1703.8	22.0	1703.8	± 22.0	82.3
F08-LP-007-32	1168	69927	38.1	9.4290	2.8	3.9656	4.2	0.2712	3.1	0.75	1546.8	42.8	1627.2	33.7	1732.7	50.6	1732.7	± 50.6	89.3
F08-LP-008																			
F08-LP-008-35	150	1980	1.6	18.0715	49.6	0.0446	50.0	0.0058	6.0	0.12	37.5	2.2	44.3	21.7	425.8	1177.9	37.5	± 2.2	8.8
F08-LP-008-31	142	2602	3.0	17.8487	48.4	0.0463	48.8	0.0060	6.0	0.12	38.5	2.3	45.9	21.9	453.4	1139.2	38.5	± 2.3	8.5
F08-LP-008-1	61	497	0.9	22.9858	106.7	0.0361	106.9	0.0060	6.9	0.06	38.7	2.7	36.0	37.8	-138.6	1208.7	38.7	± 2.7	-27.9
F08-LP-008-16	146	922	1.1	18.2364	49.7	0.0458	50.1	0.0061	6.5	0.13	38.9	2.5	45.4	22.3	405.5	1182.4	38.9	± 2.5	9.6
F08-LP-008-34	274	2006	1.8	23.0639	32.6	0.0364	33.1	0.0061	5.5	0.17	39.1	2.1	36.3	11.8	-147.0	828.2	39.1	± 2.1	-26.6
F08-LP-008-3	207	1433	1.7	29.7830	60.4	0.0283	60.8	0.0061	6.7	0.11	39.3	2.6	28.3	17.0	-825.6	1874.9	39.3	± 2.6	-4.8
F08-LP-008-32	325	2508	2.4	25.7837	22.1	0.0330	22.2	0.0062	2.5	0.11	39.7	1.0	33.0	7.2	-431.3	584.7	39.7	± 1.0	-9.2
F08-LP-008-7	168	1118	0.9	29.3790	35.1	0.0290	35.3	0.0062	3.7	0.11	39.7	1.5	29.0	10.1	-786.8	1019.7	39.7	± 1.5	-5.0
F08-LP-008-22	351	1685	2.5	20.1615	15.0	0.0426	17.8	0.0062	9.4	0.53	40.0	3.8	42.4	7.4	176.2	352.6	40.0	± 3.8	22.7
F08-LP-008-5	165	566	0.9	14.8959	22.9	0.0585	23.0	0.0063	1.4	0.06	40.6	0.6	57.7	12.9	841.9	483.3	40.6	± 0.6	4.8
F08-LP-008-29	120	1171	1.3	18.0245	39.7	0.0490	40.3	0.0064	6.8	0.17	41.1	2.8	48.5	19.1	431.6	918.4	41.1		

Analysis	U (ppm)	206Pb 204Pb	U/Th	Isotope ratios						Apparent ages (Ma)						Best age (Ma)	± (Ma)	Conc (%)	
				206Pb 207Pb	± (%)	207Pb 235U	± (%)	206Pb 238U	± (%)	error corr.	206Pb 238U	± (Ma)	207Pb 235U	± (Ma)	206Pb 207Pb				± (Ma)
F08-TL-006																			
F08-TL-006-18	267	3720	1.0	16.6501	19.1	0.0500	19.6	0.0060	4.6	0.23	38.8	1.8	49.5	9.5	605.7	416.5	38.8	± 1.8	6.4
F08-TL-006-25	1034	10908	1.0	18.6030	10.7	0.0449	11.0	0.0061	2.6	0.23	38.9	1.0	44.6	4.8	360.8	242.6	38.9	± 1.0	10.8
F08-TL-006-15	409	6588	1.2	22.1932	14.6	0.0387	14.8	0.0062	2.1	0.14	40.0	0.8	38.5	5.6	-52.5	357.1	40.0	± 0.8	-76.2
F08-TL-006-30	728	12432	2.6	21.6745	12.3	0.0401	12.5	0.0063	2.5	0.20	40.5	1.0	39.9	4.9	4.8	296.2	40.5	± 1.0	845.4
F08-TL-006-12	1465	12378	0.7	20.9391	5.3	0.0419	5.4	0.0064	1.3	0.23	40.9	0.5	41.7	2.2	87.3	125.1	40.9	± 0.5	46.9
F08-TL-006-8	530	8616	1.6	20.8505	12.8	0.0423	12.9	0.0064	1.4	0.11	41.1	0.6	42.0	5.3	97.3	304.2	41.1	± 0.6	42.2
F08-TL-006-21	590	6222	2.0	19.8554	24.6	0.0444	24.8	0.0064	2.9	0.12	41.1	1.2	44.1	10.7	211.8	578.4	41.1	± 1.2	19.4
F08-TL-006-28	544	8766	4.1	22.3955	13.5	0.0394	14.4	0.0064	5.2	0.36	41.2	2.1	39.3	5.6	-74.6	330.4	41.2	± 2.1	-55.2
F08-TL-006-29	256	10614	3.8	22.5869	19.7	0.0392	20.4	0.0064	5.2	0.25	41.3	2.1	39.0	7.8	-95.4	488.5	41.3	± 2.1	-43.2
F08-TL-006-36	589	13068	3.5	21.2860	10.3	0.0416	10.7	0.0064	3.0	0.28	41.3	1.2	41.4	4.3	48.2	246.3	41.3	± 1.2	85.7
F08-TL-006-16	188	3780	4.0	19.7411	27.7	0.0453	28.7	0.0065	7.4	0.26	41.7	3.1	45.0	12.6	225.2	650.9	41.7	± 3.1	18.5
F08-TL-006-35	479	11010	4.2	21.8251	15.0	0.0412	15.1	0.0065	1.9	0.13	41.9	0.8	41.0	6.1	-11.9	364.4	41.9	± 0.8	-352.6
F08-TL-006-20	489	7428	0.9	22.7062	18.2	0.0396	18.4	0.0065	3.0	0.16	41.9	1.2	39.5	7.1	-108.4	450.9	41.9	± 1.2	-38.7
F08-TL-006-14	766	12426	0.6	21.3062	6.3	0.0424	6.9	0.0065	2.8	0.41	42.1	1.2	42.1	2.8	45.9	150.1	42.1	± 1.2	91.6
F08-TL-006-17	320	5100	0.6	20.8321	23.2	0.0435	23.2	0.0066	1.8	0.08	42.2	0.8	43.2	9.8	99.4	554.5	42.2	± 0.8	42.4
F08-TL-006-23	574	11682	1.6	21.1961	5.9	0.0427	6.1	0.0066	1.6	0.26	42.2	0.7	42.5	2.5	58.2	140.8	42.2	± 0.7	72.5
F08-TL-006-33	776	9930	1.0	19.8496	10.0	0.0457	12.0	0.0066	6.7	0.55	42.3	2.8	45.4	5.3	212.5	231.9	42.3	± 2.8	19.9
F08-TL-006-10	402	8232	1.0	22.8165	14.9	0.0400	16.6	0.0066	7.2	0.44	42.5	3.1	39.8	6.5	-120.3	369.2	42.5	± 3.1	-35.3
F08-TL-006-11	419	9786	1.8	21.2782	11.6	0.0429	12.1	0.0066	3.6	0.29	42.5	1.5	42.7	5.1	49.0	278.0	42.5	± 1.5	86.8
F08-TL-006-24	390	8160	3.6	22.2072	12.8	0.0412	13.5	0.0066	4.5	0.33	42.6	1.9	41.0	5.4	-54.0	311.9	42.6	± 1.9	-79.0
F08-TL-006-22	469	12426	3.9	21.8280	15.3	0.0420	15.3	0.0066	1.1	0.07	42.7	0.5	41.7	6.3	-12.2	370.3	42.7	± 0.5	-349.5
F08-TL-006-13	251	4266	0.5	23.7038	29.3	0.0388	29.3	0.0067	1.1	0.04	42.8	0.5	38.6	11.1	-215.3	748.8	42.8	± 0.5	-19.9
F08-TL-006-6	490	5838	2.7	17.3063	12.5	0.0535	12.9	0.0067	2.9	0.22	43.1	1.2	52.9	6.6	521.5	276.1	43.1	± 1.2	8.3
F08-TL-006-1	481	9906	1.5	23.3633	16.8	0.0398	16.8	0.0067	1.5	0.09	43.4	0.6	39.7	6.6	-179.1	421.2	43.4	± 0.6	-24.2
F08-TL-006-19	380	9990	3.4	26.9606	40.3	0.0346	40.4	0.0068	2.8	0.07	43.4	1.2	34.5	13.7	-549.9	1122.4	43.4	± 1.2	-7.9
F08-TL-006-5	96	2538	1.3	19.9182	31.0	0.0469	31.1	0.0068	3.1	0.10	43.6	1.3	46.6	14.2	204.5	734.8	43.6	± 1.3	21.3
F08-TL-006-2	436	9366	3.7	22.5262	15.3	0.0417	15.5	0.0068	2.7	0.17	43.7	1.2	41.5	6.3	-88.8	376.7	43.7	± 1.2	-49.2
F08-TL-006-34	438	6240	0.9	22.2912	16.0	0.0424	16.0	0.0069	1.2	0.07	44.1	0.5	42.2	6.6	-63.2	391.8	44.1	± 0.5	-69.8
F08-TL-006-4	607	12738	3.3	21.6683	8.6	0.0440	8.7	0.0069	1.1	0.12	44.4	0.5	43.7	3.7	5.5	208.5	44.4	± 0.5	809.5
F08-TL-006-9	647	18882	2.5	23.7466	14.4	0.0403	14.5	0.0069	2.0	0.14	44.6	0.9	40.1	5.7	-219.9	362.7	44.6	± 0.9	-20.3
F08-TL-006-31	729	10698	0.8	21.5587	8.8	0.0446	9.2	0.0070	2.7	0.29	44.8	1.2	44.3	4.0	17.7	210.7	44.8	± 1.2	253.5
F08-TL-006-3	311	5406	1.1	20.2411	8.8	0.0475	10.3	0.0070	5.4	0.52	44.8	2.4	47.1	4.8	167.0	206.6	44.8	± 2.4	26.8
F08-TL-006-32	636	9354	1.0	21.4772	11.0	0.0448	11.6	0.0070	3.6	0.31	44.8	1.6	44.5	5.0	26.7	264.8	44.8	± 1.6	167.6
F08-TL-006-7	570	13416	2.8	20.5667	7.0	0.0473	7.4	0.0071	2.3	0.31	45.4	1.0	47.0	3.4	129.7	166.0	45.4	± 1.0	35.0
F08-TL-006-27	61	41052	1.9	11.0336	2.1	3.0367	2.4	0.2430	1.2	0.48	1402.3	14.5	1416.9	18.4	1438.9	40.4	1438.9	± 40.4	97.5
F08-TL-006-26	438	161220	1.6	9.2855	1.8	4.3291	2.2	0.2915	1.3	0.57	1649.2	18.6	1698.9	18.5	1760.8	33.6	1760.8	± 33.6	93.7
F08-TL-009																			
F08-TL-009-12	2360	627	0.4	16.3521	19.7	0.0417	21.8	0.0050	9.5	0.43	31.8	3.0	41.5	8.9	644.7	426.1	31.8	± 3.0	4.9
F08-TL-009-47	311	1225	3.0	23.3832	9.2	0.0369	9.7	0.0063	3.1	0.32	40.2	1.2	36.8	3.5	-181.2	229.4	40.2	± 1.2	-22.2
F08-TL-009-32	670	2178	1.6	22.6984	6.8	0.0381	6.9	0.0063	0.8	0.12	40.3	0.3	38.0	2.6	-107.5	168.5	40.3	± 0.3	-37.5
F08-TL-009-43	663	1669	1.0	23.1809	11.0	0.0376	11.5	0.0063	3.4	0.29	40.6	1.4	37.4	4.2	-159.6	274.8	40.6	± 1.4	-25.4
F08-TL-009-23	1017	3158	1.2	22.0610	4.6	0.0395	4.8	0.0063	1.5	0.31	40.6	0.6	39.3	1.9	-37.9	111.3	40.6	± 0.6	-107.0
F08-TL-009-16	1557	685	0.7	15.9195	28.2	0.0551	28.4	0.0064	2.6	0.09	40.9	1.1	54.5	15.0	702.0	612.5	40.9	± 1.1	5.8
F08-TL-009-30	293	876	0.6	22.8188	8.7	0.0385	9.1	0.0064	2.7	0.30	40.9	1.1	38.4	3.4	-120.6	214.3	40.9	± 1.1	-34.0
F08-TL-009-46	194	714	1.0	29.3885	30.6	0.0300	30.7	0.0064	2.7	0.09	41.0	1.1	30.0	9.1	-787.7	883.2	41.0	± 1.1	-5.2
F08-TL-009-41	1421	1536	0.5	20.8909	5.4	0.0426	5.7	0.0065	1.8	0.31	41.5	0.7	42.3	2.4	92.8	128.2	41.5	± 0.7	44.7
F08-TL-009-37	1274	1658	0.5	22.3521	5.3	0.0400	5.7	0.0065	2.2	0.39	41.6	0.9	39.8	2.2	-69.9	128.7	41.6	± 0.9	-59.6
F08-TL-009-42	546	2164	3.9	22.3796	12.2	0.0400	12.4	0.0065	2.3	0.19	41.7	1.0	39.8	4.8	-72.9	298.7	41.7	± 1.0	-57.2
F08-TL-009-8	1511	1282	0.3	21.5188	2.7	0.0416	3.4	0.0065	2.1	0.61	41.7	0.9	41.4	1.4	22.1	64.9	41.7	± 0.9	188.6
F08-TL-009-48	866	2752	2.6	22.1329	5.3	0.0404	6.4	0.0065	3.6	0.56	41.7	1.5	40.2	2.5	-45.8	129.8	41.7	± 1.5	-91.0
F08-TL-009-2	618	1602	2.2	24.3548	14.6	0.0370	14.6	0.0065	1.0	0.06	42.0	0.4	36.9	5.3	-283.9	373.8	42.0	± 0.4	-14.8
F08-TL-009-6	809	2279	2.6	23.2054	8.6	0.0390	8.6	0.0066	0.7	0.08	42.1	0.3	38.8	3.3	-162.2	214.3	42.1	± 0.3	-26.0
F08-TL-009-50	855	595	0.4	18.2418	13.6	0.0496	13.6	0.0066	1.6	0.12	42.2	0.7	49.2	6.6	404.8	304.7	42.2	± 0.7	10.4
F08-TL-009-7	754	1674	2.6	23.1233	8.9	0.0393	9.0	0.0066	0.9	0.10	42.3	0.4	39.1	3.4	-153.4	221.7	42.3	± 0.4	-27.6
F08-TL-009-27	780	1035	0.5	17.6979	19.0	0													

Analysis	U (ppm)	206Pb 204Pb	U/Th	206Pb 207Pb	± (%)	207Pb 235U	Isotope ratios				206Pb 238U	± (%)	error corr.	Apparent ages (Ma)				Best age (Ma)	± (Ma)	Conc (%)
							206Pb (%)	238U (%)	207Pb (%)	235U (%)				206Pb (Ma)	207Pb 235U (Ma)	206Pb (Ma)	207Pb (Ma)			
F08-TL-012																				
F08-TL-012-25	247	1904	3.8	25.1899	16.7	0.0416	19.4	0.0076	9.7	0.50	48.8	4.7	41.4	7.9	-370.5	436.7	48.8	±	4.7	-13.2
F08-TL-012-10	280	2818	7.1	24.4658	22.3	0.0457	23.4	0.0081	7.2	0.31	52.0	3.7	45.3	10.4	-295.5	575.0	52.0	±	3.7	-17.6
F08-TL-012-39	219	2344	2.2	30.0381	33.8	0.0373	33.9	0.0081	2.1	0.06	52.2	1.1	37.2	12.4	-850.0	991.6	52.2	±	1.1	-6.1
F08-TL-012-21	970	5680	9.5	22.1862	5.4	0.0508	6.5	0.0082	3.6	0.55	52.4	1.9	50.3	3.2	-51.7	131.5	52.4	±	1.9	-101.5
F08-TL-012-14	1679	15534	7.2	21.9841	4.1	0.0517	5.4	0.0082	3.5	0.64	52.9	1.8	51.2	2.7	-29.4	100.2	52.9	±	1.8	-179.7
F08-TL-012-13	817	8818	8.8	22.2784	5.0	0.0514	7.2	0.0083	5.2	0.72	53.3	2.8	50.9	3.6	-61.8	122.0	53.3	±	2.8	-86.2
F08-TL-012-40	1234	5810	5.0	20.4736	8.7	0.0566	9.4	0.0084	3.6	0.38	54.0	1.9	55.9	5.1	140.3	204.5	54.0	±	1.9	38.5
F08-TL-012-43	1597	10446	7.7	21.4278	1.7	0.0541	3.5	0.0084	3.0	0.87	54.0	1.6	53.5	1.8	32.3	40.6	54.0	±	1.6	167.2
F08-TL-012-5	2294	18106	7.2	21.3321	2.0	0.0551	2.7	0.0085	1.8	0.67	54.7	1.0	54.4	1.4	43.0	47.7	54.7	±	1.0	127.1
F08-TL-012-19	2233	20430	9.5	21.5531	3.1	0.0555	4.0	0.0087	2.6	0.64	55.6	1.4	54.8	2.2	18.3	74.8	55.6	±	1.4	303.7
F08-TL-012-20	986	9120	7.2	18.0576	9.8	0.0662	11.7	0.0087	6.5	0.55	55.6	3.6	65.1	7.4	427.5	218.0	55.6	±	3.6	13.0
F08-TL-012-33	1461	10254	11.6	20.6260	3.1	0.0585	3.7	0.0087	2.0	0.55	56.1	1.1	57.7	2.1	122.9	72.1	56.1	±	1.1	45.7
F08-TL-012-18	1753	15266	10.2	21.4032	2.4	0.0564	3.2	0.0088	2.0	0.63	56.2	1.1	55.7	1.7	35.0	58.6	56.2	±	1.1	160.4
F08-TL-012-29	864	9662	4.3	22.6109	7.5	0.0535	7.5	0.0088	0.9	0.12	56.3	0.5	52.9	3.9	-98.1	183.8	56.3	±	0.5	-57.4
F08-TL-012-15	1820	14078	8.6	21.1268	2.2	0.0578	2.6	0.0089	1.3	0.52	56.8	0.8	57.0	1.4	66.1	51.9	56.8	±	0.8	86.0
F08-TL-012-16	1690	11254	11.0	21.3293	3.3	0.0576	4.1	0.0089	2.5	0.61	57.2	1.4	56.9	2.3	43.3	78.3	57.2	±	1.4	132.2
F08-TL-012-8	1304	8728	6.9	21.8832	3.6	0.0564	7.6	0.0089	6.7	0.88	57.4	3.8	55.7	4.1	-18.3	86.6	57.4	±	3.8	-313.5
F08-TL-012-2	1492	13144	6.1	21.3111	3.9	0.0583	4.8	0.0090	2.9	0.60	57.8	1.7	57.5	2.7	45.4	92.1	57.8	±	1.7	127.3
F08-TL-012-12	473	5898	8.6	21.6957	13.2	0.0586	13.4	0.0092	2.2	0.17	59.2	1.3	57.8	7.5	2.4	319.7	59.2	±	1.3	2437.6
F08-TL-012-7	323	2158	2.4	23.2786	38.3	0.0567	38.3	0.0096	1.5	0.04	61.4	0.9	56.0	20.9	-170.0	985.5	61.4	±	0.9	-36.1
F08-TL-012-1	951	9628	4.3	20.3644	3.4	0.0662	3.8	0.0098	1.8	0.47	62.8	1.1	65.1	2.4	152.9	79.3	62.8	±	1.1	41.1
F08-TL-012-32	1405	28846	8.6	16.9079	8.3	0.0831	11.2	0.0102	7.6	0.68	65.4	4.9	81.1	8.7	572.4	180.1	65.4	±	4.9	11.4
F08-TL-012-27	629	31482	6.5	12.5226	5.2	0.2277	10.6	0.0207	9.2	0.87	132.0	12.0	208.3	19.9	1193.4	103.3	132.0	±	12.0	11.1
F08-TL-012-42	52	28374	4.1	11.4020	2.2	2.5799	3.9	0.2133	3.2	0.83	1246.6	36.6	1295.0	28.6	1376.0	42.2	1376.0	±	42.2	90.6
F08-TL-012-22	143	47200	1.7	11.1910	1.9	2.7916	3.3	0.2266	2.7	0.81	1316.6	31.9	1353.3	24.7	1411.8	37.0	1411.8	±	37.0	93.3
F08-TL-012-30	593	159250	24.7	11.1366	0.9	2.7851	2.9	0.2250	2.8	0.96	1308.0	33.3	1351.6	22.0	1421.1	16.4	1421.1	±	16.4	92.0
F08-TL-012-34	1903	271792	9.2	10.8555	1.8	2.7365	2.3	0.2155	1.5	0.63	1257.8	16.6	1338.4	17.1	1469.8	34.0	1469.8	±	34.0	85.6
F08-TL-012-23	859	225782	2.7	10.6044	1.6	2.8584	2.4	0.2198	1.8	0.75	1281.0	21.1	1371.0	18.3	1514.1	30.6	1514.1	±	30.6	84.6
F08-TL-012-44	497	80660	6.0	10.5594	2.4	2.8388	5.9	0.2174	5.4	0.91	1268.2	62.6	1365.9	44.7	1522.1	45.4	1522.1	±	45.4	83.3
F08-TL-012-9	586	115818	5.4	9.7325	1.6	3.7664	3.0	0.2659	2.5	0.84	1519.7	34.4	1585.6	24.2	1674.3	30.1	1674.3	±	30.1	90.8
F08-TL-012-45	944	205624	115.8	9.7087	2.1	3.7008	2.2	0.2606	0.8	0.35	1492.8	10.4	1571.5	17.8	1678.9	38.6	1678.9	±	38.6	88.9
F08-TL-012-4	376	92474	2.4	9.6201	0.9	4.2058	3.0	0.2934	2.9	0.96	1658.7	42.3	1675.2	24.8	1695.8	16.4	1695.8	±	16.4	97.8
F08-TL-012-41	607	185460	2.6	9.5563	2.5	3.9310	4.1	0.2725	3.3	0.80	1553.2	45.4	1620.1	33.3	1708.0	45.5	1708.0	±	45.5	90.9
F08-TL-012-3	277	42950	2.6	9.3214	1.6	4.4660	3.6	0.3019	3.2	0.89	1700.9	47.1	1724.7	29.5	1753.7	30.0	1753.7	±	30.0	97.0
F08-TL-012-24	444	133690	9.1	7.8149	6.4	5.1066	8.6	0.2894	5.9	0.68	1638.7	84.9	1837.2	73.6	2070.1	112.0	2070.1	±	112.0	79.2
F08-TL-012-26	447	87814	1.0	5.5870	2.7	11.6795	5.5	0.4733	4.8	0.87	2497.8	99.2	2579.1	51.6	2643.5	45.2	2643.5	±	45.2	94.5
F08-TL-014																				
F08-TL-014-28	1036	1140	6.1	21.7049	4.7	0.0562	5.4	0.0088	2.7	0.50	56.8	1.5	55.5	2.9	1.4	113.8	56.8	±	1.5	3983.9
F08-TL-014-40	998	1339	11.0	22.7093	7.2	0.0551	7.3	0.0091	1.6	0.21	58.3	0.9	54.5	3.9	-108.7	176.4	58.3	±	0.9	-53.6
F08-TL-014-8	1300	1711	7.6	21.4662	3.2	0.0583	3.3	0.0091	0.9	0.28	58.3	0.5	57.6	1.8	28.0	75.6	58.3	±	0.5	208.2
F08-TL-014-6	1101	1582	7.8	22.1677	4.7	0.0569	4.9	0.0091	1.4	0.28	58.7	0.8	56.2	2.7	-49.7	113.9	58.7	±	0.8	-118.2
F08-TL-014-29	1408	1418	4.7	21.2782	2.8	0.0595	3.2	0.0092	1.5	0.47	58.9	0.9	58.7	1.8	49.0	66.9	58.9	±	0.9	120.1
F08-TL-014-10	1595	1838	6.6	21.3479	2.3	0.0597	2.6	0.0092	1.0	0.40	59.3	0.6	58.8	1.5	41.3	55.9	59.3	±	0.6	143.7
F08-TL-014-22	1015	1361	3.9	21.8328	5.0	0.0583	5.3	0.0092	1.6	0.30	59.3	0.9	57.6	2.9	-12.7	121.5	59.3	±	0.9	-465.5
F08-TL-014-35	885	1268	6.7	22.3092	6.0	0.0572	6.4	0.0093	2.3	0.36	59.4	1.3	56.5	3.5	-65.2	145.4	59.4	±	1.3	-91.2
F08-TL-014-24	1691	2386	9.5	21.8551	3.2	0.0588	3.2	0.0093	0.7	0.21	59.8	0.4	58.0	1.8	-15.2	76.2	59.8	±	0.4	-393.1
F08-TL-014-12	865	915	6.0	23.2055	9.3	0.0554	9.4	0.0093	0.9	0.10	59.8	0.6	54.7	5.0	-162.2	232.4	59.8	±	0.6	-36.9
F08-TL-014-21	1035	1662	7.1	22.2427	4.9	0.0579	5.2	0.0093	1.6	0.32	59.9	1.0	57.1	2.9	-57.9	119.4	59.9	±	1.0	-103.5
F08-TL-014-16	1557	1852	6.6	21.9206	5.6	0.0590	5.7	0.0094	0.8	0.14	60.2	0.5	58.2	3.2	-22.4	136.0	60.2	±	0.5	-268.1
F08-TL-014-25	1237	1652	6.9	21.2636	2.3	0.0613	2.9	0.0095	1.7	0.59	60.7	1.0	60.4	1.7	50.7	55.5	60.7	±	1.0	119.7
F08-TL-014-5	1239	2034	9.2	21.8890	3.8	0.0599	4.1	0.0095	1.4	0.33	61.0	0.8	59.1	2.3	-19.0	92.5	61.0	±	0.8	-322.0
F08-TL-014-30	1121	1477	9.5	21.5497	3.5	0.0614	3.6	0.0096	0.5	0.14	61.6	0.3	60.5	2.1	18.7	85.1	61.6	±	0.3	329.2
F08-TL-014-37	1290	1923	5.2	19.0548	8.1	0.0743	8.8	0.0103	3.6	0.41	65.8	2.4	72.8	6.2	306.4	184.1	65.8	±	2.4	21.5
F08-TL-014-34	2343	3460	10.8	18.1191	8.9	0.0811	12.4	0.0107	8.6	0.69	68.3	5.8	79.1	9.4	419.9	199.4	68.3	±	5.8	16.3
F08-TL-014-2	971	4137	8.9	12.1751	1.7	0.2764	4.2	0.0244	3.9	0.92	155.4	5.9	247.8	9.3	1248.7	32.3	155.4	±	5.9	12.4
F08-TL-08																				

Analysis	U (ppm)	206Pb 204Pb	U/Th	Isotope ratios						Apparent ages (Ma)						Best age (Ma)	± (Ma)	Conc (%)		
				206Pb 207Pb	± (%)	207Pb 235U	± (%)	206Pb 238U	± (%)	error corr.	206Pb 238U	± (Ma)	207Pb 235U	± (Ma)	206Pb 207Pb				± (Ma)	
F08-WPT-002																				
F08-WPT-002-27	1556	10898	2.8	21.2021	10.1	0.0371	10.1	0.0057	1.1	0.11	36.7	0.4	37.0	3.7	57.6	241.1	36.7	±	0.4	63.7
F08-WPT-002-14	1562	5029	3.4	23.4296	10.3	0.0336	10.5	0.0057	1.7	0.16	36.7	0.6	33.6	3.5	-186.2	258.4	36.7	±	0.6	-19.7
F08-WPT-002-24	2052	10492	2.8	22.3599	12.8	0.0362	12.9	0.0059	1.4	0.11	37.7	0.5	36.1	4.6	-70.7	313.7	37.7	±	0.5	-53.3
F08-WPT-002-19	655	2537	1.4	20.1980	19.1	0.0402	19.3	0.0059	2.5	0.13	37.8	1.0	40.0	7.6	172.0	450.4	37.8	±	1.0	22.0
F08-WPT-002-7	1739	14007	2.9	21.4880	9.3	0.0382	9.4	0.0060	1.6	0.17	38.3	0.6	38.1	3.5	25.6	222.7	38.3	±	0.6	149.7
F08-WPT-002-18	1567	9510	2.5	22.2696	9.2	0.0370	9.6	0.0060	2.6	0.28	38.4	1.0	36.9	3.5	-60.8	224.4	38.4	±	1.0	-63.2
F08-WPT-002-26	1820	6998	2.4	19.9666	11.6	0.0415	11.6	0.0060	0.6	0.05	38.6	0.2	41.3	4.7	198.9	269.9	38.6	±	0.2	19.4
F08-WPT-002-9	1274	15502	3.5	20.1306	17.6	0.0412	17.7	0.0060	1.5	0.09	38.6	0.6	41.0	7.1	179.8	412.9	38.6	±	0.6	21.5
F08-WPT-002-5	2031	3190	4.2	19.4287	7.4	0.0427	7.6	0.0060	1.8	0.24	38.6	0.7	42.4	3.2	261.9	169.4	38.6	±	0.7	14.7
F08-WPT-002-35	1100	1446	1.2	17.0180	24.7	0.0487	24.8	0.0060	1.7	0.07	38.7	0.7	48.3	11.7	558.2	546.2	38.7	±	0.7	6.9
F08-WPT-002-30	1576	6737	2.9	20.3411	9.3	0.0408	9.4	0.0060	1.3	0.13	38.7	0.5	40.6	3.7	155.6	218.7	38.7	±	0.5	24.9
F08-WPT-002-16	1632	8989	3.2	20.8437	7.8	0.0399	7.9	0.0060	0.9	0.11	38.7	0.3	39.7	3.1	98.1	185.9	38.7	±	0.3	39.5
F08-WPT-002-8	1995	7927	3.5	20.1828	5.9	0.0413	6.1	0.0060	1.2	0.19	38.9	0.5	41.1	2.4	173.8	138.8	38.9	±	0.5	22.4
F08-WPT-002-21	1263	10338	3.2	22.8758	11.6	0.0367	11.7	0.0061	1.1	0.09	39.1	0.4	36.6	4.2	-126.7	287.8	39.1	±	0.4	-30.8
F08-WPT-002-25	1133	2979	3.1	22.6102	11.1	0.0371	11.1	0.0061	0.9	0.08	39.1	0.4	37.0	4.0	-98.0	273.6	39.1	±	0.4	-39.9
F08-WPT-002-28	1552	9810	2.6	21.9737	11.4	0.0382	11.5	0.0061	0.7	0.06	39.1	0.3	38.1	4.3	-28.3	277.8	39.1	±	0.3	-138.3
F08-WPT-002-2	1481	7275	4.3	23.0607	8.9	0.0366	9.2	0.0061	2.4	0.26	39.3	1.0	36.5	3.3	-146.7	221.1	39.3	±	1.0	-26.8
F08-WPT-002-33	631	3072	3.5	23.3128	31.0	0.0363	31.1	0.0061	3.0	0.10	39.4	1.2	36.2	11.1	-173.7	787.8	39.4	±	1.2	-22.7
F08-WPT-002-6	985	4649	1.4	22.9826	13.5	0.0368	13.5	0.0061	1.0	0.08	39.4	0.4	36.7	4.9	-138.3	335.5	39.4	±	0.4	-28.5
F08-WPT-002-29	701	2540	2.6	23.6529	25.1	0.0361	25.2	0.0062	2.8	0.11	39.8	1.1	36.0	8.9	-209.9	637.9	39.8	±	1.1	-18.9
F08-WPT-002-34	961	6794	2.3	22.4805	13.9	0.0380	14.0	0.0062	1.3	0.10	39.8	0.5	37.8	5.2	-83.9	342.3	39.8	±	0.5	-47.4
F08-WPT-002-4	1308	4376	4.1	23.2835	11.4	0.0367	11.5	0.0062	1.4	0.12	39.8	0.6	36.6	4.1	-170.6	284.6	39.8	±	0.6	-23.3
F08-WPT-002-10	521	3238	2.0	26.7970	61.6	0.0319	62.0	0.0062	6.5	0.11	39.9	2.6	31.9	19.5	-533.5	1811.7	39.9	±	2.6	-7.5
F08-WPT-002-13	1544	4875	2.5	20.7513	10.1	0.0413	10.1	0.0062	0.7	0.07	39.9	0.3	41.1	4.1	108.6	239.1	39.9	±	0.3	36.8
F08-WPT-002-15	3496	8307	3.4	20.3936	5.9	0.0424	7.7	0.0063	5.0	0.64	40.3	2.0	42.1	3.2	149.5	138.7	40.3	±	2.0	26.9
F08-WPT-002-20	1183	6610	3.7	20.8822	12.3	0.0415	12.3	0.0063	0.7	0.06	40.4	0.3	41.3	5.0	93.7	292.7	40.4	±	0.3	43.1
F08-WPT-002-32	1734	8788	7.2	20.4088	9.1	0.0437	9.2	0.0065	0.7	0.07	41.5	0.3	43.4	3.9	147.8	214.6	41.5	±	0.3	28.1
F08-WPT-002-31	2539	8377	3.6	20.4071	5.9	0.0438	6.0	0.0065	0.8	0.13	41.7	0.3	43.5	2.5	147.9	139.0	41.7	±	0.3	28.2
F08-WPT-002-17	1131	11869	3.0	19.0103	10.0	0.0475	10.1	0.0066	1.2	0.12	42.1	0.5	47.1	4.6	311.7	227.8	42.1	±	0.5	13.5
F08-WPT-002-1	885	14505	4.4	18.3518	13.8	0.0539	14.1	0.0072	3.0	0.21	46.1	1.4	53.3	7.3	391.4	311.2	46.1	±	1.4	11.8
F08-WPT-002-22	928	12740	3.8	21.5956	11.2	0.0484	11.7	0.0076	3.3	0.28	48.6	1.6	48.0	5.5	13.6	270.5	48.6	±	1.6	358.1
F08-WPT-002-23	968	22766	6.3	21.1549	12.7	0.0534	12.7	0.0082	1.4	0.11	52.6	0.7	52.8	6.6	62.9	302.4	52.6	±	0.7	83.7
F08-WPT-002-12	2159	274592	11.6	10.2335	2.1	3.3207	2.9	0.2465	2.1	0.71	1420.2	26.6	1485.9	23.0	1581.0	38.7	1581.0	±	38.7	89.8
F08-WPT-002-3	856	112151	4.4	9.7429	1.5	3.8261	2.3	0.2704	1.7	0.75	1542.6	23.3	1598.2	18.3	1672.4	27.9	1672.4	±	27.9	92.2
H07-HU-001																				
H07-HU-001-20	402	4305	1.6	19.7899	37.8	0.0410	38.1	0.0059	5.0	0.13	37.8	1.9	40.8	15.3	219.5	904.5	37.8	±	1.9	17.2
H07-HU-001-3	388	2279	1.6	21.5726	15.5	0.0377	15.8	0.0059	3.2	0.20	38.0	1.2	37.6	5.8	16.1	374.4	38.0	±	1.2	235.7
H07-HU-001-12	327	2531	1.1	19.0273	26.7	0.0430	26.7	0.0059	1.6	0.06	38.1	0.6	42.7	11.2	309.7	617.6	38.1	±	0.6	12.3
H07-HU-001-4	331	2531	1.7	22.3453	14.6	0.0366	14.9	0.0059	3.1	0.21	38.2	1.2	36.5	5.3	-69.1	358.0	38.2	±	1.2	-55.2
H07-HU-001-13	433	3868	1.6	22.9925	14.6	0.0358	15.7	0.0060	5.7	0.36	38.4	2.2	35.7	5.5	-139.3	362.7	38.4	±	2.2	-27.6
H07-HU-001-7	365	3973	1.7	28.8724	35.0	0.0285	35.2	0.0060	3.7	0.11	38.4	1.4	28.6	9.9	-737.9	1004.5	38.4	±	1.4	-5.2
H07-HU-001-17	289	6244	1.7	18.6622	20.0	0.0449	20.9	0.0061	6.1	0.29	39.1	2.4	44.6	9.1	353.6	456.9	39.1	±	2.4	11.0
H07-HU-001-18	342	3129	6.2	20.0981	14.9	0.0417	15.3	0.0061	3.3	0.21	39.1	1.3	41.5	6.2	183.6	349.9	39.1	±	1.3	21.3
H07-HU-001-16	654	6234	0.8	22.2288	8.5	0.0380	9.0	0.0061	2.8	0.32	39.4	1.1	37.9	3.3	-56.4	208.5	39.4	±	1.1	-69.9
H07-HU-001-22	399	3021	1.4	20.5507	7.4	0.0417	8.5	0.0062	4.2	0.49	39.9	1.7	41.5	3.4	131.5	173.7	39.9	±	1.7	30.4
H07-HU-001-9	345	3182	1.5	25.6082	26.3	0.0340	26.5	0.0063	3.2	0.12	40.6	1.3	34.0	8.9	-413.4	698.6	40.6	±	1.3	-9.8
H07-HU-001-25	337	3906	1.8	19.7628	10.7	0.0443	11.2	0.0064	3.4	0.30	40.8	1.4	44.0	4.8	222.7	247.9	40.8	±	1.4	18.3
H07-HU-001-8	377	3150	2.0	22.5553	14.3	0.0389	14.4	0.0064	1.7	0.12	40.9	0.7	38.8	5.5	-92.0	352.7	40.9	±	0.7	-44.5
H07-HU-001-2	238	2958	1.4	27.6604	32.5	0.0318	32.7	0.0064	3.0	0.09	41.0	1.2	31.8	10.2	-619.3	907.0	41.0	±	1.2	-6.6
H07-HU-001-15	409	3675	1.3	20.8940	12.9	0.0423	13.0	0.0064	1.5	0.11	41.2	0.6	42.1	5.4	92.4	307.5	41.2	±	0.6	44.6
H07-HU-001-28	258	2951	1.7	25.7807	36.0	0.0344	36.8	0.0064	7.8	0.21	41.3	3.2	34.3	12.4	-431.0	970.9	41.3	±	3.2	-9.6
H07-HU-001-29	1089	8516	0.7	20.3096	8.9	0.0439	8.9	0.0065	0.7	0.08	41.5	0.3	43.6	3.8	159.2	208.1	41.5	±	0.3	26.1
H07-HU-001-11	372	4466	3.8	21.4297	25.9	0.0418	26.1	0.0065	3.8	0.15	41.7	1.6	41.6	10.6	32.1	628.4	41.7	±	1.6	130.1
H07-HU-001-6	230	1841	1.3	21.6988	32.4	0.0413	32.5	0.0065	2.9	0.09	41.7	1.2	41.1	13.1	2.1	799.3	41.7	±	1.2	2003.3
H07-HU-001-30	326	4116	1.6	23.7971	30.5	0.0380	30.7	0.0066	3.7	0.12	42.1	1.5	37.9	11.4	-225.2	782.9	42.1	±	1.5	-18.7
H07-HU-001-5	446	3364	1.2	22.1486	21.0	0.0408	21.1	0.0066	2.5	0.12	42.2	1.0	40.7	8.4	-					

Analysis	U (ppm)	206Pb 204Pb	U/Th	206Pb 207Pb	± (%)	207Pb 235U	Isotope ratios				206Pb 238U	Apparent ages (Ma)				Best age (Ma)	± (Ma)	Conc (%)	
							± (%)	206Pb 238U	± (%)	error corr.		± (Ma)	207Pb 235U	± (Ma)	206Pb 207Pb				
H07-HU-005																			
H07-HU-005-10	1178	30618	4.6	20.9032	41.2	0.0397	41.4	0.0060	3.3	0.08	38.7	1.3	39.5	16.0	91.3	1016.2	38.7	± 1.3	42.3
H07-HU-005-4	2549	38502	4.6	17.5698	21.8	0.0498	22.6	0.0063	5.9	0.26	40.8	2.4	49.3	10.9	488.3	486.0	40.8	± 2.4	8.3
H07-HU-005-17	620	10356	1.7	29.9297	37.2	0.0293	37.3	0.0064	1.7	0.04	40.9	0.7	29.3	10.8	-839.7	1096.0	40.9	± 0.7	-4.9
H07-HU-005-6	876	16236	2.8	20.5954	19.2	0.0427	19.4	0.0064	3.1	0.16	41.0	1.3	42.4	8.1	126.4	454.5	41.0	± 1.3	32.4
H07-HU-005-19	273	14418	2.2	27.1870	96.6	0.0324	96.6	0.0064	3.8	0.04	41.1	1.5	32.4	30.8	-572.4	1469.4	41.1	± 1.5	-7.2
H07-HU-005-29	816	17706	3.2	22.3938	13.9	0.0395	14.0	0.0064	2.1	0.15	41.2	0.9	39.3	5.4	-74.4	340.1	41.2	± 0.9	-55.4
H07-HU-005-26	566	9792	2.9	29.9684	56.5	0.0299	56.6	0.0065	1.7	0.03	41.7	0.7	29.9	16.7	-843.3	1739.9	41.7	± 0.7	-4.9
H07-HU-005-33	368	17214	1.5	15.3676	16.3	0.0583	16.7	0.0065	3.9	0.23	41.7	1.6	57.5	9.4	776.6	344.3	41.7	± 1.6	5.4
H07-HU-005-8	490	7662	3.6	23.6449	54.3	0.0380	54.4	0.0065	2.1	0.04	41.9	0.9	37.9	20.2	-209.1	1463.4	41.9	± 0.9	-20.0
H07-HU-005-14	642	12756	3.4	20.2559	25.3	0.0444	25.3	0.0065	0.8	0.03	41.9	0.3	44.1	10.9	165.3	598.7	41.9	± 0.3	25.4
H07-HU-005-25	615	17532	1.4	23.1362	34.4	0.0389	34.5	0.0065	2.3	0.07	42.0	1.0	38.8	13.1	-154.8	877.7	42.0	± 1.0	-27.1
H07-HU-005-20	853	24768	3.2	21.5248	13.4	0.0419	13.5	0.0065	2.1	0.15	42.0	0.9	41.6	5.5	21.4	322.6	42.0	± 0.9	195.8
H07-HU-005-9	611	12810	3.8	21.3842	15.5	0.0422	15.5	0.0065	0.8	0.05	42.1	0.3	42.0	6.4	37.1	373.4	42.1	± 0.3	113.3
H07-HU-005-28	611	8616	4.2	24.7254	27.3	0.0366	27.6	0.0066	4.5	0.16	42.2	1.9	36.5	9.9	-322.5	710.9	42.2	± 1.9	-13.1
H07-HU-005-18	569	10290	2.6	21.0938	19.9	0.0435	20.0	0.0066	2.3	0.11	42.7	1.0	43.2	8.5	69.8	477.3	42.7	± 1.0	61.2
H07-HU-005-34	619	8346	2.0	22.9163	21.4	0.0400	21.5	0.0067	1.4	0.07	42.8	0.6	39.9	8.4	-131.1	534.5	42.8	± 0.6	-32.6
H07-HU-005-12	155	11106	1.9	15.7380	78.5	0.0584	78.6	0.0067	3.8	0.05	42.8	1.6	57.6	44.0	726.3	2053.4	42.8	± 1.6	5.9
H07-HU-005-5	584	10776	3.5	22.3771	15.3	0.0411	15.4	0.0067	1.6	0.10	42.8	0.7	40.9	6.2	-72.6	375.3	42.8	± 0.7	-59.0
H07-HU-005-15	504	18318	4.1	19.5297	23.5	0.0472	23.5	0.0067	1.1	0.05	42.9	0.5	46.8	10.8	250.0	547.6	42.9	± 0.5	17.2
H07-HU-005-11	522	14850	3.6	18.6891	18.9	0.0494	19.1	0.0067	2.8	0.15	43.0	1.2	49.0	9.1	350.4	430.8	43.0	± 1.2	12.3
H07-HU-005-30	730	14808	2.8	23.6680	26.6	0.0390	26.6	0.0067	1.1	0.04	43.0	0.5	38.9	10.2	-211.5	677.9	43.0	± 0.5	-20.4
H07-HU-005-31	878	21414	2.8	20.6676	12.0	0.0449	12.0	0.0067	1.1	0.09	43.2	0.5	44.6	5.2	118.1	283.2	43.2	± 0.5	36.6
H07-HU-005-13	518	9162	3.5	22.4015	28.2	0.0416	28.3	0.0068	1.4	0.05	43.4	0.6	41.4	11.5	-75.2	702.5	43.4	± 0.6	-57.7
H07-HU-005-35	756	21606	3.3	21.8521	13.9	0.0429	14.0	0.0068	1.8	0.13	43.6	0.8	42.6	5.9	-14.9	337.7	43.6	± 0.8	-293.3
H07-HU-005-2	846	15288	2.6	23.5146	15.5	0.0399	15.6	0.0068	0.9	0.06	43.7	0.4	39.7	6.1	-195.2	390.8	43.7	± 0.4	-22.4
H07-HU-005-21	450	24036	3.1	18.6469	27.9	0.0504	28.0	0.0068	2.6	0.09	43.8	1.2	50.0	13.7	355.5	641.3	43.8	± 1.2	12.3
H07-HU-005-27	703	12168	2.8	19.8871	19.6	0.0475	19.7	0.0069	1.9	0.10	44.0	0.8	47.1	9.1	208.1	457.6	44.0	± 0.8	21.1
H07-HU-005-7	511	19014	4.3	19.9286	16.2	0.0474	16.3	0.0069	1.9	0.11	44.0	0.8	47.1	7.5	203.3	377.6	44.0	± 0.8	21.7
H07-HU-005-23	596	15606	2.9	21.5497	29.3	0.0441	29.3	0.0069	0.5	0.02	44.3	0.2	43.8	12.6	18.7	716.8	44.3	± 0.2	236.8
H07-HU-005-32	925	30774	3.4	22.6709	12.4	0.0420	12.5	0.0069	0.9	0.07	44.3	0.4	41.7	5.1	-104.6	306.9	44.3	± 0.4	-42.4
H07-HU-005-3	613	10320	4.1	16.8038	27.1	0.0567	27.2	0.0069	2.8	0.10	44.4	1.3	56.0	14.8	585.8	598.3	44.4	± 1.3	7.6
H07-HU-005-1	224	5232	1.6	19.7220	74.9	0.0489	75.1	0.0070	4.8	0.06	44.9	2.2	48.5	35.5	227.4	2054.5	44.9	± 2.2	19.7
H07-HU-005-22	263	123480	1.9	11.4111	1.4	2.4692	4.4	0.2044	4.2	0.95	1198.7	45.5	1263.1	31.7	1374.5	26.9	1374.5	± 26.9	87.2
H07-HU-005-24	172	126798	1.1	11.2199	2.1	3.0170	2.5	0.2455	1.4	0.56	1415.3	17.8	1411.9	19.1	1406.9	39.6	1406.9	± 39.6	100.6
H07-HU-005-16	3611	745212	17.7	9.6049	1.4	4.0167	2.1	0.2798	1.5	0.74	1590.4	21.7	1637.6	16.9	1698.7	25.8	1698.7	± 25.8	93.6
H07-HU-006																			
H07-HU-006-24	483	968	2.8	12.5440	9.6	-0.0479	9.6	-0.0044	0.5	0.05	-28.2	-0.1	-49.8	-4.9	1190.1	189.7	-28.2	± -0.1	-2.4
H07-HU-006-12	478	7789	19.3	13.4475	6.7	-0.0343	6.7	-0.0033	0.5	0.07	-21.6	-0.1	-35.4	-2.4	1051.4	134.9	-21.6	± -0.1	-2.1
H07-HU-006-38	684	1172	5.1	26.0564	35.7	0.0282	35.7	0.0053	1.5	0.04	34.2	0.5	28.2	9.9	-459.0	967.4	34.2	± 0.5	-7.5
H07-HU-006-5	493	1274	3.7	22.6801	15.5	0.0361	15.8	0.0059	2.9	0.19	38.2	1.1	36.0	5.6	-105.6	383.1	38.2	± 1.1	-36.1
H07-HU-006-30	1379	2888	3.7	21.7527	12.5	0.0388	12.7	0.0061	1.7	0.13	39.4	0.7	38.7	4.8	-3.9	303.5	39.4	± 0.7	-1019.6
H07-HU-006-25	2094	3595	3.5	23.3691	10.6	0.0362	10.7	0.0061	1.6	0.15	39.4	0.6	36.1	3.8	-179.7	265.8	39.4	± 0.6	-22.0
H07-HU-006-20	3672	4722	7.1	22.3064	4.6	0.0380	4.7	0.0061	1.3	0.27	39.5	0.5	37.9	1.8	-64.8	111.4	39.5	± 0.5	-60.9
H07-HU-006-3	767	2795	4.3	24.7519	15.8	0.0345	16.2	0.0062	3.5	0.22	39.8	1.4	34.4	5.5	-325.3	409.0	39.8	± 1.4	-12.2
H07-HU-006-37	451	1138	2.4	27.0584	26.9	0.0316	27.0	0.0062	2.2	0.08	39.9	0.9	31.6	8.4	-559.6	737.0	39.9	± 0.9	-7.1
H07-HU-006-35	1929	7336	4.6	20.6872	7.9	0.0421	8.0	0.0063	1.3	0.17	40.6	0.5	41.9	3.3	115.9	186.9	40.6	± 0.5	35.1
H07-HU-006-6	616	1138	3.0	24.6870	15.4	0.0354	15.8	0.0063	3.3	0.21	40.8	1.3	35.4	5.5	-318.5	397.8	40.8	± 1.3	-12.8
H07-HU-006-15	989	1979	4.2	23.5284	10.8	0.0374	10.9	0.0064	0.9	0.08	41.0	0.4	37.3	4.0	-196.7	272.2	41.0	± 0.4	-20.8
H07-HU-006-13	185	801	2.4	17.8929	33.7	0.0495	34.1	0.0064	4.7	0.14	41.3	1.9	49.1	16.3	447.9	770.0	41.3	± 1.9	9.2
H07-HU-006-29	1117	5302	5.2	23.0998	10.5	0.0385	10.7	0.0065	1.9	0.18	41.5	0.8	38.4	4.0	-150.9	260.8	41.5	± 0.8	-27.5
H07-HU-006-36	2154	3090	4.0	21.8226	5.5	0.0408	5.7	0.0065	1.3	0.23	41.5	0.5	40.6	2.3	-11.6	133.6	41.5	± 0.5	-357.9
H07-HU-006-1	1489	2301	3.9	25.0690	15.9	0.0358	16.2	0.0065	2.8	0.17	41.8	1.1	35.7	5.7	-358.1	414.6	41.8	± 1.1	-11.7
H07-HU-006-8	1089	1938	4.2	21.8802	13.5	0.0411	13.8	0.0065	2.8	0.20	41.9	1.2	40.9	5.5	-18.0	327.4	41.9	± 1.2	-233.0
H07-HU-006-19	1017	2275	3.2	20.2953	14.8	0.0455	14.9	0.0067	1.8	0.12	43.1	0.8	45.2	6.6	160.8	346.9	43.1	± 0.8	26.8
H07-HU-006-21	446	418	11.8	24.3428	16.3	0.0460	16.4	0.0081	1.6	0.10	52.2	0.8	45.7	7.3	-282.6	416.8	52.2	± 0.8	-18.5
H07-HU-006-7	955	2849	5.9	20.4881	26.1	0.0558	26.4	0.0083	3.6	0.14	53.3	1.9	55.2	14.2	138.7	622.8	53.3	± 1.9	38.4
H07-HU-006-40	2671	10302	11.1	20.8830	4.4														

APPENDIX C

$^{40}\text{Ar}/^{39}\text{Ar}$

C.1 Methods

Argon isotopes were analyzed using static mode noble gas mass spectrometry at the New Mexico Geochronology Research Laboratory (NMGRL). Samples were loaded into 20-hole aluminum trays with FC-2 sanidine as the flux monitor, with an assigned age of 28.201 Ma (Kuiper et al., 2008). The Kuiper age for Fish Canyon was chosen because it has been calibrated to the Astronomical Time Scale, and therefore is believed to be the most accurate. The large uncertainty in the decay constant ($5.463\text{e}^{10} \pm 2.14\text{e}^{-11}$) results in large (1 – 2 Ma) external error in comparison to the ~0.1 – 0.2% precision of the $^{40}\text{Ar}/^{39}\text{Ar}$ method. For K-feldspar samples, FC-2 was placed in every third hole; the remainder of the samples were packaged with FC-2 placed at the 0°, 90°, 180°, and 270° locations. Three fine-grained biotites (F08-LP-003, 007, and 008) were wrapped in copper foil prior to irradiation and loaded into 6-hole aluminum trays to avoid possible irradiated sample dispersal. The trays were stacked and sealed in evacuated quartz cylinders and irradiated in the central thimble of the TRIGA reactor in Denver, CO. In total, four irradiations (NM – 212, 218, 220, and 223) were done; one for 10 hours, one for 60, and two more for 10 hours, respectively. For correction factors refer to the bottom of the data tables in this section.

Following irradiation, unknown samples were loaded into Cu foil packets and step heated in a double vacuum Mo furnace. Biotite, muscovite, and hornblende steps

ranged from 3 – 7 minutes, but were typically 4 minutes. K-feldspar heating steps were highly variable, and were designed to resolve the age spectrum and maximize recovery of diffusion coefficients. Isothermal replicates were run to determine excess argon in each diffusion domain (e.g. Harrison et al., 1993). During heating the gas was reacted with a SAES GP-50 getter at 450°C. The gas was then expanded into the second stage, where it was reacted with two GP-50 getters (one at 20°C and the other at 450°C) and a W filament run at 2000°C. K-feldspars were cleaned for 2 minutes, and biotite, muscovite, and hornblende were cleaned for 4 minutes. The temperature in the furnace was measured with a thermocouple in contact with the base of the crucible that was calibrated with Cu foil melting experiments. Typical temperature offsets were $80 \pm 15^\circ\text{C}$. Blanks and backgrounds were measured before, during, and after each biotite, muscovite, and hornblende analysis, and before and after each K-feldspar analysis.

The neutron flux was monitored with Fish Canyon (FC-2) sanidine. Six crystals from each location in the aluminum disks were fused with a Synrad CO₂ laser with a 3.3 W beam for 20 seconds. The gas was reacted with 2 GP-50 getters (one at 20°C and one at 450°C) for 3 to 5 minutes, and cleaned with a 2000°C W filament and a cold finger operated at -141°C. A plane was fit to the mean of each monitor location, and J values were assigned to the unknowns based on their geometry in relation to the monitors. Errors in the J values are approximately 0.1 to 0.2%.

Data were reduced using MassSpec v. 7.700 written by A. Deino. The internal errors reflect uncertainties in the mass discrimination, blanks and baselines, J error, interfering reactions, and the signal intensity vs. time regressions. External errors reflect the error in the decay constant of potassium and the error of FC-2. Integrated ages were calculated via summation of all isotopes, and errors are determined by quadratic summation of signal uncertainties. Plateau ages are determined by weighting by the inverse variance; errors are the summation of the weighted factors (Taylor, 1982). If the calculated MSWD

was greater than 1 the error was multiplied by the square root of the MSWD. Precision the age measurement error was typically $\pm 0.15\%$.

Huron Peak Biotite Vertical Traverse

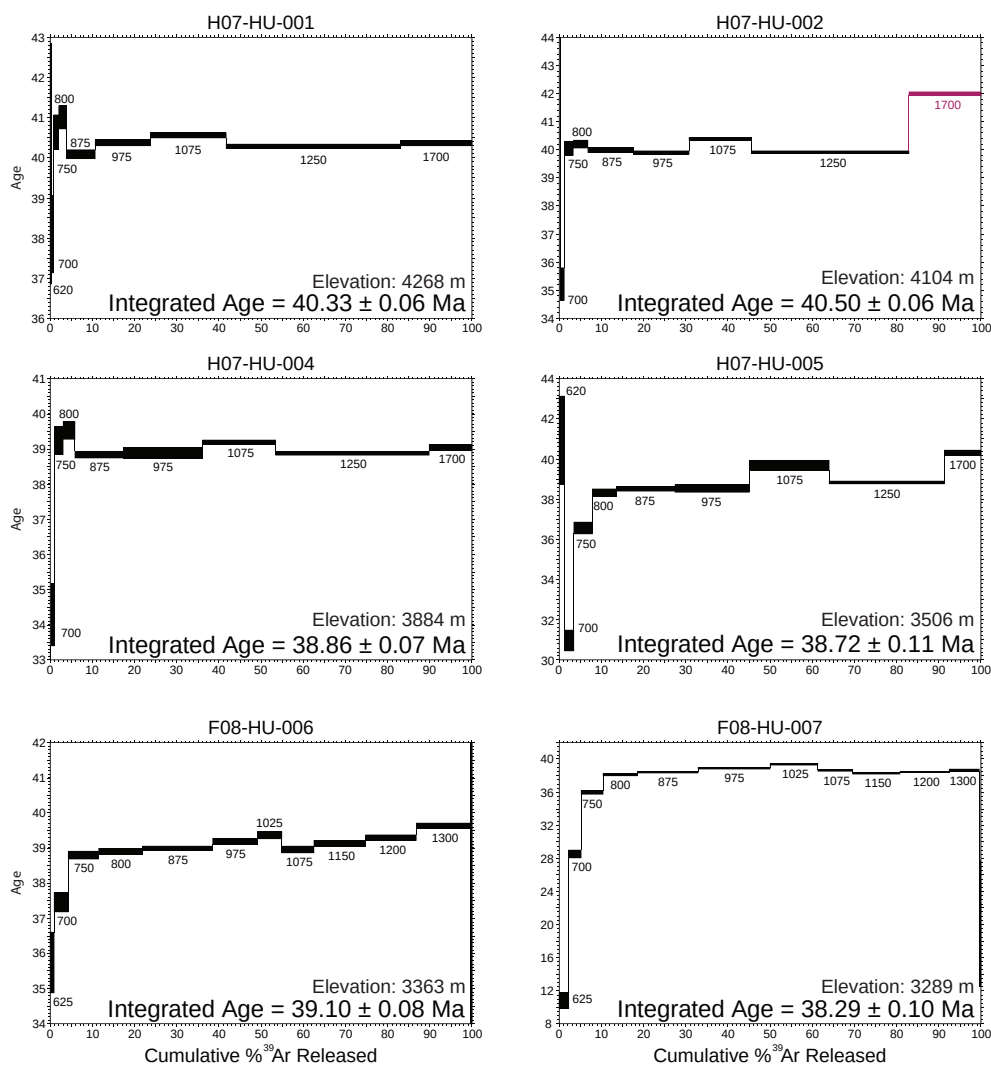


Figure C.1: Biotite age spectra from samples on the Huron Peak vertical traverse. Samples with H07 at the beginning of their names were collected and analyzed roughly a year before those that begin with F08. Ages generally decrease with decreasing elevation. Purple steps have been omitted from age calculations because they are anomalously old and likely represent non-biotite inclusions. Errors are reported at 1-sigma without external errors.

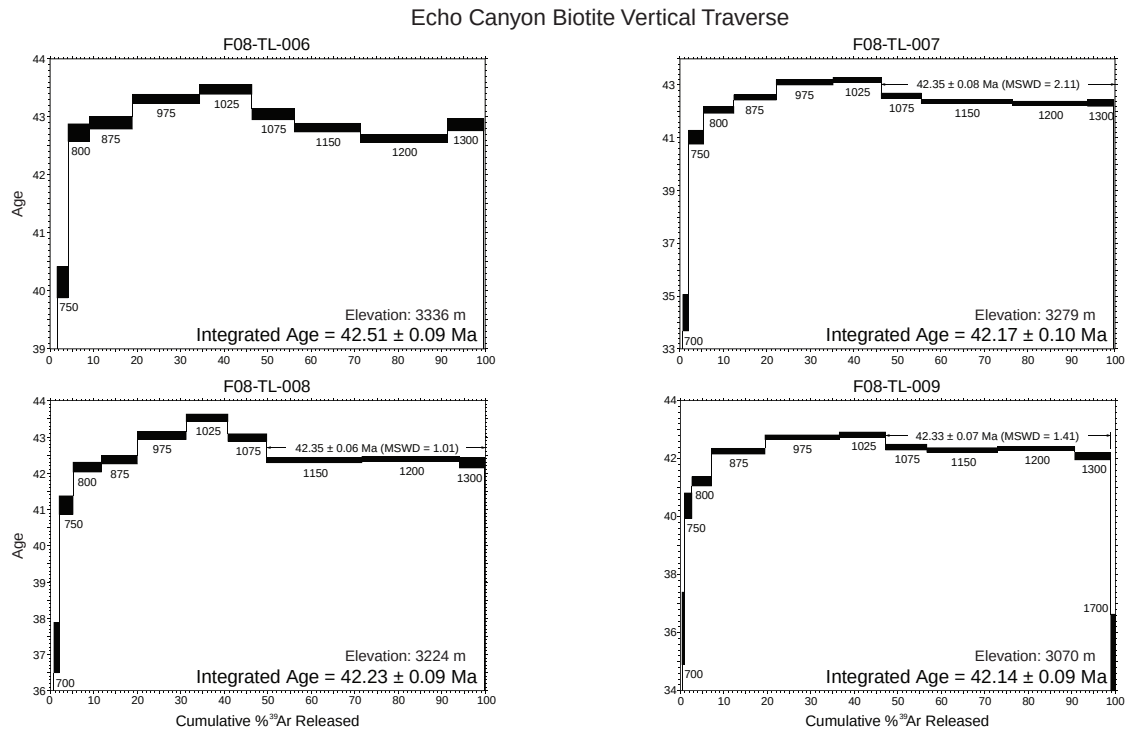


Figure C.2: Biotite age spectra from samples on the Echo Canyon vertical traverse. Three of the four age spectra have plateaus as defined by three or more steps within 2-sigma that make up more than 50% of the ^{39}Ar released. The shape of the spectra is interpreted to indicate recoil of ^{39}Ar . Reported ages are the integrated ages as discussed in the text. Errors are reported at 1-sigma without external errors.

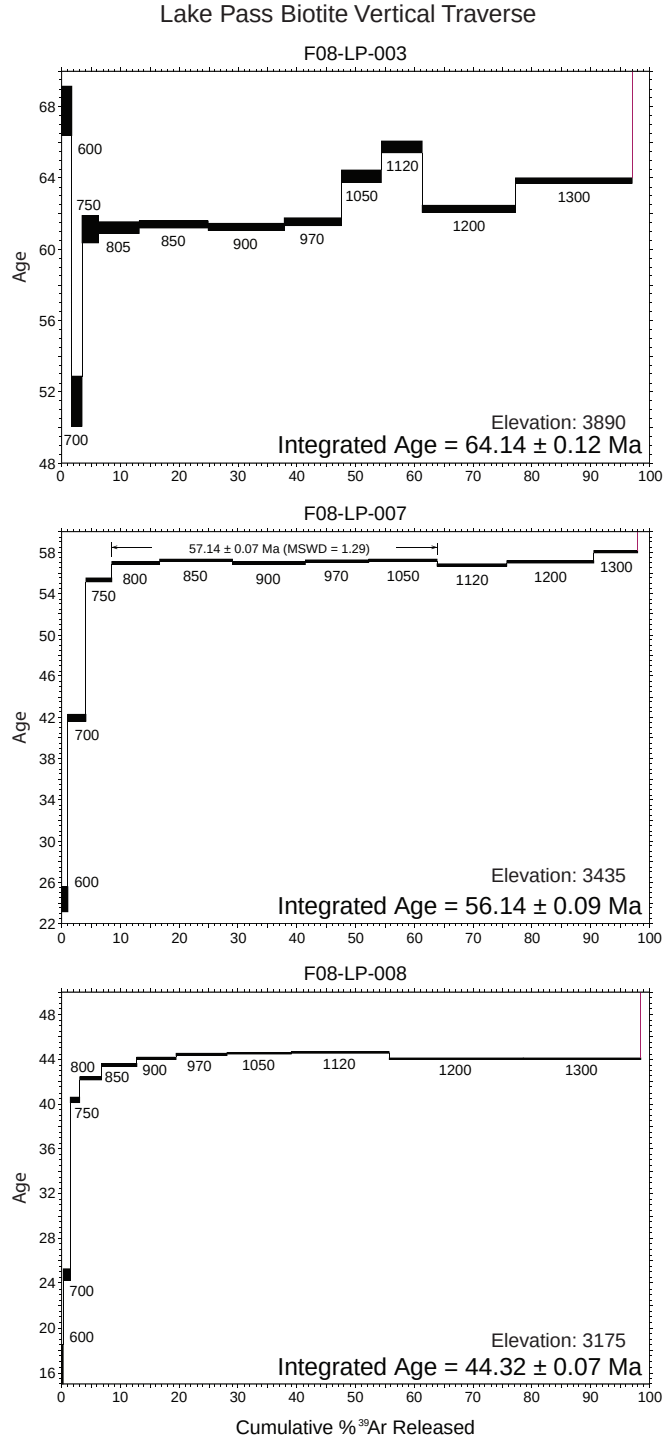


Figure C.3: Biotite age spectra from samples on the Lake Pass vertical traverse. Purple steps have been omitted from age calculations because they are anomalously old and likely represent non-biotite inclusions. The hump shape is interpreted to indicate recoil of ^{39}Ar . Reported ages are the integrated ages, as discussed in the text. Errors are reported at 1-sigma.

Huron Peak Biotite Age Spectra

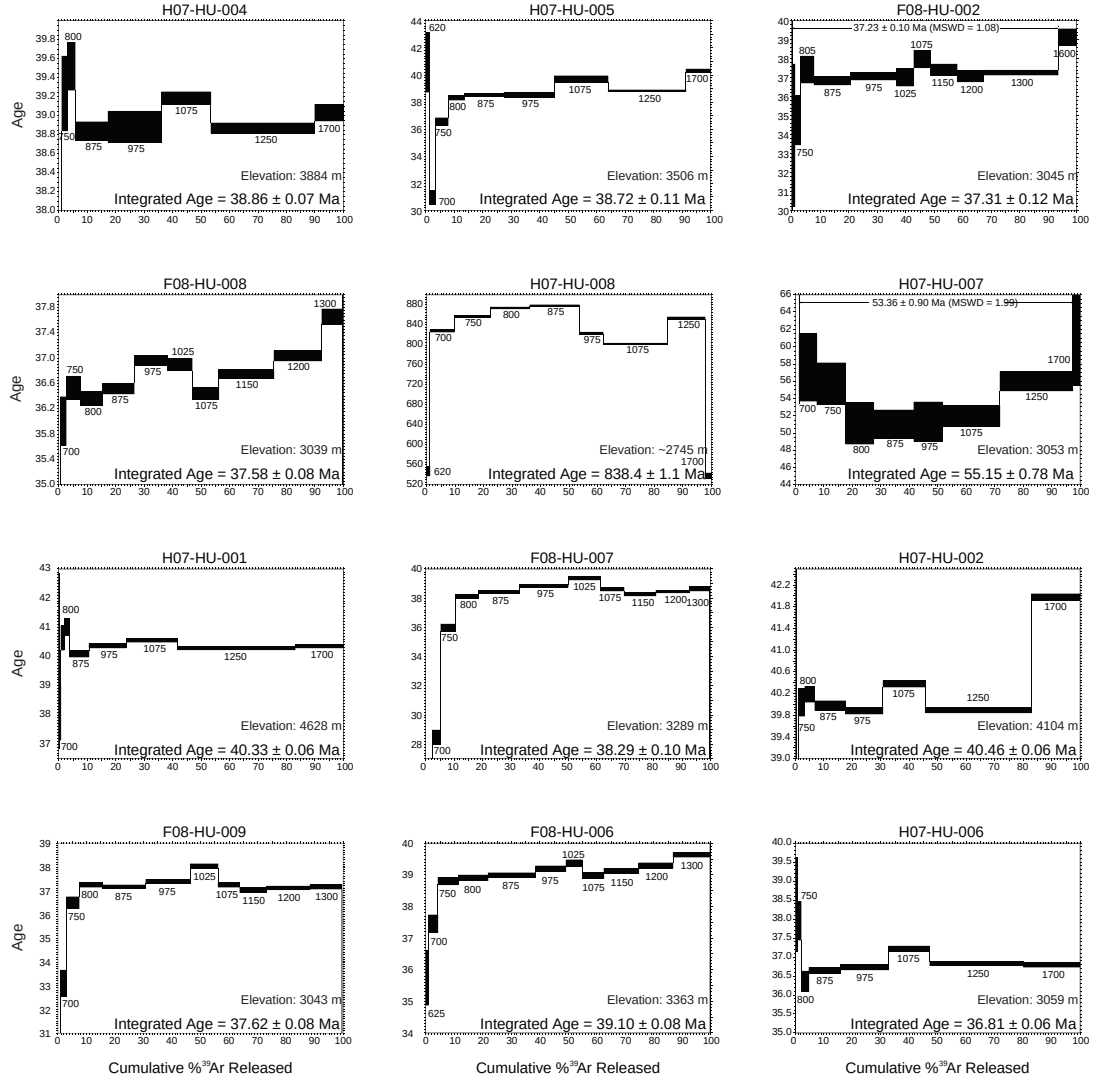


Figure C.4: Biotite age spectra from the Huron Peak area. Plateaus are defined by three or more steps overlapping at 2-sigma, consisting of at least 50% of the total ^{39}Ar released. The hump shape is interpreted to indicate recoil of ^{39}Ar . Reported ages are the integrated ages, as discussed in the text. Errors are reported at 1-sigma.

Twin Lakes Biotite Age Spectra

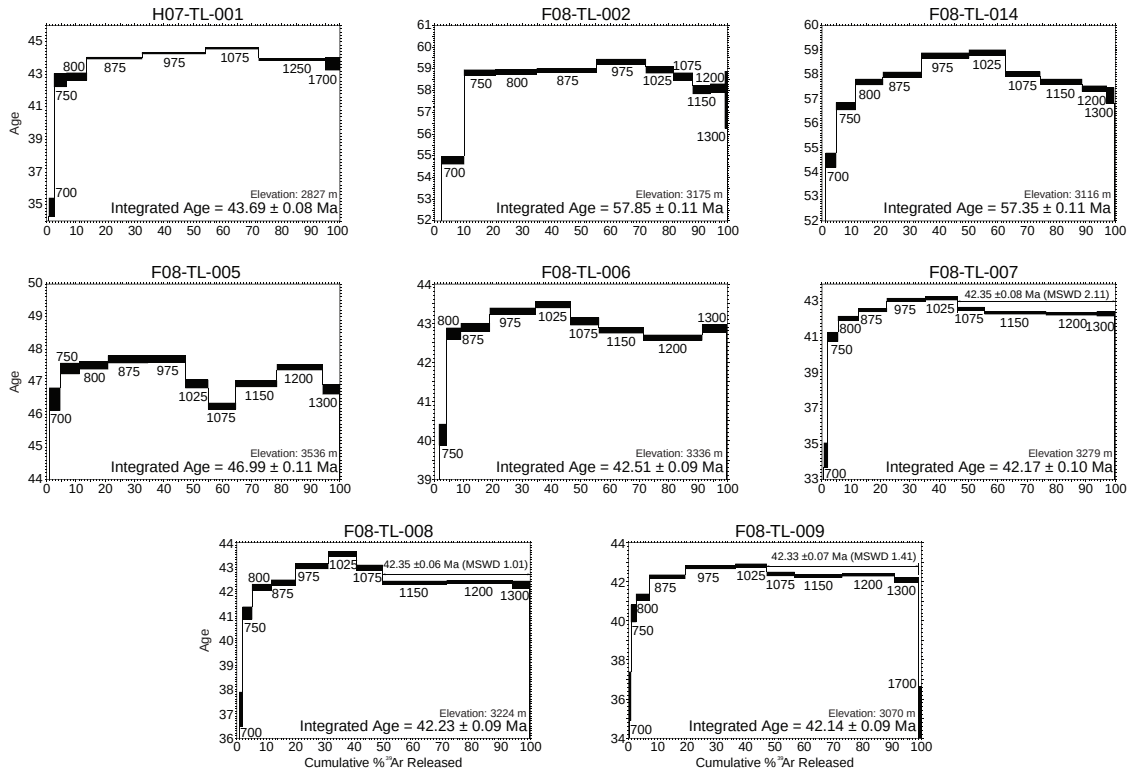


Figure C.5: Biotite age spectra from the Twin Lakes area. Plateaus are defined by three or more steps overlapping at 2-sigma, consisting of at least 50% of the total ^{39}Ar released. The hump shape is interpreted to indicate recoil of ^{39}Ar . Reported ages are the integrated ages, as discussed in the text. Errors are reported at 1-sigma.

Table C.1: Biotite $^{40}\text{Ar}/^{39}\text{Ar}$ analytical data

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1\sigma$ (Ma)	Time (min)
F08-HU-002, Biotite, 1.24 mg, J=0.01216 $\pm$ 0.10%, D=1.0014 $\pm$ 0.001, NM-218F, Lab#=57977-01											
B	625	9.623	0.1709	28.95	0.537	3.0	11.1	0.2	23.7	19.8	5
C	700	5.167	0.0420	12.27	3.09	12.2	29.8	1.1	34.0	3.8	5
D	750	3.113	-0.0009	5.194	6.76	-	50.7	3.1	34.8	1.3	5
E	800	2.157	0.0019	1.542	15.7	272.1	78.9	7.8	37.49	0.71	5
F	875	1.804	0.0029	0.4383	42.3	173.0	92.9	20.6	36.90	0.23	5
G	975	1.751	0.0030	0.2251	54.3	171.3	96.2	36.9	37.13	0.20	5
H	1025	1.774	0.0104	0.3109	20.1	49.2	94.9	42.9	37.08	0.47	5
I	1075	1.776	0.0058	0.1700	19.3	87.6	97.2	48.7	38.04	0.46	5
J	1150	1.757	0.0129	0.1905	31.0	39.5	96.8	58.0	37.49	0.29	5
K	1200	1.760	0.0270	0.2572	30.8	18.9	95.7	67.3	37.13	0.30	5
L	1300	1.754	0.0901	0.2056	87.6	5.7	96.6	93.6	37.32	0.14	5
X M	1600	2.102	0.0117	1.092	21.4	43.4	84.7	100.0	39.20	0.44	5
Integrated age $\pm 1\sigma$ n=12 K2O=8.48% Age – 37.31 $\pm$0.12											
Plateau $\pm 1\sigma$ steps B-L n=11 MSWD=1.15 Age – 37.23 $\pm$0.10											
F08-HU-006, Biotite, 5.94 mg, J=0.0021151 $\pm$ 0.08%, D=1.004 $\pm$ 0.001, NM-220J, Lab#=58088-01											
X A	625	27.81	0.0322	62.53	2.03	15.8	33.5	1.0	35.76	0.87	5
X B	700	13.85	0.0135	13.77	6.45	37.9	70.6	4.4	37.47	0.28	5
X C	750	11.00	0.0082	2.904	13.8	62.2	92.2	11.5	38.81	0.11	5
X D	800	10.48	0.0053	1.038	20.1	96.2	97.1	21.9	38.921	0.088	5
X E	875	10.41	0.0050	0.7235	32.5	103.0	97.9	38.6	39.012	0.069	5
X F	975	10.60	0.0072	1.206	20.6	70.5	96.6	49.3	39.216	0.090	5
X G	1025	10.77	0.0084	1.603	11.0	60.7	95.6	55.0	39.38	0.10	5
X H	1075	10.65	0.0088	1.552	14.8	58.1	95.7	62.6	38.986	0.097	5
X I	1150	10.64	0.0194	1.385	24.0	26.3	96.2	74.9	39.149	0.084	5
X J	1200	10.64	0.0806	1.254	23.1	6.3	96.6	86.9	39.317	0.083	5
X K	1300	10.86	0.0229	1.698	25.1	22.3	95.4	99.8	39.650	0.077	5
X L	1700	438.6	0.7539	1452.8	0.377	0.68	2.1	100.0	35.7	10.3	5
Integrated age $\pm 1\sigma$ n=12 K2O=5.93% Age – 39.097 $\pm$0.077											
F08-HU-007, Biotite, 4.72 mg, J=0.0021429 $\pm$ 0.06%, D=1.004 $\pm$ 0.001, NM-220K, Lab#=58090-01											
X A	625	42.59	0.0832	134.6	2.85	6.1	6.6	2.3	11.03	1.00	5
X B	700	16.88	0.0255	31.78	3.75	20.0	44.3	5.3	29.10	0.48	5
X C	750	13.05	0.0126	12.11	6.47	40.5	72.6	10.4	36.74	0.26	5
X D	800	11.19	0.0083	3.887	10.3	61.3	89.7	18.6	38.92	0.14	5
X E	875	10.89	0.0085	2.600	18.0	60.3	92.9	33.0	39.23	0.11	5
X F	975	11.17	0.0105	3.162	21.3	48.7	91.6	50.0	39.68	0.10	5
X G	1025	11.20	0.0135	2.810	14.2	37.7	92.6	61.3	40.18	0.11	5
X H	1075	10.83	0.0203	2.238	10.5	25.1	93.9	69.7	39.43	0.14	5
X I	1150	10.67	0.0502	2.015	13.9	10.2	94.5	80.8	39.07	0.11	5
X J	1200	10.55	0.3102	1.510	14.7	1.6	96.0	92.6	39.263	0.093	5
X K	1300	11.26	0.4113	3.782	8.8	1.2	90.4	99.6	39.46	0.15	5
X L	1700	343.3	0.4027	1144.2	0.483	1.3	1.5	100.0	20.5	7.8	5
Integrated age $\pm 1\sigma$ n=12 K2O=4.76% age – 38.29 $\pm$0.10											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1\text{s}$ (Ma)	Time (min)
F08-HU-008, Biotite, 5.22 mg, J=0.0021453 $\pm$ 0.05%, D=1.004 $\pm$ 0.001, NM-220K, Lab#=58099-01											
X A	625	36.92	0.0984	97.90	0.95	5.2	21.6	0.7	31.1	1.6	5
X B	700	13.88	0.0297	14.88	2.88	17.2	68.3	2.8	36.82	0.40	5
X C	750	10.85	0.0137	4.170	6.72	37.2	88.6	7.7	37.35	0.19	5
X D	800	10.05	0.0093	1.625	10.8	54.8	95.2	15.5	37.18	0.11	5
X E	875	9.948	0.0093	1.126	15.3	54.8	96.7	26.6	37.339	0.085	5
X F	975	10.04	0.0125	1.048	16.1	40.7	96.9	38.3	37.798	0.085	5
X G	1025	10.07	0.0117	1.214	11.9	43.7	96.4	47.0	37.73	0.10	5
X H	1075	9.977	0.0141	1.292	12.8	36.1	96.2	56.3	37.26	0.10	5
X I	1150	9.984	0.0169	1.040	26.6	30.3	96.9	75.7	37.579	0.073	5
X J	1200	10.02	0.0381	0.9111	23.1	13.4	97.3	92.5	37.874	0.083	5
X K	1300	10.74	0.0560	2.789	10.2	9.1	92.4	99.8	38.51	0.12	5
X L	1700	654.5	0.3690	2194.1	0.218	1.4	0.9	100.0	24.1	15.8	5
Integrated age $\pm 1\text{s}$ n=12 K2O=4.72% Age – 37.581 $\pm$0.076											
F08-HU-009, Biotite, 4.3 mg, J=0.0021398 $\pm$ 0.05%, D=1.004 $\pm$ 0.001, NM-220K, Lab#=58091-01											
X A	625	39.27	0.1213	116.8	1.36	4.2	12.1	1.0	18.5	1.3	5
X B	700	15.25	0.0337	22.13	2.63	15.2	57.1	3.1	33.76	0.56	5
X C	750	12.00	0.0128	8.094	5.85	39.8	80.1	7.6	37.22	0.25	5
X D	800	10.33	0.0089	1.764	10.5	57.3	95.0	15.6	37.98	0.11	5
X E	875	10.11	0.0065	1.100	19.9	78.1	96.8	30.9	37.897	0.080	5
X F	975	10.26	0.0095	1.416	20.2	53.6	95.9	46.4	38.127	0.091	5
X G	1025	10.50	0.0153	1.633	12.6	33.4	95.4	56.1	38.78	0.10	5
X H	1075	10.24	0.0223	1.489	10.0	22.8	95.7	63.8	37.97	0.10	5
X I	1150	10.26	0.0561	1.756	12.3	9.1	95.0	73.3	37.76	0.11	5
X J	1200	10.07	0.2174	1.080	19.7	2.3	97.0	88.4	37.841	0.079	5
X K	1300	10.38	0.1558	2.068	14.6	3.3	94.2	99.7	37.900	0.096	5
X L	1700	400.4	0.3191	1351.9	0.396	1.6	0.2	100.0	3.6	9.4	5
Integrated age $\pm 1\text{s}$ n=12 K2O=5.43% Age – 37.615 $\pm$0.084											
F08-LP-003, Biotite, 2 mg, J=0.0023076 $\pm$ 0.07%, D=1.004 $\pm$ 0.001, NM-223D, Lab#=58895-01											
X L	1680	32.73	0.0052	10.71	1.62	98.0	90.3	2.9	120.79	0.94	6
X A	600	31.05	0.0360	49.83	1.05	14.2	52.6	4.7	67.7	1.4	6
X B	700	20.01	0.0464	25.94	0.91	11.0	61.7	6.3	51.4	1.4	6
X C	750	19.60	0.0154	16.57	1.64	33.1	75.0	9.3	61.05	0.78	6
X D	800	16.37	0.0037	5.555	3.90	138.8	90.0	16.2	61.16	0.33	6
X E	850	15.27	0.0042	1.693	6.59	121.3	96.7	27.9	61.32	0.21	6
X F	900	15.05	0.0005	1.051	7.24	1030.1	97.9	40.7	61.17	0.20	6
X G	970	15.22	0.0032	1.378	5.55	160.4	97.3	50.6	61.49	0.22	6
X H	1050	16.08	0.0027	2.185	3.76	186.9	96.0	57.3	64.01	0.34	6
X I	1120	16.35	0.0027	1.731	3.96	188.1	96.9	64.3	65.67	0.32	6
X J	1200	15.72	0.0027	2.502	8.9	188.0	95.3	80.1	62.19	0.19	6
X K	1300	15.77	0.0018	1.336	11.2	286.7	97.5	100.0	63.79	0.15	6
Integrated age $\pm 1\text{s}$ n=12 K2O=4.69% Age – 64.14 $\pm$0.12											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-LP-007, Biotite, 5.4 mg, J=0.002377 $\pm$ 0.07%, D=1.004 $\pm$ 0.001, NM-223J, Lab#=58927-01											
X A	600	33.56	0.1871	94.57	2.33	2.7	16.8	1.2	24.3	1.2	6
X B	700	14.98	0.5400	17.83	6.16	0.94	65.1	4.2	41.94	0.32	6
X C	750	14.36	0.3770	5.001	8.9	1.4	89.9	8.7	55.31	0.19	6
D	800	13.88	0.0747	1.932	16.2	6.8	95.9	16.7	56.99	0.13	6
E	850	13.63	0.0103	0.8633	25.1	49.3	98.1	29.2	57.25	0.11	6
F	900	13.55	0.0066	0.8244	24.9	77.2	98.2	41.6	56.98	0.12	6
G	970	13.67	0.0084	1.063	21.7	60.4	97.7	52.3	57.18	0.11	6
H	1050	13.71	0.0109	1.150	23.3	46.8	97.5	63.9	57.25	0.12	6
X I	1120	13.48	0.0073	0.7405	24.0	70.1	98.4	75.8	56.76	0.11	6
X J	1200	13.50	0.0086	0.5786	29.8	59.4	98.7	90.7	57.07	0.10	6
X K	1300	13.68	0.0224	0.3918	14.9	22.7	99.2	98.0	58.05	0.12	6
X L	1680	23.10	0.0112	4.370	3.94	45.7	94.4	100.0	92.47	0.33	6
Integrated age $\pm 1s$ n=12 K2O=6.02% Age – 56.961 $\pm$0.088											
Plateau $\pm 1s$ steps D-H n=5 MSWD=1.29 Age – 57.138 $\pm$0.072											
F08-LP-008, Biotite, 9.7 mg, J=0.0023774 $\pm$ 0.08%, D=1.004 $\pm$ 0.001, NM-223J, Lab#=58926-02											
X A	600	53.12	0.2345	167.1	1.42	2.2	7.1	0.3	16.4	2.1	6
X B	700	17.10	0.1225	38.47	4.71	4.2	33.5	1.5	24.77	0.54	6
X C	750	13.44	0.0291	13.70	6.69	17.5	69.9	3.1	40.40	0.26	6
X D	800	11.88	0.0116	6.899	15.3	44.1	82.8	6.9	42.32	0.14	6
X E	850	10.97	0.0078	2.863	24.1	65.2	92.3	12.8	43.50	0.11	6
X F	900	11.03	0.0094	2.603	27.5	54.2	93.0	19.6	44.09	0.11	6
X G	970	11.02	0.0093	2.267	35.3	55.1	93.9	28.2	44.46	0.10	6
X H	1050	11.10	0.0138	2.480	44.8	37.0	93.4	39.2	44.546	0.083	6
X I	1120	10.77	0.0226	1.263	67.5	22.6	96.6	55.7	44.652	0.069	6
X J	1200	10.48	0.0269	0.7745	93.3	18.9	97.8	78.6	44.052	0.064	6
X K	1300	10.38	0.1150	0.4471	81.7	4.4	98.8	98.6	44.052	0.061	6
X L	1680	20.43	0.0449	3.980	5.57	11.4	94.3	100.0	81.89	0.27	6
Integrated age $\pm 1s$ n=12 K2O=6.80% Ages – 44.316 $\pm$0.072											
F08-TL-002, Biotite, 5.03 mg, J=0.0021156 $\pm$ 0.09%, D=1.004 $\pm$ 0.001, NM-220J, Lab#=58076-01											
X A	625	20.80	0.1190	41.57	4.43	4.3	41.0	2.7	32.67	0.59	5
X B	700	16.07	0.0084	5.718	12.5	60.7	89.5	10.2	54.83	0.18	5
X C	750	15.82	0.0046	1.215	17.8	111.5	97.7	20.8	58.88	0.13	5
X D	800	15.67	0.0034	0.6940	23.8	151.4	98.7	35.1	58.90	0.11	5
X E	875	15.70	0.0058	0.7147	33.8	88.4	98.7	55.3	58.97	0.11	5
X F	975	16.09	0.0095	1.661	28.1	53.5	97.0	72.2	59.38	0.12	5
X G	1025	15.94	0.0115	1.509	15.8	44.4	97.2	81.7	59.02	0.15	5
X H	1075	15.87	0.0238	1.562	10.9	21.4	97.1	88.2	58.69	0.18	5
X I	1150	15.96	0.0802	2.430	9.9	6.4	95.5	94.2	58.09	0.19	5
X J	1200	15.91	0.2809	2.237	8.3	1.8	96.0	99.1	58.16	0.20	5
X K	1300	22.94	3.745	27.61	1.34	0.14	65.8	100.0	57.6	1.3	5
X L	1700	1703.8	5.876	5861.3	0.082	0.087	-1.6	100.0	-111.4	53.0	5
Integrated age $\pm 1s$ n=12 K2O=6.02% Ages – 57.85 $\pm$0.1											

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	37Ar/39Ar	36Ar/39Ar (x 10-3)	39ArK (x 10-15 mol)	K/Ca	40Ar (%)	39Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-005, Biotite, 5.1 mg, J=0.002144±0.06%, D=1.004±0.001, NM-220K, Lab#=58089-01											
X A	625	103.4	0.0865	328.3	1.58	5.9	6.2	1.0	24.9	2.6	5
X B	700	20.62	0.0132	28.28	5.67	38.7	59.5	4.7	47.49	0.35	5
X C	750	14.45	0.0043	6.547	10.2	120.0	86.6	11.3	48.44	0.17	5
X D	800	13.77	0.0039	4.137	15.1	130.3	91.1	21.0	48.55	0.12	5
X E	875	13.34	0.0035	2.530	20.9	147.2	94.4	34.6	48.73	0.11	5
X F	975	13.45	0.0056	2.869	19.8	91.9	93.7	47.4	48.75	0.11	5
X G	1025	13.18	0.0066	2.685	12.0	77.8	94.0	55.1	47.96	0.13	5
X H	1075	12.62	0.0050	1.404	14.7	102.6	96.7	64.6	47.265	0.099	5
X I	1150	12.75	0.0084	1.216	21.5	60.4	97.2	78.6	47.968	0.096	5
X J	1200	12.78	0.0322	0.8682	24.2	15.8	98.0	94.2	48.485	0.088	5
X K	1300	13.38	0.0440	3.504	8.7	11.6	92.3	99.9	47.79	0.15	5
X L	1700	807.3	0.4466	2747.5	0.192	1.1	-0.6	100.0	-17.9	20.2	5
Integrated age ± 1s n=12 K2O=5.43% Ages – 47.96 ±0.11											
F08-TL-006, Biotite, 5.83 mg, J=0.0021128±0.11%, D=1.004±0.001, NM-220J, Lab#=58080-03											
X A	625	43.37	0.2587	140.4	1.29	2.0	4.3	0.7	7.3	1.7	5
X B	700	19.41	0.0820	36.48	1.75	6.2	44.5	1.6	33.06	0.73	5
X C	750	13.86	0.0164	11.37	4.71	31.1	75.8	4.2	40.13	0.27	5
X E	800	12.12	0.0273	3.181	9.2	18.7	92.3	9.1	42.71	0.15	5
X F	875	11.88	0.0233	2.223	18.2	21.9	94.5	19.0	42.87	0.11	5
X G	975	11.80	0.0115	1.582	28.7	44.4	96.0	34.4	43.290	0.080	5
X H	1025	11.70	0.0184	1.097	22.3	27.7	97.2	46.4	43.455	0.085	5
X I	1075	11.52	0.0399	0.8703	18.0	12.8	97.8	56.1	43.027	0.097	5
X J	1150	11.39	0.0513	0.6382	28.3	9.9	98.4	71.4	42.794	0.074	5
X K	1200	11.32	0.1411	0.5837	37.2	3.6	98.6	91.5	42.612	0.072	5
X L	1300	11.71	0.1325	1.714	15.4	3.9	95.8	99.8	42.85	0.10	5
X M	1700	413.7	4.936	1388.2	0.387	0.10	0.9	100.0	14.9	10.6	5
Integrated age ± 1s n=12 K2O=5.78% Ages – 42.508 ±0.088											
F08-TL-007, Biotite, 4.74 mg, J=0.0021119±0.09%, D=1.004±0.001, NM-220J, Lab#=58085-01											
X A	625	56.11	0.5025	174.4	1.03	1.0	8.2	0.7	17.7	2.2	4
X B	700	21.48	0.0538	42.32	2.01	9.5	41.8	2.0	34.34	0.69	5
X C	750	14.12	0.0142	11.48	5.29	36.0	76.0	5.6	40.99	0.26	5
X D	800	12.33	0.0073	4.481	10.2	70.0	89.3	12.4	42.03	0.14	5
X E	875	11.95	0.0097	2.760	14.6	52.8	93.2	22.2	42.50	0.10	5
X F	975	11.96	0.0106	2.307	19.5	47.9	94.3	35.3	43.06	0.10	5
X G	1025	11.83	0.0158	1.795	16.5	32.2	95.5	46.3	43.149	0.098	5
H	1075	11.67	0.0316	1.785	13.7	16.2	95.5	55.5	42.558	0.099	5
I	1150	11.43	0.0369	1.185	31.4	13.8	97.0	76.5	42.332	0.076	5
J	1200	11.43	0.1083	1.253	25.8	4.7	96.8	93.8	42.264	0.079	5
K	1300	12.55	0.0579	5.023	9.0	8.8	88.2	99.8	42.28	0.13	5
L	1700	717.1	2.014	2416.2	0.254	0.25	0.5	100.0	12.8	18.6	5
Integrated age ± 1s n=12 K2O=5.73% Age – 42.170 ±0.096											
Plateau ± 1s steps H-L n=5 MSWD=2.11 Age – 42.351 ±0.075											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10 ⁻³)	^{39}ArK (x 10 ⁻¹⁵ mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-008, Biotite, 5.85 mg, J=0.0021132±0.08%, D=1.004±0.001, NM-220J, Lab#=58086-01											
X A	625	60.44	0.3066	191.7	1.52	1.7	6.3	0.9	14.6	1.8	5
X B	700	23.21	0.1205	45.70	2.07	4.2	41.8	2.1	37.17	0.70	5
X C	750	15.32	0.0219	15.45	5.60	23.3	70.2	5.3	41.11	0.26	5
X D	800	12.69	0.0131	5.600	11.3	39.0	87.0	11.8	42.16	0.14	5
X E	875	12.23	0.0151	3.892	14.4	33.8	90.6	20.1	42.35	0.12	5
X F	975	12.04	0.0151	2.636	19.4	33.8	93.5	31.2	43.02	0.11	5
X G	1025	11.95	0.0220	1.883	16.8	23.2	95.4	40.9	43.513	0.100	5
X H	1075	11.68	0.0559	1.475	15.6	9.1	96.3	49.8	42.97	0.10	5
I	1150	11.40	0.0534	1.079	38.1	9.6	97.2	71.7	42.344	0.077	5
J	1200	11.36	0.0847	0.9265	38.9	6.0	97.7	94.1	42.379	0.072	5
K	1300	12.20	0.0829	3.859	10.0	6.2	90.7	99.9	42.28	0.14	5
L	1700	733.1	1.759	2470.9	0.228	0.29	0.4	100.0	11.8	19.0	5
Integrated age ± 1s n=12 K2O=5.41% Age – 42.228 ±0.093											
Plateau ± 1s steps I-L n=4 MSWD=1.01 Age – 42.352 ±0.061											
F08-TL-009, Biotite, 5.04 mg, J=0.0021149±0.10%, D=1.004±0.001, NM-220J, Lab#=58078-01											
X A	625	50.22	0.2184	159.0	0.77	2.3	6.4	0.5	12.5	2.4	5
X B	700	19.52	0.0747	34.12	0.88	6.8	48.3	1.0	36.2	1.3	5
X C	750	14.38	0.0241	12.92	2.76	21.1	73.4	2.7	40.39	0.44	5
X D	800	11.84	0.0103	3.583	7.29	49.6	91.1	7.2	41.23	0.17	5
X E	875	11.42	0.0072	1.218	20.1	70.6	96.9	19.5	42.277	0.099	5
X F	975	11.39	0.0074	0.7104	27.8	68.5	98.2	36.7	42.752	0.080	5
X G	1025	11.52	0.0139	1.053	17.3	36.8	97.3	47.3	42.848	0.088	5
H	1075	11.49	0.0224	1.334	15.4	22.8	96.6	56.8	42.418	0.096	5
I	1150	11.38	0.0376	1.054	26.4	13.6	97.3	73.0	42.318	0.078	5
J	1200	11.31	0.1504	0.8404	28.9	3.4	97.9	90.8	42.362	0.075	5
K	1300	12.02	0.2040	3.474	13.4	2.5	91.6	99.0	42.11	0.12	6
X L	1700	105.3	0.2664	325.9	1.58	1.9	8.5	100.0	34.4	2.3	5
Integrated age ± 1s n=12 K2O=5.86% Age – 42.138 ±0.085											
Plateau ± 1s steps H-K n=4 MSWD=1.41 Age – 42.328 ±0.066											
F08-TL-014, Biotite, 4.68 mg, J=0.0021111±0.10%, D=1.004±0.001, NM-220J, Lab#=58082-01											
X A	625	25.93	0.3060	59.92	2.00	1.7	31.8	1.5	31.56	0.83	5
X B	700	17.62	0.3572	11.32	4.70	1.4	81.2	4.9	54.42	0.30	5
X C	750	15.80	0.0436	3.073	9.1	11.7	94.3	11.5	56.63	0.15	5
X D	800	15.56	0.0080	1.367	12.8	63.7	97.4	20.9	57.62	0.12	5
X E	875	15.59	0.0124	1.192	17.9	41.1	97.7	33.9	57.91	0.12	5
X F	975	15.82	0.0168	1.260	22.4	30.3	97.7	50.2	58.69	0.11	5
X G	1025	15.81	0.0227	1.132	17.3	22.5	97.9	62.8	58.82	0.12	5
X H	1075	15.57	0.0286	1.117	16.1	17.8	97.9	74.5	57.94	0.11	5
X I	1150	15.46	0.0480	1.040	19.6	10.6	98.0	88.8	57.63	0.11	5
X J	1200	15.46	0.1103	1.307	11.4	4.6	97.6	97.1	57.35	0.12	5
X K	1300	17.10	0.2589	7.157	3.61	2.0	87.7	99.7	57.06	0.33	5
X L	1700	418.7	3.360	1401.9	0.399	0.15	1.1	100.0	18.1	9.9	5
Integrated age ± 1s n=12 K2O=5.34% Age – 57.35 ±0.11											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1\text{s}$ (Ma)	Time (min)
H07-HU-001, Biotite, 5.79 mg, J=0.0022974 $\pm$ 0.07%, D=1.0006 $\pm$ 0.001, NM-212E, Lab#=57449-01											
X A	625	79.83	0.2567	237.8	0.97	2.0	12.0	0.3	39.8	3.0	4
X B	700	17.85	0.0456	29.45	1.97	11.2	51.2	0.8	38.05	0.95	7
X C	750	13.44	0.0210	12.44	4.15	24.3	72.7	2.0	40.59	0.42	7
X D	800	11.29	0.0144	4.861	6.7	35.4	87.3	3.9	40.96	0.29	5
X E	875	10.04	0.0076	1.365	24.1	67.4	96.0	10.8	40.04	0.11	7
X F	975	9.803	0.0088	0.3315	45.6	58.2	99.0	23.8	40.329	0.074	7
X G	1075	9.852	0.0155	0.3522	63.2	33.0	99.0	41.7	40.510	0.067	8
X H	1250	9.758	0.0681	0.2741	145.3	7.5	99.2	83.1	40.237	0.052	8
X I	1700	9.894	0.0934	0.6799	59.4	5.5	98.1	100.0	40.313	0.067	8
Integrated age $\pm 1\text{s}$ n=9 K2O=10.15% Age – 40.329 $\pm$0.060											
H07-HU-002, Biotite, 6.65 mg, J=0.0023005 $\pm$ 0.06%, D=1.0006 $\pm$ 0.001, NM-212E, Lab#=57442-01											
X A	625	75.63	0.3885	183.1	2.01	1.3	28.5	0.3	88.6	2.1	3
X B	700	21.88	0.3866	45.54	6.07	1.3	38.6	1.3	35.22	0.58	7
X C	750	14.64	0.0857	17.01	12.9	6.0	65.7	3.4	40.05	0.26	7
X D	800	11.43	0.0326	5.979	21.3	15.7	84.6	6.8	40.20	0.15	5
X E	875	10.20	0.0175	1.980	67.2	29.1	94.3	17.7	39.994	0.090	6
X F	975	9.776	0.0166	0.6376	81.3	30.8	98.1	30.8	39.900	0.061	6
X G	1075	9.935	0.0208	0.7736	92.1	24.5	97.7	45.7	40.392	0.059	7
X H	1250	9.795	0.0662	0.7112	231.1	7.7	97.9	83.0	39.911	0.054	7
X I	1700	10.35	0.1102	0.8999	104.9	4.6	97.5	100.0	41.995	0.064	8
Integrated age $\pm 1\text{s}$ n=9 K2O=15.54% Age – 40.499 $\pm$0.061											
H07-HU-004, Biotite, 5.99 mg, J=0.0022969 $\pm$ 0.07%, D=1.0006 $\pm$ 0.001, NM-212E, Lab#=57448-01											
X A	625	149.9	0.3255	488.1	0.84	1.6	3.8	0.3	23.9	5.0	4
X B	700	26.00	0.1808	60.20	3.11	2.8	31.6	1.2	34.24	0.89	7
X C	750	15.99	0.0591	22.23	6.31	8.6	58.9	3.1	39.18	0.39	7
X D	800	12.60	0.0244	10.52	9.6	20.9	75.3	5.9	39.47	0.25	4
X E	875	10.47	0.0092	3.842	38.3	55.7	89.2	17.4	38.790	0.097	5
X F	975	9.684	0.0125	1.151	62.4	40.7	96.5	36.2	38.84	0.17	7
X G	1075	9.794	0.0289	1.279	57.6	17.6	96.2	53.5	39.137	0.068	7
X H	1250	9.542	0.1063	0.7093	121.6	4.8	97.9	90.0	38.822	0.054	8
X I	1700	9.810	0.2678	1.534	33.3	1.9	95.6	100.0	38.984	0.088	8
Integrated age $\pm 1\text{s}$ n=9 K2O=9.30% Age – 38.863 $\pm$0.074											
H07-HU-005, Biotite, 6.56 mg, J=0.0022977 $\pm$ 0.06%, D=1.0006 $\pm$ 0.001, NM-212E, Lab#=57444-01											
X A	625	107.0	0.1346	328.8	4.20	3.8	9.2	1.2	40.9	2.2	4
X B	700	22.64	0.0740	51.51	8.1	6.9	32.8	3.6	30.91	0.52	6
X C	750	14.94	0.0193	20.84	15.2	26.4	58.8	7.9	36.53	0.30	7
X D	800	11.26	0.0115	6.939	19.5	44.5	81.8	13.6	38.28	0.18	5
X E	875	10.41	0.0104	3.904	47.8	49.2	88.9	27.5	38.47	0.11	6
X F	975	9.953	0.0101	2.346	60.7	50.4	93.0	45.1	38.50	0.19	8
X G	1075	10.26	0.0165	2.471	65.3	31.0	92.9	64.0	39.63	0.25	8
X H	1250	9.697	0.0909	1.263	94.5	5.6	96.2	91.4	38.794	0.065	8
X I	1700	10.31	0.3654	2.211	29.6	1.4	94.0	100.0	40.28	0.13	8
Integrated age $\pm 1\text{s}$ n=9 K2O=8.79% Age – 38.72 $\pm$0.1											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10 ⁻³)	^{39}ArK (x 10 ⁻¹⁵ mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H07-HU-006, Biotite, 5.72 mg, J=0.0022981±0.06%, D=1.0006±0.001, NM-212E, Lab#=57450-01											
X A	625	105.6	0.2482	339.5	0.69	2.1	5.0	0.2	21.9	3.8	4
X B	700	20.91	0.0789	39.58	1.64	6.5	44.1	0.8	38.4	1.2	7
X C	750	13.51	0.0232	14.86	4.03	22.0	67.5	2.3	37.92	0.51	7
X D	800	11.20	0.0171	8.346	7.3	29.9	78.0	4.9	36.33	0.27	5
X E	875	9.376	0.0073	1.940	30.9	69.9	93.9	15.9	36.621	0.083	7
X F	975	8.991	0.0085	0.5755	47.7	59.8	98.1	32.9	36.698	0.069	7
X G	1075	9.164	0.0235	0.7612	40.6	21.7	97.6	47.3	37.192	0.071	8
X H	1250	8.958	0.1038	0.4131	92.3	4.9	98.7	80.2	36.796	0.054	8
X I	1700	9.066	0.1429	0.8106	55.7	3.6	97.5	100.0	36.769	0.065	8
Integrated age ± 1s n=9 K2O=8.21% Age – 36.810 ±0.059											
H07-HU-007, Biotite, .3 mg, J=0.0022965±0.06%, D=1.0006±0.001, NM-212E, Lab#=57446-01											
X A	625	129.3	0.1163	315.0	0.084	4.4	28.0	1.4	146.0	19.2	4
B	700	16.68	0.0143	9.376	0.367	35.8	83.4	7.7	57.5	3.9	5
C	750	13.93	-0.0020	1.646	0.596	-	96.5	17.8	55.6	2.4	7
D	800	13.92	-0.0189	5.407	0.581	-	88.5	27.7	51.0	2.4	4
E	875	14.33	-0.0107	6.893	0.82	-	85.8	41.6	50.9	1.6	7
F	975	15.10	0.0006	9.240	0.596	809.6	81.9	51.8	51.2	2.3	7
G	1075	13.69	0.0182	3.931	1.19	28.1	91.5	71.9	51.9	1.2	6
H	1250	16.00	0.1725	8.490	1.50	3.0	84.4	97.5	55.9	1.1	8
I	1700	56.12	1.080	135.2	0.148	0.47	29.0	100.0	67.1	11.7	8
Integrated age ± 1s n=9 K2O=3.28% Age – 55.15 ±0.78											
Plateau ± 1s steps B-I n=8 MSWD=1.99 Age – 53.36 ±0.90											
H07-HU-008, Biotite, .22 mg, J=0.0023021±0.06%, D=1.0006±0.001, NM-212E, Lab#=57438-02											
X A	625	221.0	-0.2187	233.9	0.202	-	68.7	1.3	548.6	9.8	4
X B	700	255.8	-0.0569	21.15	1.29	-	97.6	9.8	830.9	3.0	7
X C	750	261.2	-0.0373	2.811	1.93	-	99.7	22.5	859.5	2.3	7
X D	800	268.1	0.0006	3.627	2.11	811.9	99.6	36.4	877.1	1.9	5
X E	875	269.8	0.0012	4.330	2.64	432.2	99.5	53.7	881.1	1.9	7
X F	975	249.4	-0.0025	5.685	1.27	-	99.3	62.1	825.9	2.6	8
X G	1075	240.7	-0.0006	3.440	3.44	-	99.6	84.6	804.4	1.7	8
X H	1250	261.8	0.0122	8.934	2.02	41.8	99.0	97.9	856.5	2.1	8
X I	1700	170.4	0.6240	73.70	0.313	0.82	87.3	100.0	539.1	5.8	8
Integrated age ± 1s n=9 K2O=11.55% Age – 838.4 ±1.1											
H07-TL-001, Biotite, 7.08 mg, J=0.0023009±0.06%, D=1.0006±0.001, NM-212E, Lab#=57436-01											
X A	625	57.66	0.2571	177.2	5.98	2.0	9.2	0.8	22.2	1.4	3
X B	700	28.57	0.1694	68.41	12.8	3.0	29.3	2.6	34.86	0.57	6
X C	750	17.26	0.0459	23.72	29.8	11.1	59.4	6.8	42.66	0.41	7
X D	800	12.07	0.0238	5.947	49.2	21.4	85.4	13.8	42.89	0.23	5
X E	875	11.10	0.0127	1.733	134.0	40.3	95.4	32.6	44.011	0.069	6
X F	975	10.87	0.0156	0.7061	153.5	32.7	98.1	54.2	44.310	0.059	7
X G	1075	11.12	0.0294	1.319	129.1	17.3	96.5	72.3	44.613	0.067	7
X H	1250	10.97	0.0930	1.388	162.4	5.5	96.3	95.2	43.928	0.067	7
X I	1700	11.26	0.4464	2.716	34.2	1.1	93.2	100.0	43.64	0.39	8
Integrated age ± 1s n=9 K2O=16.77% Age – 43.691 ±0.082											

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	37Ar/39Ar	36Ar/39Ar (x 10 ⁻³)	39ArK (x 10 ⁻¹⁵ mol)	K/Ca	40Ar (%)	39Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H08-HU-10, Biotite, .66 mg, J=0.011833±0.11%, D=1.0014±0.001, NM-218D, Lab#=57962-01											
X A	625	72.45	0.0495	23.63	1.23	10.3	90.4	0.7	1050.0	6.6	5
X B	700	80.62	0.0149	7.465	4.11	34.2	97.3	3.2	1201.5	3.9	5
X C	750	81.17	0.0111	3.936	9.8	46.1	98.6	9.0	1219.3	2.0	5
X D	800	82.53	0.0054	0.8323	23.1	94.2	99.7	22.7	1244.4	2.3	5
X E	875	83.33	0.0022	0.3596	33.8	228.7	99.9	42.8	1254.7	1.9	5
X F	975	82.32	0.0071	0.3556	17.6	71.4	99.9	53.2	1243.7	2.3	5
X G	1025	79.82	-0.0010	0.2932	11.8	-	99.9	60.2	1216.2	2.5	5
X H	1075	81.21	0.0029	0.5193	17.9	173.1	99.8	70.9	1230.9	2.9	5
X I	1150	83.24	0.0087	0.3893	21.1	58.7	99.9	83.4	1253.6	2.4	5
X J	1200	82.42	0.0092	0.5532	10.9	55.4	99.8	89.9	1244.1	2.0	5
X K	1300	84.02	0.0366	0.4171	15.9	13.9	99.9	99.3	1262.1	1.9	5
X L	1600	97.46	0.4554	26.21	1.19	1.1	92.1	100.0	1324.9	8.8	6
Integrated age ± 1s n=12 K2O=8.28% Age – 1243.3 ±1.5											
H08-HU-9, Biotite, 1.86 mg, J=0.011844±0.11%, D=1.0014±0.001, NM-218D, Lab#=57960-01											
X A	625	5.613	0.1256	11.82	12.9	4.1	37.9	3.2	45.5	1.1	5
X B	700	5.842	0.2366	3.110	14.8	2.2	84.6	6.9	103.97	0.68	5
X C	750	6.054	0.1871	1.833	22.7	2.7	91.3	12.7	115.92	0.57	5
X D	800	5.935	0.0431	0.5355	38.0	11.8	97.4	22.2	121.06	0.36	5
X E	875	6.030	0.0180	0.4077	51.1	28.3	98.0	35.1	123.69	0.33	5
X F	975	6.116	0.0304	0.4795	43.5	16.8	97.7	46.0	125.03	0.36	5
X G	1025	5.895	0.0583	0.4855	37.1	8.7	97.7	55.3	120.57	0.39	5
X H	1075	5.880	0.0279	0.2491	54.5	18.3	98.8	69.0	121.62	0.28	5
X I	1150	5.928	0.0675	0.1932	73.0	7.6	99.2	87.4	123.00	0.23	5
X J	1200	6.103	0.5463	0.4423	31.6	0.93	98.6	95.3	125.90	0.40	5
X K	1300	6.543	0.8444	0.7481	12.5	0.60	97.7	98.4	133.48	0.82	5
X L	1600	9.204	0.3014	6.323	6.18	1.7	80.0	100.0	152.9	1.7	5
Integrated age ± 1s n=12 K2O=6.94% Age – 120.24 ±0.22											
Notes:											
Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.											
Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.											
Integrated age calculated by summing isotopic measurements of all steps.											
Integrated age error calculated by quadratically combining errors of isotopic measurements of all steps.											
Plateau age is inverse-variance-weighted mean of selected steps.											
Plateau age error is inverse-variance-weighted mean error (Taylor, 1982) times root MSWD where MSWD>1.											
Plateau error is weighted error of Taylor (1982).											
Decay constants and isotopic abundances after Min et al. (2000).											
X symbol preceding sample ID denotes analyses excluded from plateau age calculations.											
Weight percent K2O calculated from 39Ar signal, sample weight, and instrument sensitivity.											
Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.201 Ma (Kuiper et al., 2008).											
Decay Constant (LambdaK (total)) = 5.46e-10/a											
Correction factors:											
(39Ar/37Ar)Ca = 0.0007 ± 5e-05											
(36Ar/37Ar)Ca = 0.00028 ± 2e-05											
(38Ar/39Ar)K = 0.013											
⁽⁴⁰ Ar/ ³⁹ Ar)K = 0.01 ± 0.002											

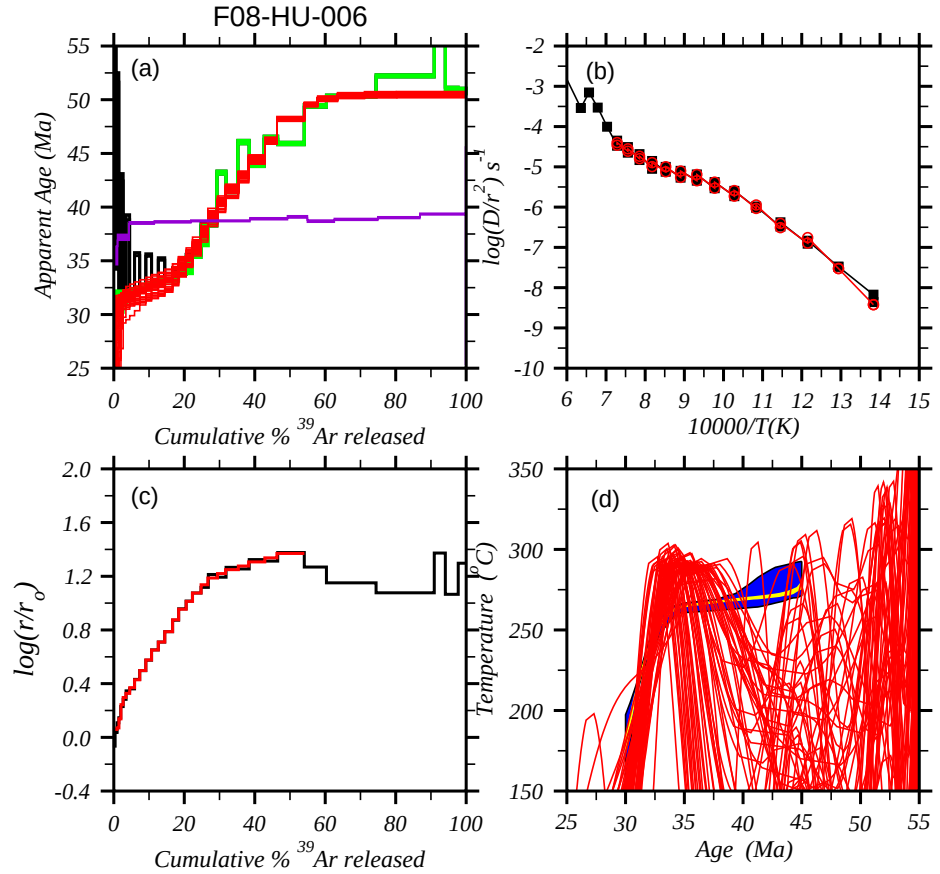
Table C.2: Hornblende $^{40}\text{Ar}/^{39}\text{Ar}$ analytical data

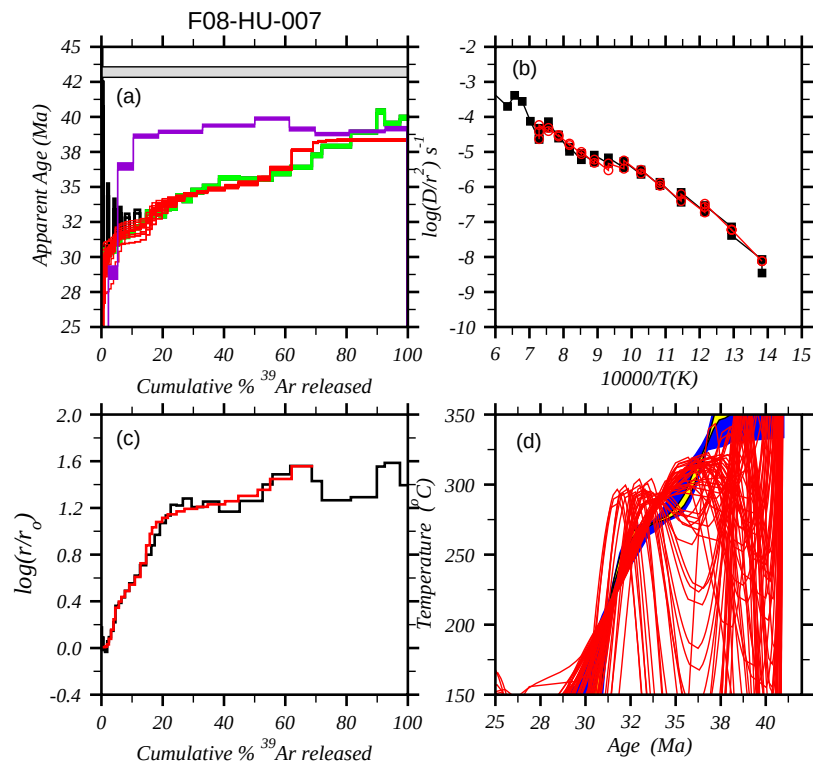
ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-LP-008, Hornblende, 14.57 mg, J=0.0023947 $\pm$ 0.10%, D=1.004 $\pm$ 0.001, NM-223K, Lab#=58937-01											
A	900	61.18	0.2158	63.99	13.4	2.4	69.1	14.0	176.56	0.86	6
B	1000	12.93	0.2738	5.933	11.8	1.9	86.6	26.2	48.39	0.17	6
C	1050	16.38	1.288	8.691	7.30	0.40	85.0	33.8	60.05	0.25	6
D	1080	23.67	4.138	12.64	6.19	0.12	85.7	40.3	86.98	0.38	6
E	500	26.29	5.464	12.87	6.01	0.093	87.3	46.5	98.23	0.37	0
F	1110	22.61	6.043	9.774	7.22	0.084	89.4	54.1	86.87	0.34	6
G	1110	22.16	5.965	9.799	3.93	0.086	89.2	58.1	84.95	0.46	6
H	1120	18.29	6.187	7.409	6.77	0.082	90.8	65.2	71.66	0.32	6
I	1140	16.42	6.006	6.185	8.7	0.085	91.9	74.2	65.22	0.25	6
J	1160	16.38	4.840	5.937	5.16	0.11	91.7	79.6	64.89	0.29	6
K	1180	17.43	2.856	7.562	2.43	0.18	88.5	82.1	66.52	0.46	6
L	1220	17.01	1.714	6.850	2.21	0.30	88.9	84.4	65.18	0.56	6
M	1260	21.12	3.842	10.91	4.95	0.13	86.2	89.6	78.32	0.37	6
N	1650	27.56	4.776	13.71	10.0	0.11	86.7	100.0	102.19	0.32	6
Integrated age $\pm 1s$ n=14 K2O=1.06% Age – 89.70 $\pm$0.24											
F08-TL-002, Hornblende, 21.28 mg, J=0.0021157 $\pm$ 0.09%, D=1.004 $\pm$ 0.001, NM-220J, Lab#=58077-01											
A	800	16.76	0.0484	4.963	16.6	10.5	91.3	14.3	58.28	0.14	5
B	900	17.18	0.2774	4.579	9.9	1.8	92.3	22.8	60.33	0.18	5
C	1000	23.47	2.674	16.52	13.7	0.19	80.1	34.5	71.52	0.26	5
D	1020	22.43	5.860	14.51	5.25	0.087	83.0	39.1	70.99	0.38	5
E	1040	19.48	5.528	8.058	5.63	0.092	90.1	43.9	66.99	0.32	5
F	1060	18.67	4.139	6.377	8.7	0.12	91.7	51.3	65.32	0.25	5
G	1080	18.16	4.302	5.358	14.5	0.12	93.2	63.7	64.60	0.19	5
H	1100	17.66	4.253	4.684	15.0	0.12	94.2	76.5	63.42	0.18	5
I	1120	18.71	5.017	8.020	3.20	0.10	89.6	79.3	63.96	0.47	5
J	1140	19.41	4.409	9.960	1.90	0.12	86.7	80.9	64.20	0.71	5
K	1160	19.48	4.050	11.27	2.41	0.13	84.6	83.0	62.89	0.60	5
L	1180	18.98	3.674	9.448	5.75	0.14	86.9	87.9	62.89	0.34	5
M	1200	18.93	3.714	7.993	10.7	0.14	89.1	97.1	64.35	0.22	5
N	1650	47.53	2.790	104.8	3.37	0.18	35.3	100.0	64.0	1.0	5
Integrated age $\pm 1s$ n=14 K2O=0.99% Age – 64.31 $\pm$0.15											

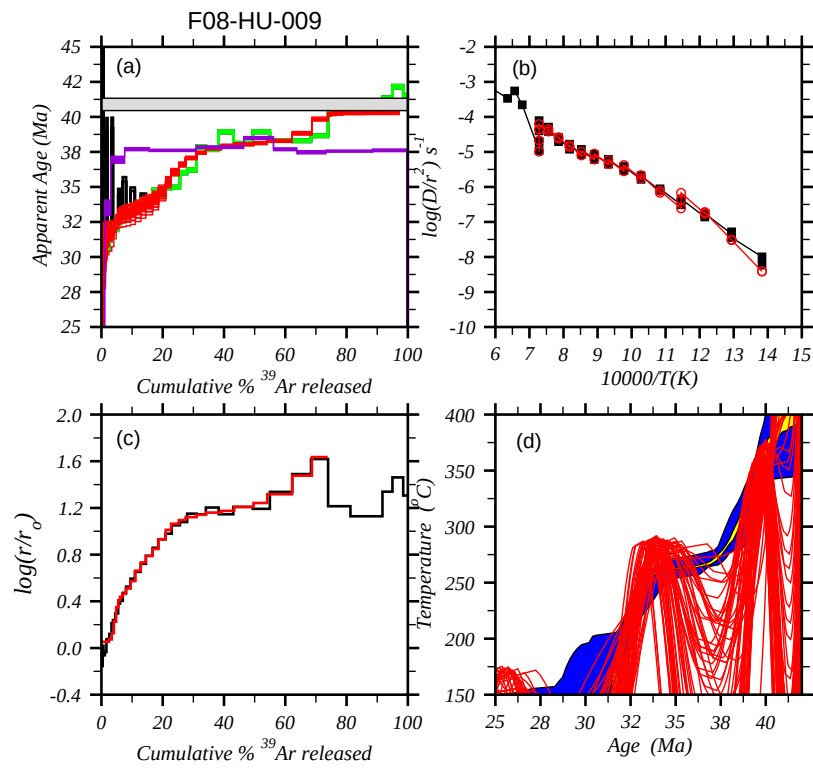
ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10 ⁻³)	^{39}ArK (x 10 ⁻¹⁵ mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-006, Hornblende, 10 mg, J=0.0021121±0.10%, D=1.004±0.001, NM-220J, Lab#=58081-01											
A	800	98.83	2.703	274.3	1.86	0.19	18.2	6.5	68.4	2.8	5
B	900	20.49	0.4639	29.54	2.19	1.1	57.6	14.1	45.0	1.2	5
C	1000	19.97	3.789	24.62	3.22	0.13	65.1	25.4	49.70	0.60	5
D	1020	18.77	5.800	21.86	1.39	0.088	68.1	30.2	48.9	1.3	5
E	1040	17.20	10.81	20.28	1.33	0.047	70.3	34.9	46.5	1.2	5
F	1060	16.14	10.08	17.94	1.38	0.051	72.3	39.7	44.86	0.89	5
G	1080	20.18	7.717	32.65	2.33	0.066	55.3	47.8	42.87	0.68	5
H	1100	14.55	7.922	13.88	3.48	0.064	76.3	60.0	42.63	0.49	5
I	1120	13.65	6.830	8.714	2.63	0.075	85.3	69.2	44.62	0.46	5
J	1140	14.21	7.006	12.06	0.95	0.073	79.0	72.5	43.1	1.2	5
K	1160	15.11	6.057	15.12	1.41	0.084	73.7	77.4	42.73	0.85	5
L	1180	15.23	6.124	14.64	2.46	0.083	74.9	86.0	43.74	0.51	5
M	1200	16.50	7.767	18.02	2.61	0.066	71.6	95.1	45.35	0.70	5
N	1650	101.9	8.201	315.0	1.41	0.062	9.3	100.0	36.5	2.7	5
Integrated age ± 1s n=14 K ₂ O=0.52% Age – 46.18 ±0.41											
F08-TL-009, Hornblende, 16.32 mg, J=0.0021143±0.10%, D=1.004±0.001, NM-220J, Lab#=58079-01											
A	800	28.56	0.3655	57.00	1.92	1.4	41.1	4.5	44.9	1.1	5
B	900	13.96	0.2472	4.940	3.32	2.1	89.7	12.3	47.81	0.53	5
C	1000	14.20	1.423	4.384	3.92	0.36	91.7	21.4	49.74	0.45	5
D	1020	15.76	4.860	14.64	1.65	0.10	75.1	25.3	45.35	0.83	5
E	1040	16.19	8.261	15.82	2.01	0.062	75.3	30.0	46.83	0.81	5
F	1060	16.28	9.207	16.79	2.57	0.055	74.2	36.0	46.42	0.63	5
G	1080	14.92	9.829	13.89	3.87	0.052	77.9	45.0	44.72	0.49	5
H	1100	13.74	9.410	10.46	4.58	0.054	83.2	55.7	43.95	0.41	5
I	1120	13.84	8.303	10.06	2.52	0.061	83.5	61.6	44.40	0.60	5
J	1140	14.49	5.778	10.26	1.17	0.088	82.4	64.3	45.8	1.0	5
K	1160	14.96	4.874	14.47	1.17	0.10	74.1	67.1	42.5	1.1	5
L	1180	13.52	3.487	8.984	1.95	0.15	82.5	71.6	42.74	0.70	5
M	1200	13.84	4.776	9.333	2.54	0.11	82.9	77.6	44.00	0.53	5
N	1650	29.96	9.549	63.01	9.6	0.053	40.5	100.0	46.64	0.52	5
Integrated age ± 1s n=14 K ₂ O=0.48% Age – 45.85 ±0.26											

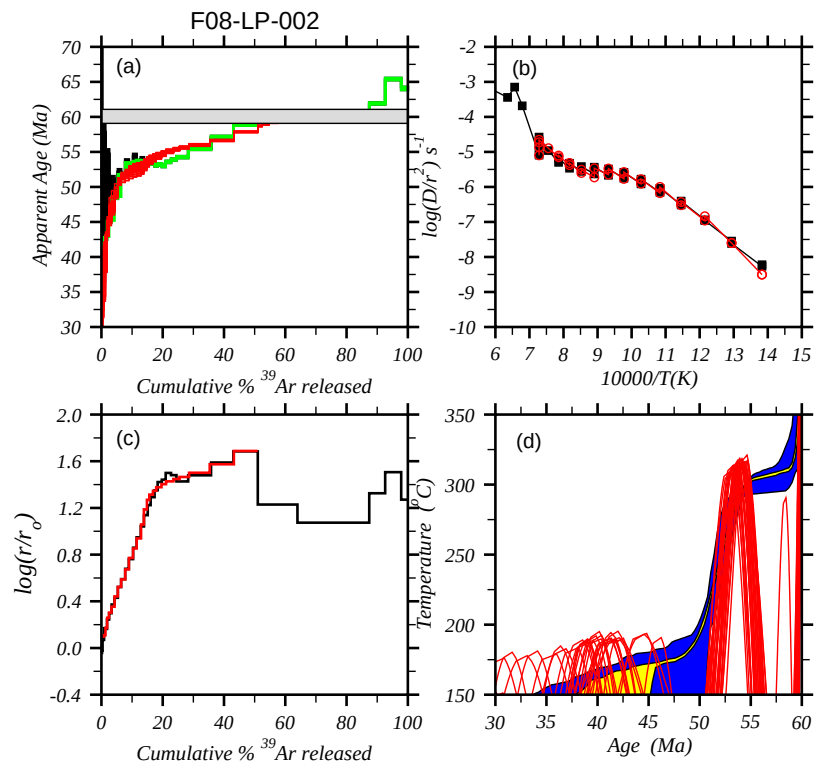
ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10 ⁻³)	^{39}ArK (x 10 ⁻¹⁵ mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-014, Hornblende, 19.07 mg, J=0.0021111±0.09%, D=1.004±0.001, NM-220J, Lab#=58083-01											
A	800	153.8	3.740	128.0	2.37	0.14	75.6	12.0	402.7	3.8	5
B	900	19.82	1.166	9.153	3.56	0.44	86.8	30.1	65.34	0.75	5
C	1000	47.48	13.83	47.41	3.24	0.037	72.9	46.5	130.26	0.84	5
D	1020	59.78	83.43	81.11	1.20	0.006	71.4	52.6	167.4	3.0	5
E	1040	26.66	76.24	35.34	1.14	0.007	84.5	58.3	89.7	2.5	5
F	1060	18.91	22.21	15.64	1.13	0.023	85.3	64.1	62.2	1.3	5
G	1080	19.66	49.50	12.30	1.33	0.010	102.4	70.9	78.8	10.5	5
H	1100	23.98	31.63	17.52	1.16	0.016	89.3	76.7	82.7	1.3	5
I	1120	27.90	32.80	33.06	0.543	0.016	74.7	79.5	80.6	2.3	5
J	1140	28.20	30.76	24.19	0.457	0.017	83.7	81.8	90.9	3.3	5
K	1160	24.35	19.10	23.76	0.669	0.027	77.6	85.2	72.6	2.2	5
L	1180	21.50	9.577	15.63	0.92	0.053	82.2	89.8	67.5	1.4	5
M	1200	22.04	9.198	19.30	0.657	0.055	77.6	93.2	65.3	1.8	5
N	1650	98.70	7.421	277.2	1.35	0.069	17.6	100.0	66.4	2.5	5
Integrated age ± 1s n=14 K2O=0.19% Age – 130.6 ±1.1											
H07-TL-001, Hornblende, 7.9 mg, J=0.0023017±0.06%, D=1.002±0.001, NM-212E, Lab#=57440-01											
A	800	87.26	1.299	136.2	2.64	0.39	54.0	5.1	188.6	1.4	5
B	900	17.47	0.7258	21.48	2.31	0.70	64.0	9.6	46.50	0.72	5
C	1000	16.21	2.184	14.85	3.68	0.23	74.0	16.8	49.91	0.47	5
D	1050	17.02	4.410	12.15	3.16	0.12	81.1	22.9	57.38	0.51	5
E	1080	16.61	4.506	7.632	5.19	0.11	88.7	33.0	61.19	0.37	5
F	1100	16.41	4.548	5.765	7.1	0.11	91.9	46.9	62.64	0.28	5
G	1120	15.24	4.292	4.359	4.95	0.12	93.9	56.5	59.47	0.33	5
H	1140	15.42	3.879	7.022	2.14	0.13	88.6	60.7	56.81	0.64	5
I	1160	16.27	4.145	11.02	1.21	0.12	82.1	63.0	55.6	1.2	5
J	1220	17.27	4.789	5.454	6.01	0.11	93.0	74.7	66.63	0.32	5
K	1650	16.90	4.054	6.301	13.0	0.13	91.0	100.0	63.81	0.24	5
Integrated age ± 1s n=11 K2O=1.09% Age – 67.32 ±0.21											
Notes:											
Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.											
Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.											
Integrated age calculated by summing isotopic measurements of all steps.											
Integrated age error calculated by quadratically combining errors of isotopic measurements of all steps.											
Plateau age is inverse-variance-weighted mean of selected steps.											
Plateau age error is inverse-variance-weighted mean error (Taylor, 1982) times root MSWD where MSWD>1.											
Plateau error is weighted error of Taylor (1982).											
Decay constants and isotopic abundances after Min et al. (2000).											
Weight percent K2O calculated from ^{39}Ar signal, sample weight, and instrument sensitivity.											
Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.201 Ma (Kuiper et al., 2008).											
Decay Constant (LambdaK (total)) = 5.46e-10/a											
Correction factors:											
$(^{39}\text{Ar}/^{37}\text{Ar})\text{Ca} = 0.0007 \pm 5\text{e-}05$											
$(^{36}\text{Ar}/^{37}\text{Ar})\text{Ca} = 0.00028 \pm 2\text{e-}05$											
$(^{38}\text{Ar}/^{39}\text{Ar})\text{K} = 0.013$											
$(^{40}\text{Ar}/^{39}\text{Ar})\text{K} = 0.01 \pm 0.002$											

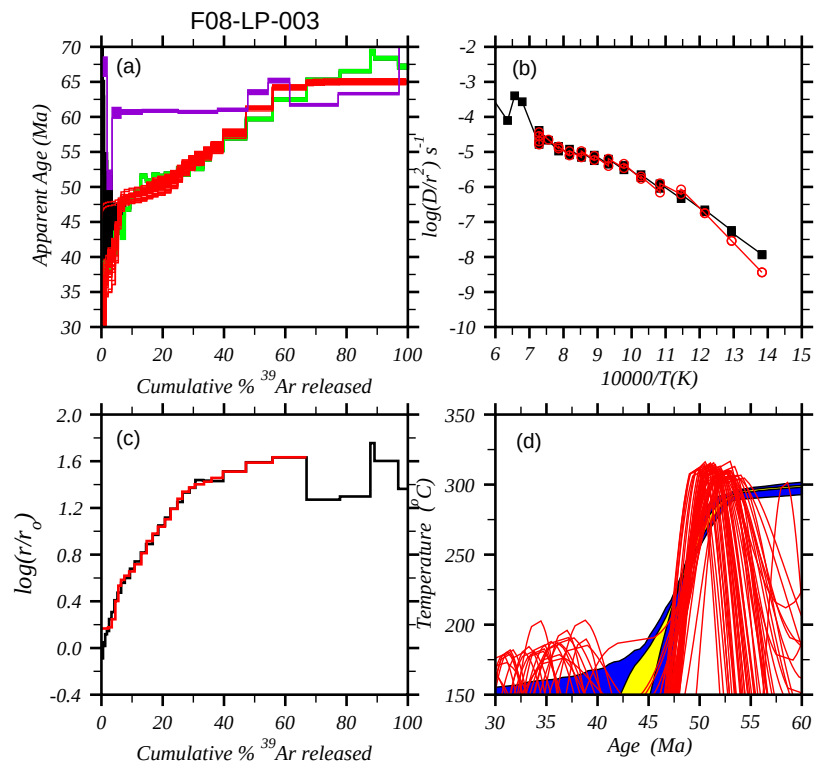
Figure C.6: (a) K-feldspar age spectra – $^{40}\text{Ar}/^{39}\text{Ar}$ K-feldspar age spectra and associated MDD modeling. Black spectra are K-feldspar analyses, red spectra are models, green spectra are measured spectra corrected for excess argon, purple spectra are coexisting biotites, and gray bars are U/Pb emplacement ages (b) Arrhenius plot – black are measured and red are modeled values. (c) Log r/r_0 plot – black line is calculated from measured data and red line is modeled. (d) Thermal models – blue/yellow polygons are cooling models, red lines are unconstrained models that allow reheating events.

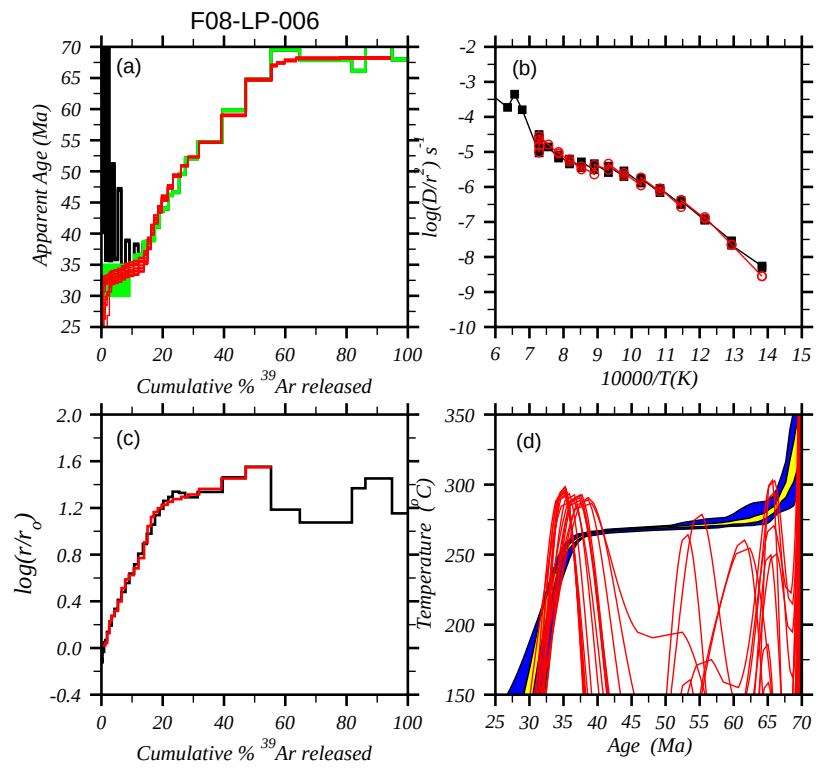


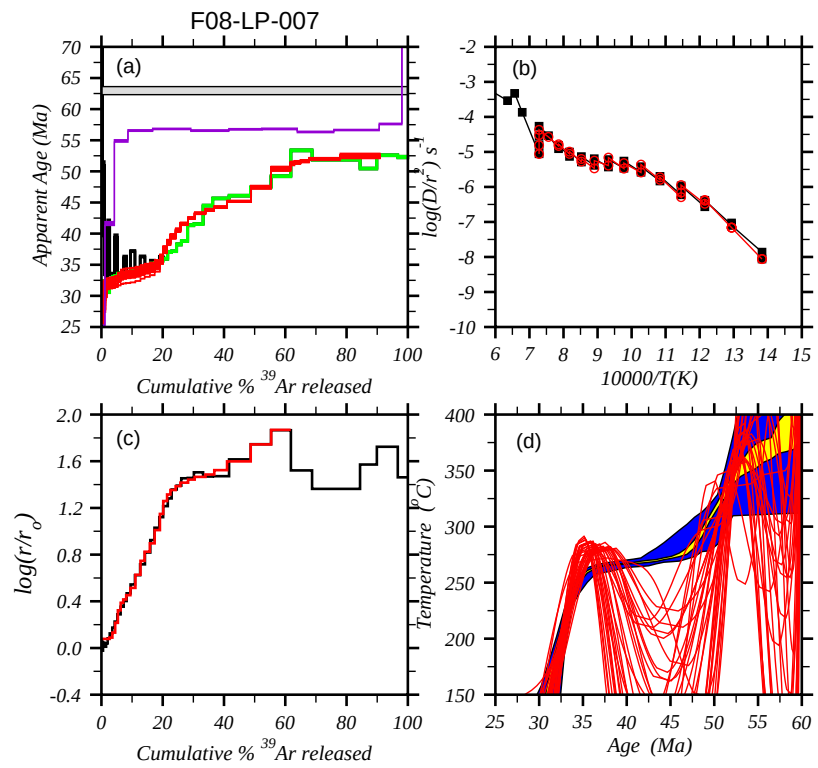


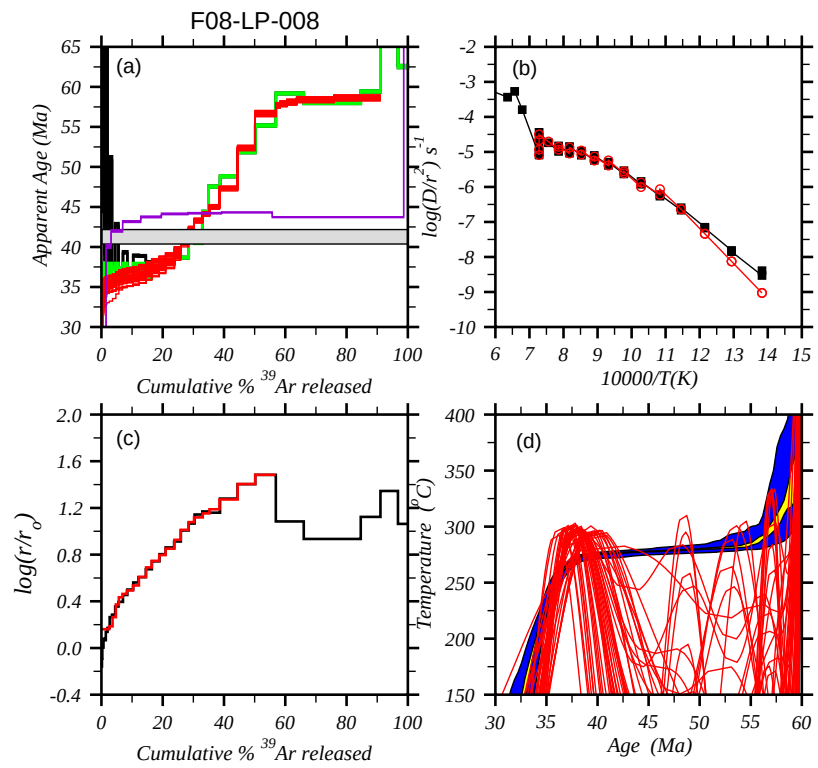


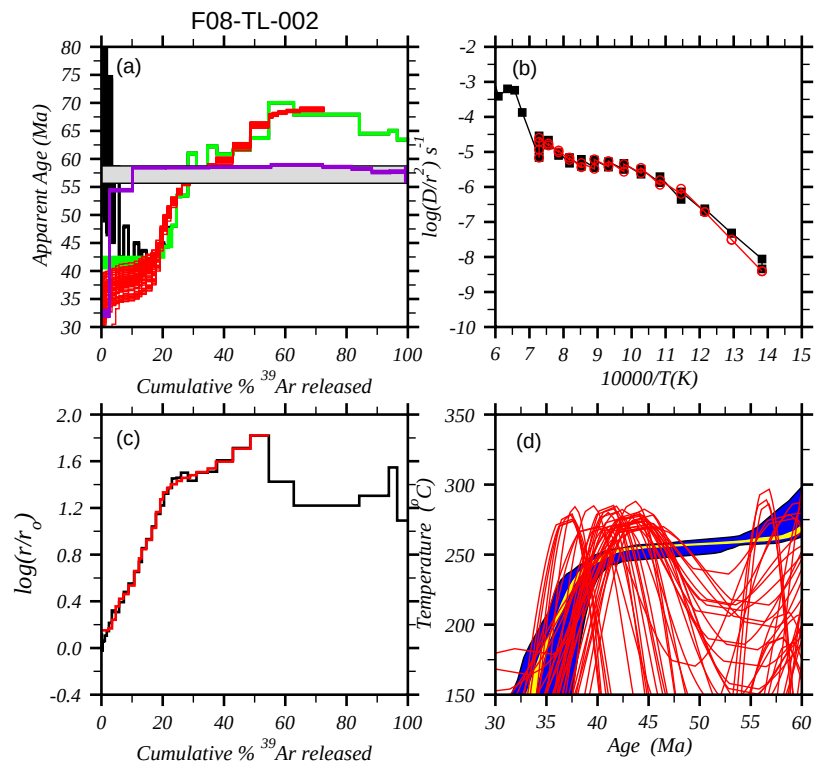


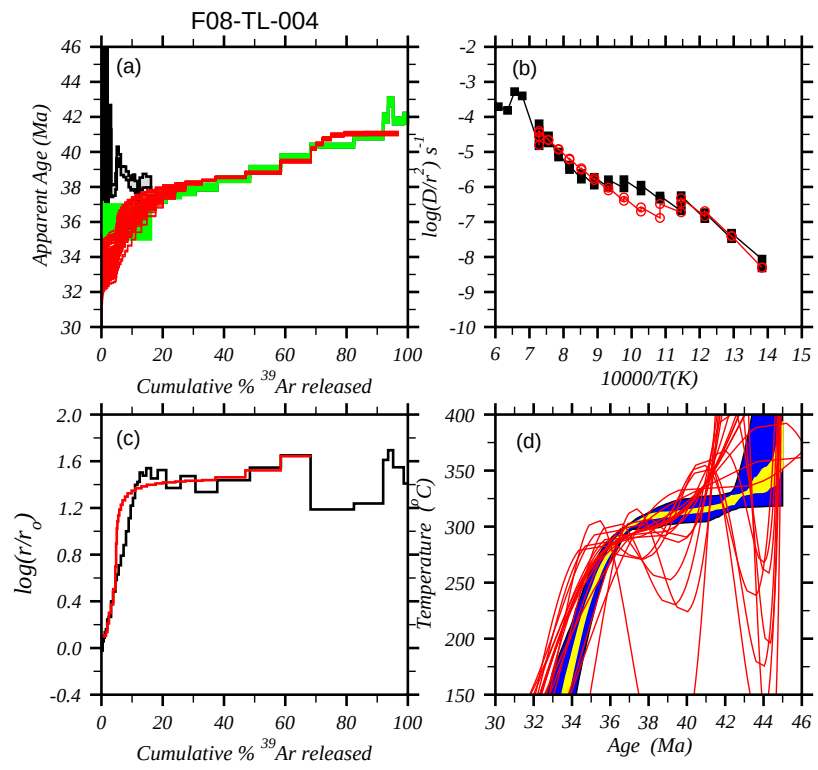


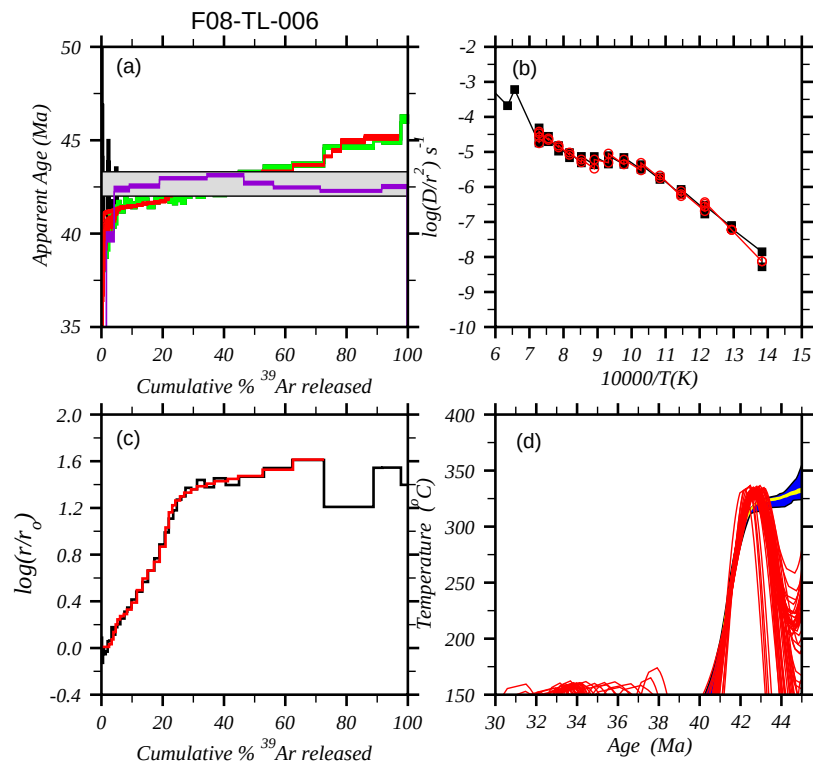


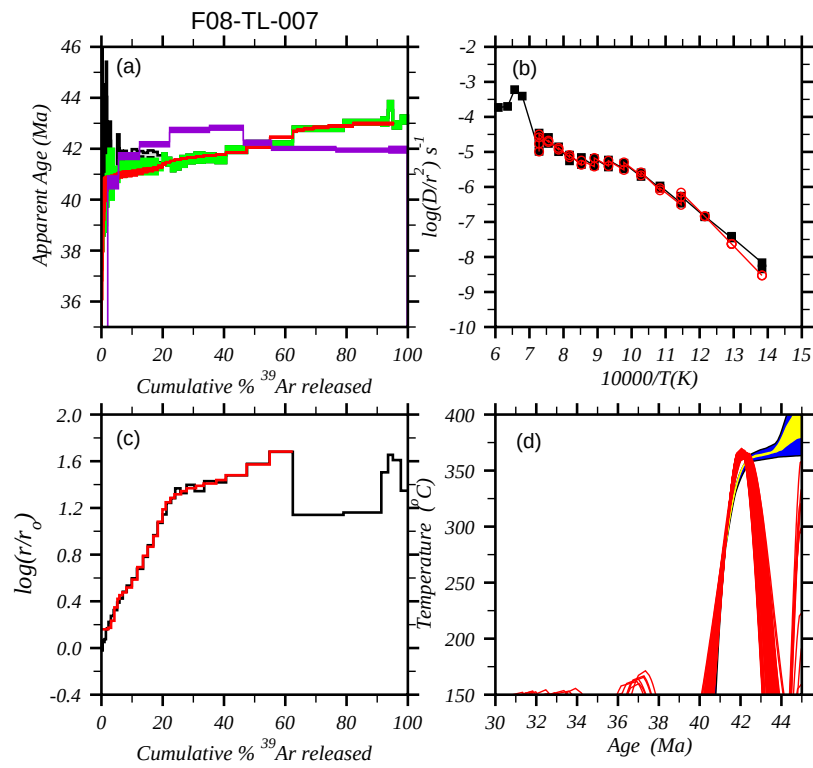


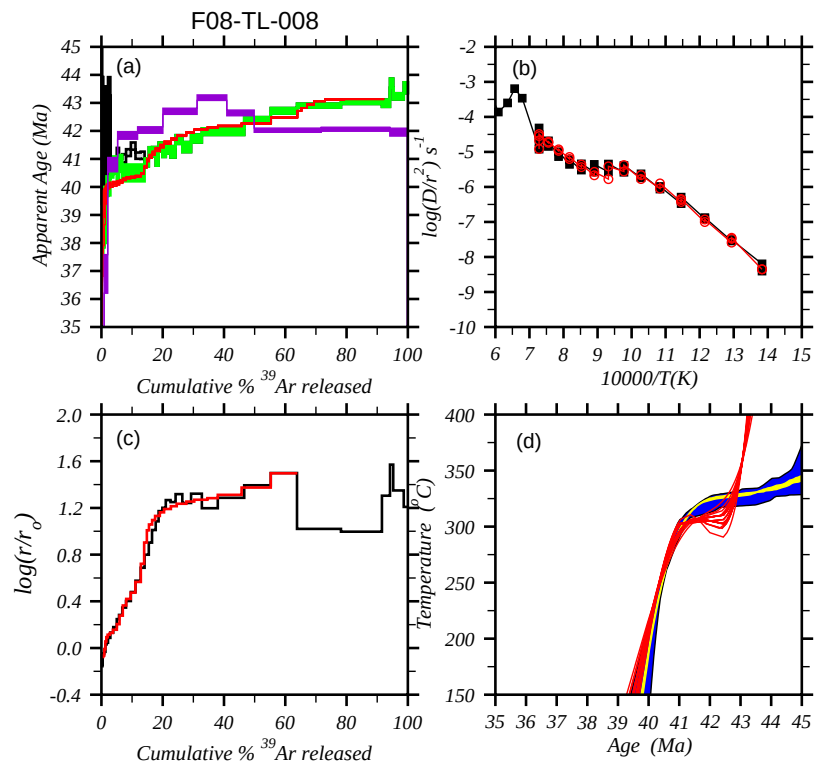


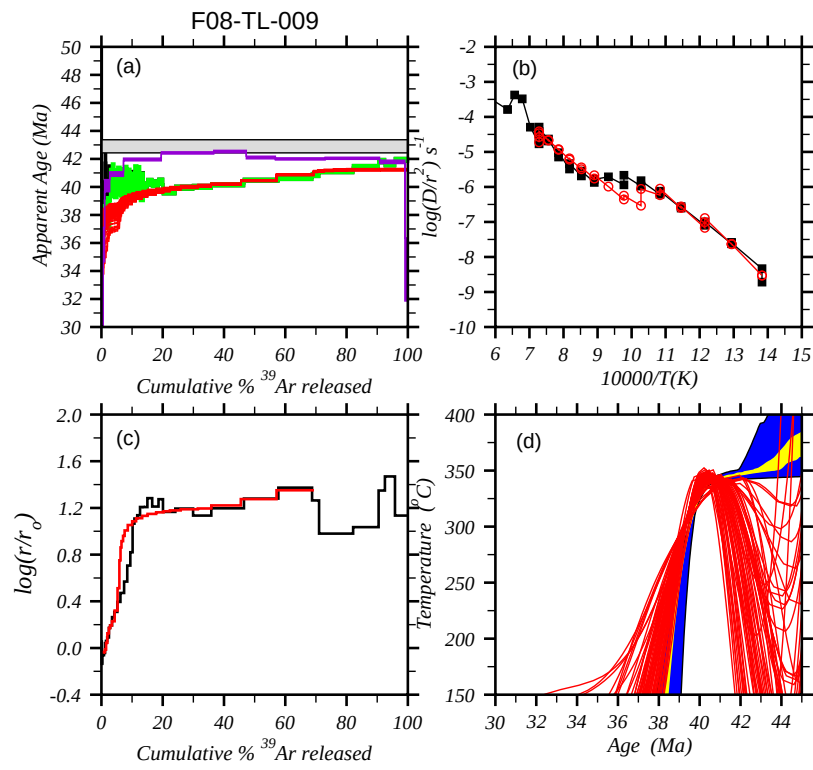


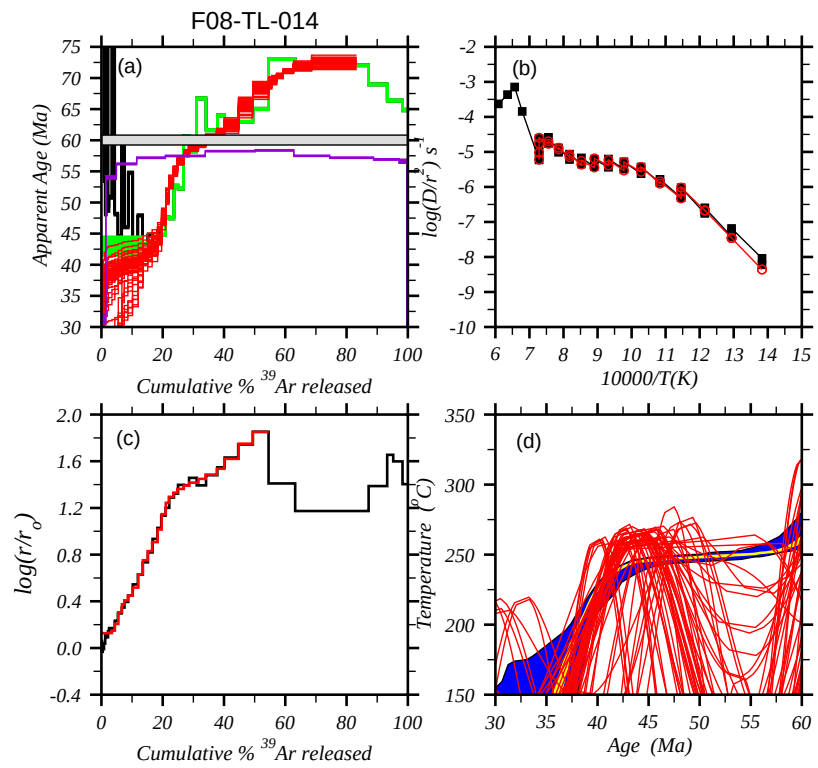


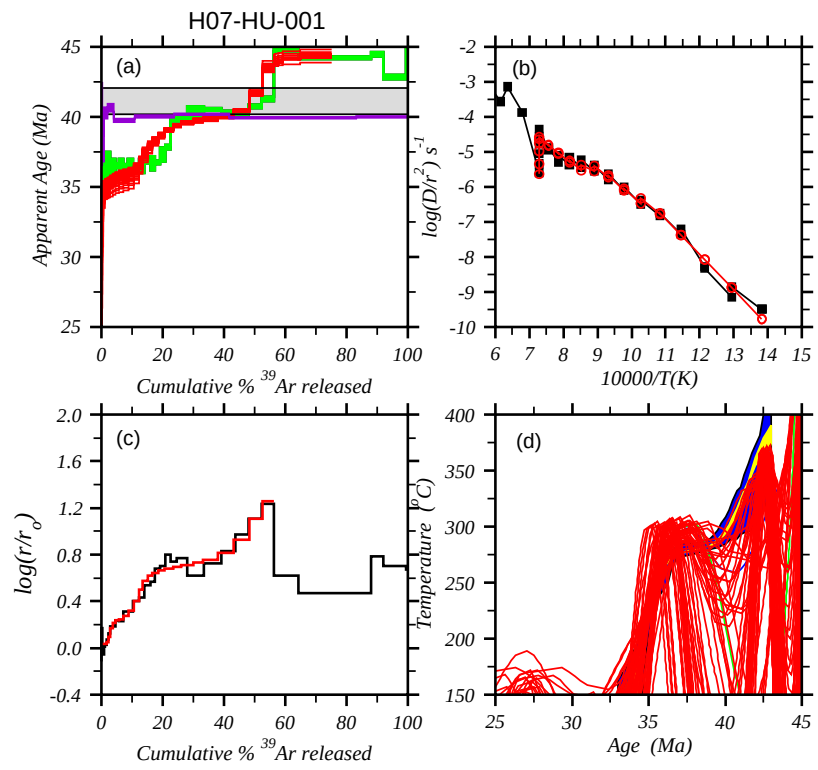


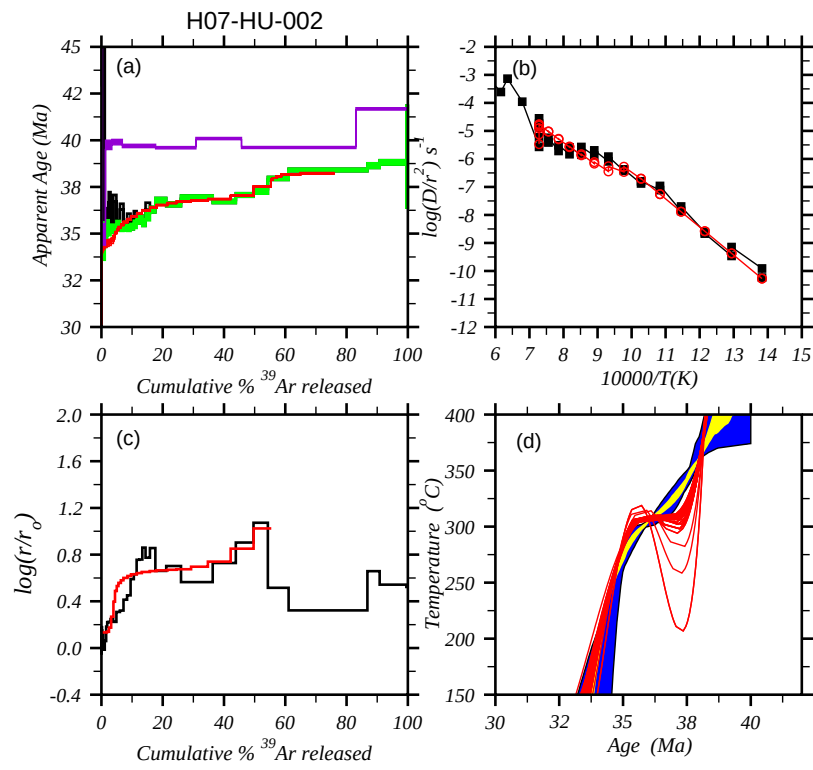


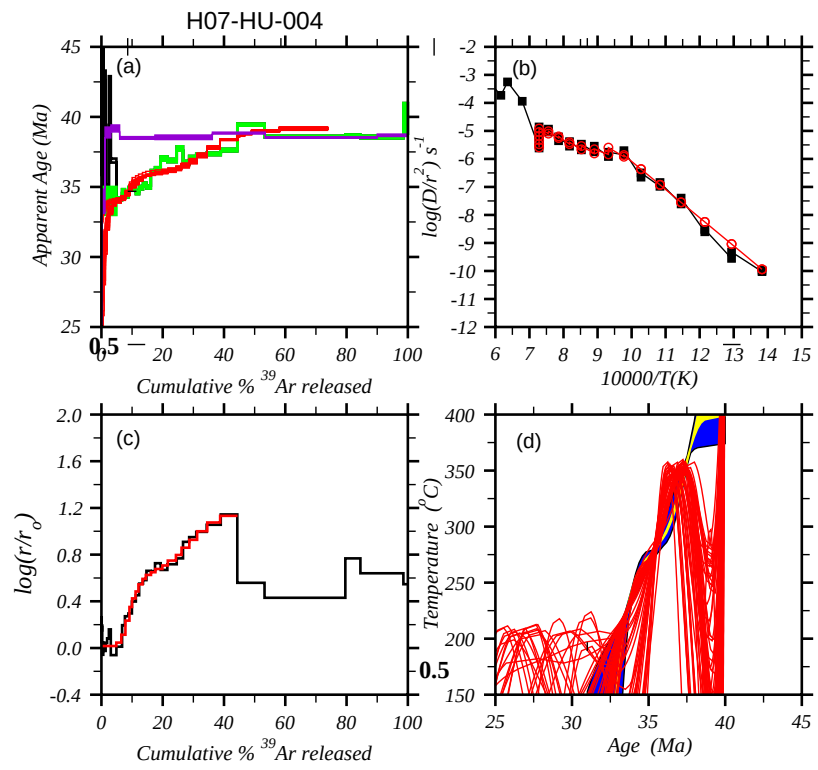


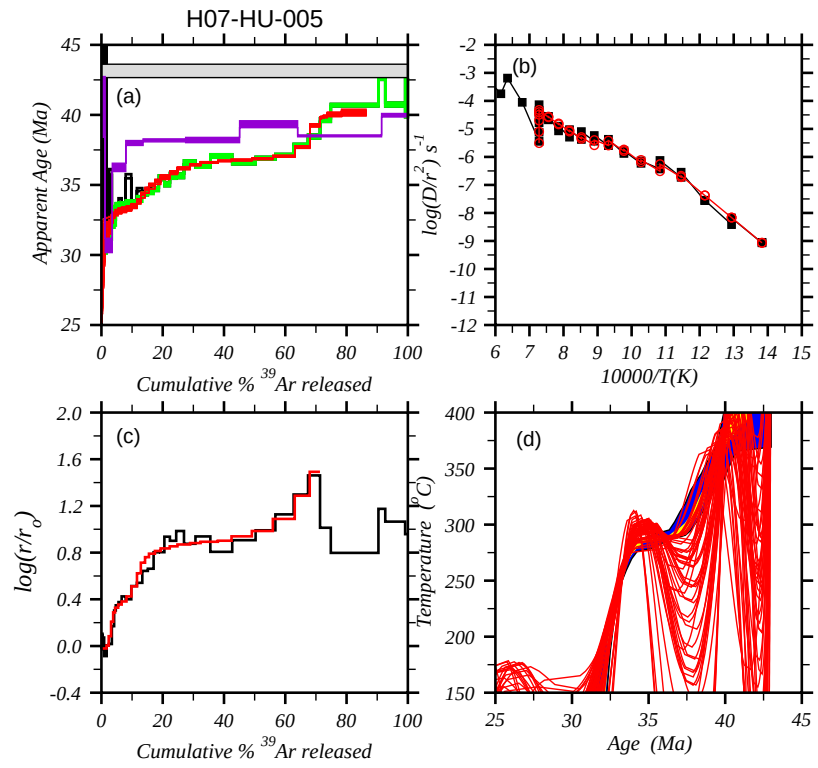


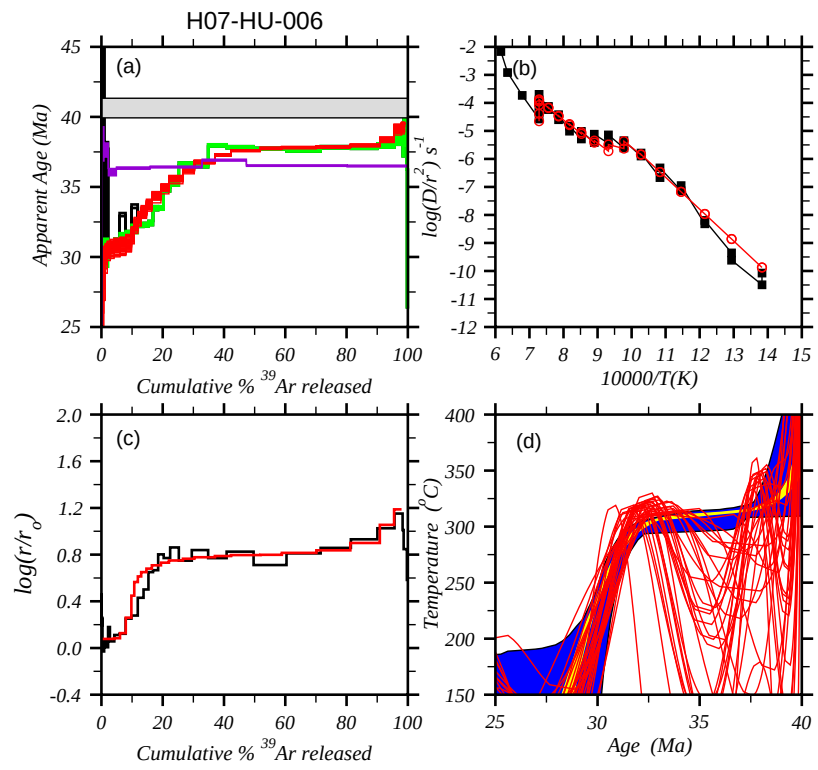


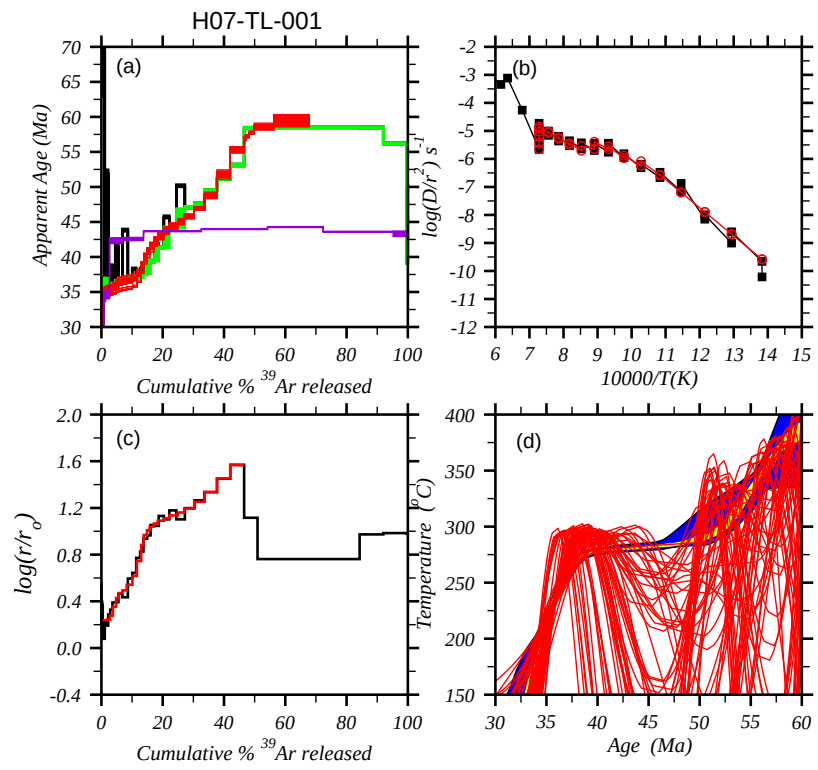


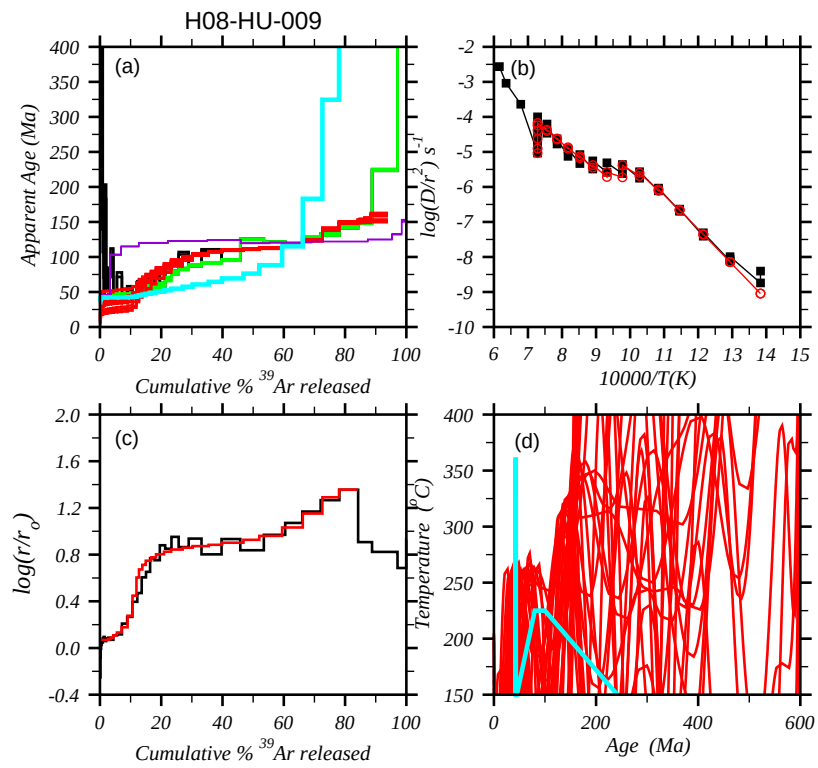


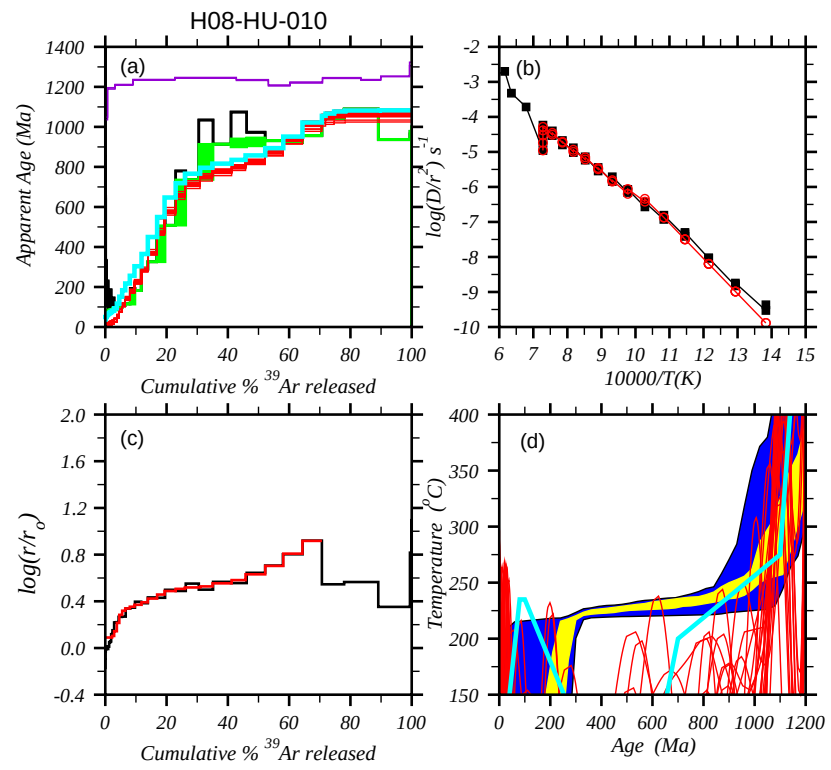


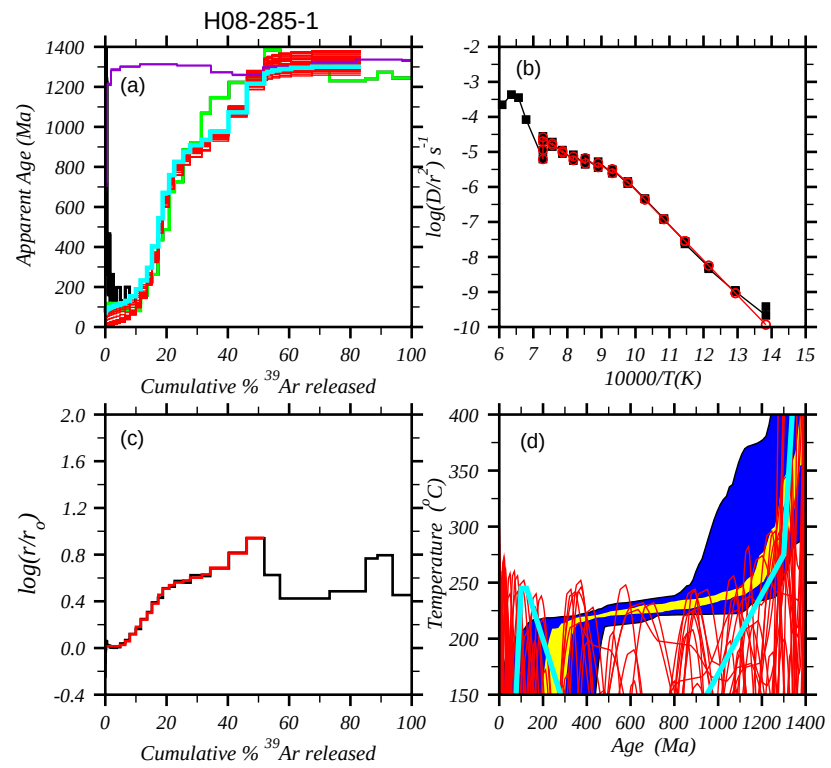












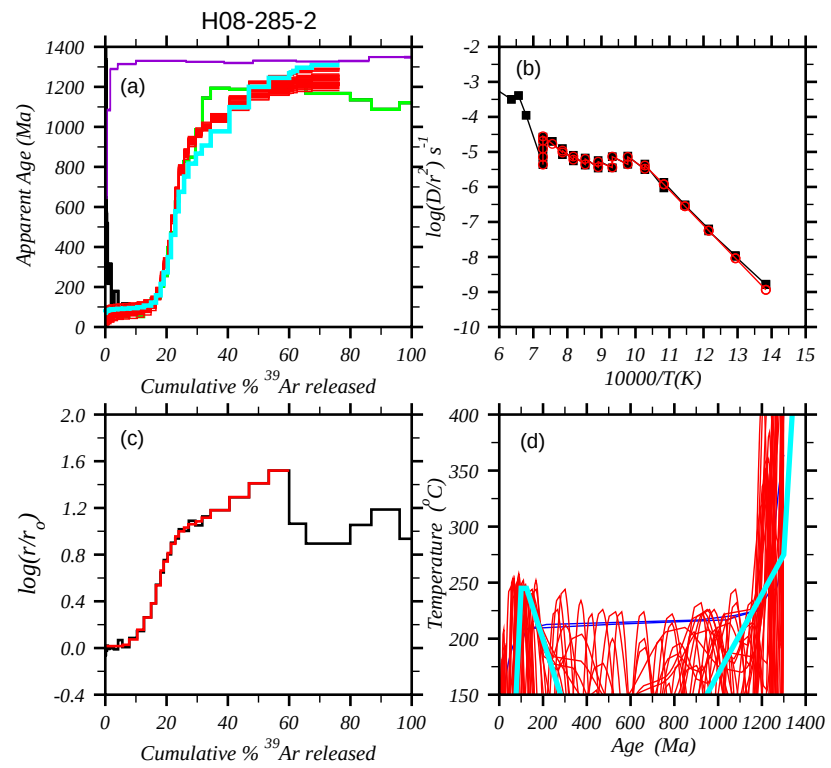


Table C.3: K-Feldspar $^{40}\text{Ar}/^{39}\text{Ar}$ analytical data

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10 ⁻³)	^{39}ArK (x 10 ⁻¹⁵ mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-HU-006, K-Feldspar, 13.2 mg, J=0.0021672±0.12%, D=1.0014±0.001, NM-220L, Lab#=58602-01											
A	450	455.4	0.0898	661.4	1.36	5.7	57.1	0.3	818.0	5.1	10
B	450	43.51	0.0467	88.44	1.37	10.9	39.9	0.6	67.6	1.2	20
C	500	30.59	0.0487	50.04	1.89	10.5	51.7	1.0	61.64	0.89	10
D	500	17.15	0.0638	28.00	2.36	8.0	51.8	1.5	34.87	0.66	20
E	550	21.07	0.0878	26.22	3.47	5.8	63.2	2.3	52.08	0.44	10
F	550	11.84	0.0730	12.92	4.04	7.0	67.8	3.1	31.53	0.37	20
G	600	15.45	0.0890	15.36	5.01	5.7	70.7	4.2	42.78	0.34	10
H	600	9.865	0.0863	6.472	5.84	5.9	80.7	5.5	31.27	0.22	20
I	650	12.07	0.0965	7.158	7.0	5.3	82.5	7.0	39.06	0.23	10
J	650	9.046	0.0777	2.925	9.9	6.6	90.5	9.1	32.16	0.14	20
K	700	10.27	0.0725	4.045	10.0	7.0	88.4	11.3	35.62	0.14	10
L	700	8.741	0.0624	1.707	11.7	8.2	94.3	13.8	32.37	0.10	20
M	750	9.643	0.0666	2.010	10.7	7.7	93.9	16.1	35.53	0.11	10
N	750	8.753	0.0630	1.322	12.5	8.1	95.6	18.8	32.86	0.11	20
O	800	9.590	0.0693	2.146	11.6	7.4	93.4	21.3	35.17	0.11	10
P	800	8.887	0.0596	1.523	13.8	8.6	95.0	24.3	33.148	0.096	20
Q	850	9.362	0.0603	2.192	10.5	8.5	93.1	26.6	34.23	0.12	10
R	850	9.181	0.0471	1.912	12.6	10.8	93.9	29.3	33.84	0.12	20
S	900	9.970	0.0423	3.172	10.4	12.1	90.6	31.5	35.46	0.14	10
T	900	9.817	0.0306	2.690	14.0	16.7	91.9	34.5	35.42	0.11	20
U	950	11.36	0.0250	5.299	11.5	20.4	86.2	37.0	38.41	0.15	10
V	950	11.36	0.0215	5.343	13.3	23.8	86.1	39.9	38.38	0.15	20
W	1000	13.48	0.0305	8.304	13.7	16.7	81.8	42.8	43.21	0.15	10
X	1000	12.48	0.0257	6.424	17.3	19.8	84.8	46.6	41.47	0.13	20
Y	1050	13.94	0.0220	7.347	16.0	23.2	84.4	50.0	46.05	0.16	10
Z	1050	13.14	0.0267	6.539	20.3	19.1	85.3	54.4	43.92	0.14	20
AA	1100	13.84	0.0347	6.664	17.7	14.7	85.8	58.2	46.46	0.15	10
AB	1100	13.65	0.0363	6.491	33.0	14.1	86.0	65.3	45.93	0.11	30
AC	1150	14.27	0.0414	5.548	25.8	12.3	88.5	70.9	49.43	0.13	10
AD	1200	14.19	0.0480	4.450	53.0	10.6	90.8	82.3	50.34	0.10	10
AE	1250	14.47	0.0896	3.770	54.7	5.7	92.3	94.1	52.220	0.095	10
AF	1300	17.13	0.3489	7.023	9.7	1.5	88.0	96.2	58.86	0.18	10
AG	1470	13.87	0.0998	2.802	10.9	5.1	94.1	98.6	51.02	0.15	1
AH	1670	16.49	0.0503	11.84	6.55	10.1	78.8	100.0	50.82	0.26	10

Integrated age $\pm 1s$ n=34 K₂O=6.22% Age = 46.395 $\pm$ 0.099

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-HU-007, K-Feldspar, 14.7 mg, J=0.0021656±0.10%, D=1.0014±0.001, NM-220L, Lab#=58605-01											
A	450	457.6	0.0016	1239.1	1.54	318.8	20.0	0.2	330.7	6.7	10
B	450	42.88	0.0249	112.0	2.18	20.5	22.8	0.4	38.4	1.6	20
C	500	26.97	0.0295	55.29	2.74	17.3	39.4	0.7	41.63	0.88	10
D	500	15.27	0.0318	26.12	4.65	16.0	49.5	1.2	29.69	0.43	20
E	500	12.57	0.0211	16.81	6.77	24.2	60.5	1.9	29.85	0.37	40
F	550	14.82	0.0439	20.17	4.91	11.6	59.8	2.4	34.78	0.46	10
G	550	10.13	0.0462	8.097	6.52	11.1	76.4	3.1	30.38	0.25	20
H	550	9.933	0.0354	7.310	7.93	14.4	78.3	4.0	30.53	0.23	40
I	600	13.28	0.0404	15.83	5.87	12.6	64.8	4.6	33.77	0.39	10
K	600	9.170	0.0326	4.327	10.2	15.7	86.1	5.7	30.99	0.18	40
L	650	10.85	0.0335	7.978	8.05	15.2	78.3	6.5	33.33	0.24	10
M	650	8.757	0.0244	2.491	11.1	20.9	91.6	7.7	31.49	0.15	20
N	700	9.874	0.0279	5.011	13.2	18.3	85.0	9.1	32.95	0.14	10
O	700	8.653	0.0217	1.874	16.5	23.5	93.6	10.8	31.80	0.11	20
P	750	9.299	0.0210	2.806	16.6	24.3	91.1	12.6	33.24	0.13	10
Q	750	8.681	0.0212	1.313	18.9	24.0	95.5	14.6	32.550	0.098	20
R	800	9.289	0.0285	2.816	15.8	17.9	91.1	16.3	33.19	0.13	10
S	800	9.059	0.0168	2.187	10.3	30.3	92.9	17.4	33.02	0.16	10
T	850	9.641	0.0181	4.075	16.0	28.2	87.5	19.1	33.11	0.14	10
U	850	9.282	0.0244	2.996	18.2	20.9	90.5	21.0	32.96	0.12	20
V	900	10.99	0.0210	8.273	15.0	24.3	77.8	22.6	33.53	0.19	10
W	900	10.48	0.0172	6.563	18.2	29.6	81.5	24.5	33.51	0.13	20
X	950	12.43	0.0140	12.52	19.3	36.4	70.2	26.6	34.26	0.20	10
Y	950	11.67	0.0103	10.08	26.7	49.6	74.4	29.4	34.08	0.15	20
Z	1000	12.61	0.0101	12.73	35.3	50.5	70.1	33.2	34.70	0.16	10
AA	1000	11.63	0.0089	9.146	49.7	57.3	76.7	38.4	35.01	0.13	20
AB	1050	11.87	0.0102	9.409	63.0	49.9	76.6	45.1	35.65	0.11	10
AC	1050	11.06	0.0115	6.744	70.5	44.2	82.0	52.6	35.570	0.095	20
AD	1100	10.86	0.0122	6.049	30.3	41.9	83.5	55.8	35.58	0.12	10
AE	1100	10.72	0.0151	5.240	54.7	33.7	85.5	61.6	35.95	0.10	30
AF	1100	10.86	0.0186	5.337	66.2	27.4	85.5	68.7	36.399	0.091	60
AG	1150	10.96	0.0220	4.934	31.0	23.2	86.7	71.9	37.26	0.12	10
AH	1200	10.95	0.0173	4.322	89.0	29.4	88.3	81.4	37.907	0.084	10
AI	1250	11.21	0.0325	4.352	80.1	15.7	88.5	89.9	38.909	0.089	10
AJ	1300	12.37	0.1284	7.007	24.3	4.0	83.3	92.5	40.39	0.14	10
AK	1470	11.36	0.0332	4.305	46.7	15.3	88.8	97.4	39.53	0.11	10
AL	1670	12.09	0.0140	6.414	24.3	36.3	84.3	100.0	39.94	0.13	10

Integrated age $\pm 1s$ n=37 K2O=11.37% Age = 36.367 $\pm$ 0.088

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-HU-009, K-Feldspar, 15.68 mg, J=0.0021657±0.10%, D=1.0014±0.001, NM-220L, Lab#=58606-01											
A	450	469.9	0.0349	1171.2	1.83	14.6	26.4	0.2	434.9	6.3	10
B	450	54.38	0.0244	144.1	2.52	20.9	21.7	0.4	46.2	1.7	16
C	500	38.55	0.0270	88.69	2.93	18.9	32.0	0.7	48.3	1.0	10
D	500	19.92	0.0053	39.38	5.07	96.6	41.6	1.1	32.52	0.47	20
E	500	15.75	0.0160	26.72	5.74	31.8	49.8	1.6	30.85	0.40	40
F	550	19.14	0.0212	30.71	4.11	24.0	52.6	2.0	39.43	0.49	10
G	550	12.47	0.0230	15.72	6.36	22.2	62.7	2.6	30.74	0.29	20
H	550	11.74	0.0184	12.66	8.10	27.8	68.1	3.3	31.41	0.31	40
I	600	15.27	0.0080	17.49	5.49	63.8	66.1	3.8	39.57	0.37	10
J	600	10.84	0.0299	8.985	8.29	17.1	75.5	4.5	32.12	0.26	20
K	600	10.20	0.0168	6.887	10.6	30.4	80.0	5.5	32.04	0.18	40
L	650	11.40	0.0123	8.697	6.55	41.6	77.4	6.1	34.63	0.24	10
M	650	9.659	0.0186	4.362	10.4	27.4	86.7	7.0	32.85	0.17	20
N	700	10.83	0.0160	6.000	11.9	31.9	83.6	8.1	35.53	0.17	10
O	700	9.193	0.0123	2.511	16.0	41.6	91.9	9.5	33.17	0.12	20
P	750	9.850	0.0098	3.280	16.0	51.9	90.2	10.9	34.83	0.13	10
Q	750	9.058	0.0081	1.544	21.1	62.8	95.0	12.8	33.752	0.099	20
R	800	9.532	0.0085	2.560	19.1	60.3	92.1	14.5	34.43	0.11	10
S	800	9.085	0.0059	1.270	24.3	87.1	95.9	16.7	34.168	0.096	20
T	850	9.666	0.0076	2.719	20.6	67.0	91.7	18.5	34.77	0.11	10
U	850	9.286	0.0091	1.727	26.3	56.1	94.5	20.9	34.43	0.11	20
V	900	9.994	0.0040	3.651	22.8	126.8	89.2	23.0	34.97	0.12	10
W	900	9.688	0.0061	2.608	29.6	84.1	92.0	25.6	34.98	0.10	20
X	950	10.61	0.0041	4.832	26.5	125.1	86.5	28.0	36.02	0.11	10
Y	950	10.47	0.0050	4.183	34.5	102.5	88.2	31.1	36.21	0.11	20
Z	1000	11.67	0.0046	6.818	33.8	110.0	82.7	34.1	37.84	0.12	10
AA	1000	11.21	0.0053	5.403	46.5	97.0	85.7	38.3	37.68	0.10	20
AB	1050	11.93	0.0049	6.743	53.6	103.8	83.3	43.1	38.93	0.10	10
AC	1050	11.27	0.0062	5.228	70.5	81.7	86.3	49.4	38.114	0.088	20
AD	1100	11.51	0.0091	5.319	62.5	56.2	86.3	55.0	38.943	0.097	10
AE	1100	11.17	0.0088	4.711	81.6	57.9	87.5	62.3	38.312	0.089	30
AF	1100	10.95	0.0080	3.968	68.0	63.9	89.3	68.4	38.301	0.088	60
AG	1100	11.08	0.0075	4.127	62.3	67.9	89.0	74.0	38.655	0.086	120
AH	1200	11.41	0.0049	3.714	81.1	104.7	90.4	81.2	40.394	0.081	10
AI	1250	11.32	0.0027	3.007	116.6	189.8	92.1	91.7	40.841	0.078	10
AJ	1300	11.51	0.0157	3.231	36.5	32.6	91.7	95.0	41.35	0.11	10
AK	1470	12.19	0.0168	4.819	39.2	30.3	88.3	98.5	42.15	0.12	10
AL	1670	12.73	0.0091	7.261	16.9	55.8	83.1	100.0	41.45	0.17	10

Integrated age ± 1s n=38 K2O=12.62% Age = 38.676 ±0.084

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-LP-002, K-Feldspar, 16.26 mg, J=0.0023951±0.09%, D=1.004±0.001, NM-223K, Lab#=58933-01											
B	450	201.7	0.1172	292.9	1.71	4.4	57.1	0.3	445.9	2.8	10
C	450	23.10	0.0827	39.45	1.15	6.2	49.5	0.5	49.5	1.3	20
D	500	19.80	0.0713	21.85	1.61	7.2	67.4	0.7	57.55	0.93	10
E	500	13.12	0.0817	12.07	2.42	6.2	72.9	1.1	41.42	0.58	20
F	550	17.04	0.0977	11.89	3.15	5.2	79.4	1.6	58.34	0.50	10
G	550	11.55	0.1007	5.717	4.47	5.1	85.4	2.3	42.74	0.28	20
H	600	15.04	0.1081	7.766	5.46	4.7	84.8	3.2	55.04	0.32	10
I	600	11.51	0.1182	3.644	6.31	4.3	90.7	4.2	45.19	0.22	20
J	650	13.33	0.1355	4.937	7.23	3.8	89.1	5.3	51.32	0.22	10
K	650	12.10	0.1329	3.040	8.7	3.8	92.7	6.7	48.49	0.18	20
L	700	13.43	0.1465	4.501	8.3	3.5	90.2	8.0	52.33	0.19	10
M	700	12.35	0.1188	1.261	10.1	4.3	97.1	9.6	51.79	0.15	20
N	750	13.15	0.1131	2.416	9.1	4.5	94.6	11.1	53.75	0.17	10
O	750	12.60	0.0894	0.8517	10.6	5.7	98.1	12.7	53.36	0.14	20
P	800	13.16	0.0965	1.806	8.6	5.3	96.0	14.1	54.53	0.18	10
Q	800	12.59	0.0775	0.5170	10.2	6.6	98.8	15.7	53.72	0.13	20
R	850	13.06	0.0873	1.846	7.79	5.8	95.9	16.9	54.04	0.20	10
S	850	12.63	0.0800	0.7468	9.2	6.4	98.3	18.4	53.62	0.15	20
T	900	13.18	0.0882	2.628	6.87	5.8	94.2	19.5	53.59	0.23	10
U	900	12.64	0.0702	0.9800	9.3	7.3	97.8	21.0	53.34	0.15	20
V	950	12.76	0.0668	1.572	7.41	7.6	96.4	22.1	53.11	0.17	10
W	950	12.64	0.0521	1.072	10.0	9.8	97.5	23.7	53.21	0.15	20
X	1000	12.92	0.0484	2.200	8.9	10.5	95.0	25.1	53.01	0.17	10
Y	1000	12.95	0.0462	1.856	12.6	11.1	95.8	27.1	53.57	0.14	20
Z	1050	13.38	0.0513	3.047	12.5	9.9	93.3	29.1	53.91	0.13	10
AA	1100	13.58	0.0512	3.441	26.8	10.0	92.5	33.3	54.26	0.13	10
AB	1100	13.84	0.0552	3.401	50.5	9.2	92.8	41.3	55.41	0.11	30
AC	1100	14.44	0.0790	4.052	47.8	6.5	91.8	48.9	57.17	0.11	60
AD	1100	14.91	0.0986	4.299	50.2	5.2	91.5	56.8	58.86	0.11	120
AE	1200	14.60	0.0537	2.625	77.9	9.5	94.7	69.2	59.63	0.10	10
AF	1250	14.55	0.0526	1.935	129.9	9.7	96.1	89.8	60.243	0.091	10
AG	1300	15.16	0.1534	2.689	27.1	3.3	94.8	94.1	61.92	0.13	10
AH	1500	16.45	0.3224	4.354	26.6	1.6	92.3	98.3	65.40	0.15	10
AI	1650	17.31	0.2257	8.293	11.0	2.3	85.9	100.0	64.06	0.21	10

Integrated age ± 1s n=34 K2O=6.23% Age – 58.513±0.097

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10 ⁻³)	^{39}ArK (x 10 ⁻¹⁵ mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-LP-003, K-Feldspar, 16.01 mg, J=0.0023944±0.10%, D=1.004±0.001, NM-223K, Lab#=58936-01											
B	450	263.8	0.0500	473.2	1.59	10.2	47.0	0.4	475.7	3.7	10
C	450	34.76	0.0372	75.74	1.19	13.7	35.6	0.7	53.5	1.4	20
D	500	27.78	0.0375	43.69	1.55	13.6	53.5	1.0	64.0	1.1	10
E	500	16.00	0.0477	24.04	2.30	10.7	55.6	1.6	38.57	0.69	20
F	550	18.80	0.0657	21.11	2.99	7.8	66.8	2.3	54.24	0.55	10
G	550	12.80	0.0696	13.35	3.72	7.3	69.2	3.1	38.39	0.39	20
H	600	16.09	0.0784	13.85	4.28	6.5	74.6	4.1	51.84	0.35	10
I	600	11.88	0.0906	8.587	4.97	5.6	78.7	5.3	40.48	0.28	20
J	650	13.75	0.1105	9.540	5.19	4.6	79.6	6.5	47.31	0.31	10
K	650	11.59	0.1018	5.146	6.24	5.0	86.9	8.0	43.62	0.22	20
L	700	12.94	0.1087	5.993	6.31	4.7	86.4	9.5	48.30	0.24	10
M	700	11.55	0.0907	2.479	8.6	5.6	93.7	11.5	46.81	0.17	20
N	750	12.40	0.0906	3.906	8.0	5.6	90.7	13.4	48.62	0.20	10
O	750	11.84	0.0720	1.397	10.1	7.1	96.6	15.7	49.38	0.15	20
P	800	12.90	0.0748	3.238	8.7	6.8	92.6	17.8	51.58	0.20	10
Q	800	12.14	0.0652	1.232	10.8	7.8	97.0	20.3	50.89	0.15	20
R	850	12.79	0.0749	2.754	8.9	6.8	93.7	22.4	51.74	0.17	10
S	850	12.31	0.0666	1.240	10.6	7.7	97.1	24.9	51.58	0.14	20
T	900	12.89	0.0700	2.993	8.4	7.3	93.2	26.8	51.86	0.18	10
U	900	12.50	0.0554	1.714	10.7	9.2	96.0	29.4	51.79	0.15	20
V	950	12.82	0.0543	2.166	8.4	9.4	95.0	31.3	52.60	0.18	10
W	950	12.59	0.0419	2.024	10.6	12.2	95.3	33.8	51.78	0.14	20
X	1000	13.22	0.0478	3.492	8.5	10.7	92.2	35.8	52.63	0.17	10
Y	1000	13.04	0.0413	2.908	11.6	12.4	93.4	38.6	52.58	0.14	20
Z	1050	14.09	0.0537	5.380	10.8	9.5	88.7	41.1	53.97	0.17	10
AA	1100	14.65	0.0560	6.235	18.7	9.1	87.4	45.5	55.28	0.16	10
AB	1100	15.79	0.0623	8.760	32.3	8.2	83.6	53.1	56.95	0.15	30
AC	1100	17.00	0.0785	10.66	35.9	6.5	81.5	61.5	59.69	0.15	60
AD	1100	17.48	0.0848	10.07	44.4	6.0	83.0	71.9	62.49	0.16	120
AE	1200	16.89	0.0744	5.827	41.4	6.9	89.8	81.6	65.28	0.15	10
AF	1250	16.99	0.0941	5.174	35.9	5.4	91.0	90.1	66.53	0.13	10
AG	1300	17.71	0.1166	5.465	4.76	4.4	90.9	91.2	69.21	0.33	10
AH	1500	18.71	0.1622	9.536	26.9	3.1	85.0	97.5	68.37	0.16	10
AI	1650	18.94	0.1363	11.26	10.7	3.7	82.5	100.0	67.18	0.25	10

Integrated age ± 1s n=34 K₂O=4.27% Age – 59.50 ±0.12

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-LP-006, K-Feldspar, 14.65 mg, J=0.0023944±0.10%, D=1.004±0.001, NM-223K, Lab#=58935-01											
B	450	381.0	0.0422	379.9	1.81	12.1	70.5	0.2	909.4	3.6	10
C	450	27.96	0.0351	45.15	1.44	14.5	52.3	0.4	62.9	1.1	20
D	500	30.69	0.0365	28.50	1.74	14.0	72.6	0.7	95.09	0.94	10
E	500	13.51	0.0357	13.95	2.95	14.3	69.5	1.1	40.64	0.52	20
F	550	27.36	0.0402	14.60	4.03	12.7	84.2	1.6	98.29	0.51	10
G	550	10.15	0.0495	6.329	5.07	10.3	81.6	2.3	35.93	0.29	20
H	600	19.82	0.0558	9.620	6.52	9.2	85.7	3.2	72.90	0.32	10
I	600	9.425	0.0542	3.986	7.51	9.4	87.5	4.2	35.77	0.19	20
J	650	13.47	0.0614	5.562	8.3	8.3	87.8	5.3	51.10	0.18	10
K	650	9.030	0.0532	2.538	9.9	9.6	91.7	6.7	35.91	0.14	20
L	700	12.25	0.0573	4.601	10.2	8.9	88.9	8.1	47.10	0.18	10
M	700	8.471	0.0413	1.424	12.3	12.3	95.1	9.7	34.92	0.11	20
N	750	9.621	0.0388	2.199	11.5	13.2	93.3	11.3	38.87	0.13	10
O	750	8.434	0.0317	1.003	13.6	16.1	96.5	13.1	35.291	0.095	20
P	800	9.309	0.0303	1.639	11.7	16.9	94.8	14.7	38.24	0.14	10
Q	800	8.719	0.0254	0.9094	13.5	20.1	96.9	16.5	36.636	0.099	20
R	850	9.361	0.0307	1.637	10.8	16.6	94.9	18.0	38.47	0.13	10
S	850	9.181	0.0271	0.7649	13.0	18.8	97.6	19.8	38.80	0.11	20
T	900	10.14	0.0319	2.325	10.0	16.0	93.2	21.1	40.94	0.15	10
U	900	10.00	0.0257	1.723	12.7	19.9	94.9	22.9	41.11	0.12	20
V	950	10.84	0.0251	2.543	10.3	20.4	93.1	24.2	43.64	0.15	10
W	950	10.57	0.0227	1.346	13.8	22.5	96.3	26.1	44.03	0.12	20
X	1000	11.37	0.0221	2.332	11.6	23.0	94.0	27.7	46.21	0.14	10
Y	1000	11.35	0.0197	1.877	17.3	26.0	95.1	30.0	46.66	0.12	20
Z	1050	12.38	0.0222	3.075	16.4	22.9	92.7	32.3	49.58	0.12	10
AA	1100	13.05	0.0248	3.351	32.7	20.5	92.4	36.7	52.09	0.11	10
AB	1100	13.73	0.0299	3.559	63.6	17.0	92.4	45.3	54.724	0.095	30
AC	1100	15.07	0.0424	4.027	56.5	12.0	92.1	53.0	59.83	0.11	60
AD	1100	16.21	0.0480	3.971	59.7	10.6	92.8	61.1	64.74	0.12	120
AE	1200	16.95	0.0324	2.593	65.3	15.7	95.5	69.9	69.55	0.11	10
AF	1250	16.34	0.0183	1.882	111.2	27.9	96.6	85.0	67.86	0.10	10
AG	1300	15.92	0.0183	1.847	27.6	27.9	96.6	88.7	66.15	0.13	10
AH	1500	17.66	0.0546	3.620	52.8	9.3	94.0	95.9	71.29	0.12	10
AI	1650	16.98	0.0379	3.952	30.4	13.5	93.1	100.0	68.00	0.15	10

Integrated age ± 1s n=34 K2O=8.08% Age – 60.48 ±0.10

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-LP-007, K-Feldspar, 15.78 mg, J=0.0023955±0.09%, D=1.004±0.001, NM-223K, Lab#=58932-01											
B	450	197.0	0.0444	236.2	2.91	11.5	64.6	0.3	486.9	2.4	10
C	450	18.01	0.0217	29.62	3.01	23.5	51.4	0.7	40.13	0.52	20
D	500	17.02	0.0297	17.47	4.65	17.2	69.7	1.2	51.24	0.33	10
E	500	10.64	0.0488	9.850	6.49	10.4	72.7	1.9	33.58	0.19	20
F	500	9.970	0.0827	9.174	5.81	6.2	72.9	2.6	31.55	0.24	30
G	550	13.07	0.0897	11.45	7.41	5.7	74.1	3.4	41.97	0.24	10
H	550	9.473	0.0789	5.961	9.2	6.5	81.5	4.4	33.49	0.17	20
I	550	9.197	0.0639	5.586	8.6	8.0	82.1	5.4	32.77	0.16	30
J	600	11.78	0.0578	8.944	9.5	8.8	77.6	6.5	39.62	0.20	10
K	600	8.818	0.0449	3.698	11.8	11.4	87.6	7.8	33.54	0.12	20
L	600	8.772	0.0379	3.473	10.8	13.5	88.3	9.0	33.63	0.13	29
M	650	9.966	0.0394	5.452	10.7	12.9	83.9	10.2	36.25	0.16	10
N	650	8.554	0.0326	2.644	13.7	15.7	90.9	11.7	33.74	0.11	20
O	700	9.711	0.0349	3.841	15.1	14.6	88.3	13.4	37.19	0.11	10
P	700	8.429	0.0263	1.884	18.0	19.4	93.4	15.5	34.165	0.093	20
Q	750	9.217	0.0285	2.850	16.4	17.9	90.9	17.3	36.33	0.11	10
R	750	8.501	0.0255	1.777	18.1	20.0	93.8	19.3	34.613	0.084	20
S	800	9.056	0.0310	2.850	14.4	16.5	90.7	21.0	35.64	0.11	10
T	800	8.623	0.0249	1.673	16.1	20.5	94.3	22.8	35.265	0.090	20
U	850	9.131	0.0352	2.620	12.7	14.5	91.5	24.2	36.25	0.11	10
V	850	8.896	0.0260	2.050	15.3	19.6	93.2	25.9	35.965	0.098	20
W	900	9.348	0.0304	2.725	12.6	16.8	91.4	27.3	37.05	0.11	10
X	900	9.060	0.0172	1.645	16.5	29.7	94.6	29.2	37.178	0.091	20
Y	950	9.505	0.0176	2.288	14.8	29.0	92.9	30.8	38.28	0.11	10
Z	950	9.429	0.0125	1.603	20.5	40.9	95.0	33.2	38.82	0.10	20
AA	1000	10.24	0.0155	2.334	19.6	32.9	93.3	35.4	41.361	0.099	10
AB	1000	10.10	0.0123	1.741	28.5	41.4	94.9	38.6	41.533	0.095	20
AC	1050	11.02	0.0158	2.496	30.1	32.2	93.3	41.9	44.496	0.095	10
AD	1100	11.40	0.0209	2.864	49.0	24.4	92.6	47.5	45.663	0.083	10
AE	1100	11.41	0.0252	2.549	63.5	20.2	93.4	54.6	46.096	0.083	30
AF	1100	11.83	0.0346	2.918	57.5	14.7	92.7	61.1	47.442	0.084	60
AG	1100	12.36	0.0415	3.317	54.7	12.3	92.1	67.2	49.217	0.090	120
AH	1200	13.51	0.0503	3.897	56.6	10.1	91.5	73.6	53.374	0.100	10
AI	1250	12.45	0.0220	1.507	121.9	23.2	96.4	87.3	51.865	0.080	10
AJ	1300	11.99	0.0147	1.068	40.5	34.7	97.4	91.8	50.451	0.089	10
AK	1500	12.89	0.0476	2.440	49.6	10.7	94.4	97.4	52.590	0.089	10
AL	1650	13.37	0.0396	4.274	23.2	12.9	90.6	100.0	52.30	0.13	10

Integrated age $\pm 1s$ n=37 K2O=9.04% Age = 46.446 $\pm$ 0.079

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10 ⁻³)	³⁹ ArK (x 10 ⁻¹⁵ mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-LP-008, K-Feldspar, 14.11 mg, J=0.0023947±0.09%, D=1.004±0.001, NM-223K, Lab#=58934-01											
B	450	365.5	0.1718	388.7	1.39	3.0	68.6	0.2	860.6	4.1	10
C	450	42.04	0.1183	66.19	0.786	4.3	53.5	0.3	96.0	1.9	20
D	500	36.50	0.0989	44.80	1.20	5.2	63.7	0.5	99.2	1.3	10
E	500	17.07	0.1106	22.51	1.71	4.6	61.1	0.8	45.11	0.74	20
F	550	24.65	0.1047	19.51	2.47	4.9	76.6	1.2	80.99	0.81	10
G	550	11.62	0.1168	9.096	3.55	4.4	76.9	1.8	38.73	0.40	20
H	600	20.94	0.1454	12.12	4.46	3.5	82.9	2.5	74.56	0.38	10
I	600	9.993	0.1619	4.551	5.51	3.2	86.7	3.4	37.54	0.26	20
J	650	14.29	0.1886	8.393	5.78	2.7	82.7	4.3	51.07	0.26	10
K	650	9.416	0.1751	2.722	8.1	2.9	91.6	5.6	37.39	0.16	20
L	700	10.83	0.1569	3.229	8.3	3.3	91.3	7.0	42.79	0.18	10
M	700	8.939	0.1252	1.159	11.0	4.1	96.3	8.7	37.30	0.13	20
N	750	9.508	0.1126	1.484	10.8	4.5	95.5	10.5	39.33	0.13	10
O	750	8.839	0.0866	0.8163	14.3	5.9	97.3	12.8	37.30	0.11	20
P	800	9.288	0.0825	1.055	12.9	6.2	96.7	14.8	38.92	0.12	10
Q	800	9.231	0.0739	0.8928	17.5	6.9	97.2	17.6	38.875	0.095	20
R	850	9.032	0.0612	0.8273	14.3	8.3	97.3	19.9	38.10	0.10	10
S	850	8.824	0.0483	0.6191	17.9	10.6	98.0	22.8	37.47	0.11	20
T	900	9.155	0.0408	1.283	14.3	12.5	95.9	25.1	38.04	0.11	10
U	900	8.952	0.0304	0.6990	19.3	16.8	97.7	28.2	37.907	0.088	20
V	950	9.301	0.0293	1.200	15.2	17.4	96.2	30.7	38.77	0.10	10
W	950	9.225	0.0280	1.024	17.7	18.2	96.7	33.5	38.667	0.096	20
X	1000	9.929	0.0328	1.748	13.0	15.6	94.8	35.6	40.77	0.12	10
Y	1000	9.856	0.0334	1.710	16.7	15.3	94.9	38.3	40.51	0.11	20
Z	1050	11.10	0.0458	2.891	13.6	11.1	92.3	40.5	44.35	0.14	10
AA	1100	12.09	0.0517	3.710	24.5	9.9	91.0	44.4	47.54	0.12	10
AB	1100	12.48	0.0647	4.029	36.6	7.9	90.5	50.3	48.83	0.11	30
AC	1100	13.47	0.0814	4.979	35.8	6.3	89.1	56.1	51.85	0.12	60
AD	1100	14.19	0.0859	4.761	40.5	5.9	90.1	62.6	55.17	0.11	120
AE	1200	14.38	0.0372	2.220	53.1	13.7	95.5	71.1	59.18	0.10	10
AF	1250	13.97	0.0338	1.772	101.7	15.1	96.3	87.4	57.969	0.094	10
AG	1300	14.40	0.0822	2.086	33.2	6.2	95.8	92.8	59.43	0.12	10
AH	1500	16.58	0.1788	4.072	28.9	2.9	92.8	97.4	66.21	0.14	10
AI	1650	16.17	0.1081	5.594	16.0	4.7	89.8	100.0	62.54	0.18	10

Integrated age ± 1s n=34 K2O=7.07% Age – 52.589 ±0.089

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-TL-002, K-Feldspar, 17.28 mg, J=0.0021678 $\pm$ 0.12%, D=1.0014 $\pm$ 0.001, NM-220L, Lab#=58601-01											
AK	1670	17.65	0.0650	6.868	23.3	7.8	88.5	1.9	60.96	0.17	10
A	450	838.8	0.0093	1044.8	1.79	54.9	63.2	2.0	1400.3	6.9	10
B	450	53.98	0.0462	87.46	3.08	11.0	52.1	2.2	108.3	1.0	20
C	500	55.61	0.0367	44.58	4.10	13.9	76.3	2.6	161.06	0.77	10
D	500	20.74	0.0508	27.44	4.87	10.0	60.9	2.9	49.42	0.54	20
E	550	36.93	0.0309	24.75	7.83	16.5	80.2	3.6	113.88	0.47	10
F	550	15.79	0.0391	13.10	8.87	13.0	75.5	4.3	46.67	0.26	20
G	600	23.93	0.0373	16.16	11.6	13.7	80.0	5.2	74.45	0.30	10
I	600	14.04	0.0933	8.435	10.8	5.5	82.3	6.0	45.26	0.23	20
J	650	18.02	0.0698	10.32	18.5	7.3	83.1	7.5	58.46	0.19	10
K	650	12.17	0.0574	4.571	19.2	8.9	88.9	9.0	42.42	0.16	20
L	700	13.53	0.0567	4.350	18.8	9.0	90.5	10.5	47.95	0.14	10
M	700	11.71	0.0437	3.144	22.4	11.7	92.1	12.3	42.26	0.13	20
N	750	12.35	0.0430	2.952	19.3	11.9	93.0	13.8	44.98	0.13	10
O	750	11.56	0.0623	2.690	12.1	8.2	93.2	14.8	42.22	0.17	10
P	800	11.81	0.0534	2.322	17.9	9.6	94.2	16.2	43.60	0.12	10
Q	800	11.18	0.0380	1.889	22.4	13.4	95.0	18.0	41.66	0.11	20
R	850	12.04	0.0523	3.571	16.2	9.7	91.3	19.3	43.04	0.13	10
S	850	11.56	0.0462	2.446	18.2	11.0	93.8	20.7	42.48	0.12	20
T	900	12.82	0.0547	4.592	14.7	9.3	89.4	21.9	44.93	0.14	10
U	900	12.21	0.0441	3.050	17.3	11.6	92.6	23.3	44.32	0.13	20
V	950	13.56	0.0524	4.679	14.5	9.7	89.8	24.4	47.69	0.15	10
W	950	13.40	0.0397	3.769	18.9	12.8	91.7	25.9	48.08	0.13	20
X	1000	15.56	0.0453	6.445	18.2	11.3	87.8	27.4	53.37	0.16	10
Y	1000	15.20	0.0341	5.164	27.7	15.0	90.0	29.5	53.43	0.14	20
Z	1050	17.78	0.0297	7.316	34.6	17.2	87.9	32.3	60.93	0.16	10
AA	1050	16.47	0.0273	5.869	45.2	18.7	89.5	35.9	57.54	0.13	20
AB	1100	17.69	0.0309	5.856	37.6	16.5	90.2	38.9	62.24	0.16	10
AC	1100	17.19	0.0263	5.384	64.6	19.4	90.8	44.0	60.83	0.11	30
AD	1100	17.05	0.0257	4.220	69.8	19.8	92.7	49.5	61.64	0.12	60
AE	1100	17.48	0.0265	3.836	74.9	19.3	93.5	55.5	63.72	0.11	120
AF	1200	18.92	0.0176	3.155	100.9	29.0	95.1	63.5	70.01	0.11	10
AG	1250	18.08	0.0098	2.170	264.3	52.0	96.5	84.4	67.90	0.11	10
AH	1300	17.24	0.0149	2.308	119.5	34.3	96.0	93.9	64.513	0.099	10
AI	1370	17.62	0.0593	3.190	33.5	8.6	94.7	96.6	65.01	0.13	10
AJ	1470	17.16	0.0389	3.016	43.3	13.1	94.8	100.0	63.42	0.13	10

Integrated age $\pm 1s$ n=36 K2O=12.93% Age – 63.87 $\pm$ 0.12

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	37Ar/39Ar	36Ar/39Ar (x 10-3)	39ArK (x 10-15 mol)	K/Ca	40Ar (%)	39Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-004, K-Feldspar, 12.89 mg, J=0.0021666±0.11%, D=1.0014±0.001, NM-220L, Lab#=58603-01											
A	450	384.0	-0.0073	1237.5	1.42	-	4.8	0.2	71.2	7.1	10
B	450	56.69	-0.0099	161.5	1.61	-	15.8	0.4	35.2	2.0	20
C	500	51.97	-0.0075	136.7	2.35	-	22.3	0.7	45.4	1.5	10
D	500	24.61	0.0127	52.56	2.56	40.0	36.9	1.1	35.63	0.91	20
E	500	19.86	0.0468	36.73	2.93	10.9	45.3	1.5	35.34	0.75	40
F	550	36.11	0.0280	81.64	3.07	18.2	33.2	1.9	46.9	1.0	10
G	550	17.13	0.0610	26.31	3.31	8.4	54.6	2.3	36.71	0.62	20
H	600	30.44	0.0513	66.77	5.78	9.9	35.2	3.1	41.98	0.70	10
I	600	13.44	0.0691	12.88	4.97	7.4	71.7	3.8	37.79	0.35	20
J	600	12.87	0.0478	10.94	5.58	10.7	74.9	4.6	37.80	0.30	40
K	650	14.06	0.0313	14.50	3.24	16.3	69.5	5.0	38.32	0.46	10
L	650	12.19	0.0346	6.747	4.70	14.7	83.6	5.6	39.95	0.35	20
M	700	13.87	0.0483	12.82	5.26	10.6	72.7	6.4	39.51	0.36	10
N	700	12.05	0.0501	7.175	6.36	10.2	82.4	7.2	38.93	0.25	20
O	750	13.03	0.0291	10.54	5.96	17.5	76.1	8.0	38.87	0.30	10
P	750	11.71	0.0412	6.280	6.23	12.4	84.2	8.9	38.64	0.24	20
Q	800	13.01	0.0415	10.96	4.91	12.3	75.1	9.5	38.31	0.32	10
R	800	11.98	0.0426	7.672	5.56	12.0	81.1	10.3	38.10	0.30	20
S	850	15.56	0.0164	19.61	4.99	31.1	62.7	11.0	38.28	0.42	10
T	850	13.29	0.0181	12.17	5.58	28.2	72.9	11.7	38.00	0.34	20
U	900	18.13	0.0309	29.27	5.62	16.5	52.3	12.5	37.20	0.46	10
V	900	14.71	0.0025	16.81	7.21	204.2	66.2	13.5	38.18	0.35	20
W	950	18.55	0.0087	29.66	8.46	58.9	52.7	14.6	38.35	0.39	10
X	950	16.55	0.0102	22.97	11.5	50.0	59.0	16.2	38.28	0.31	20
Y	1000	19.47	0.0170	33.59	16.2	30.1	49.0	18.4	37.41	0.39	10
Z	1000	16.97	0.0098	25.19	20.3	52.2	56.1	21.1	37.37	0.26	20
AA	1050	18.68	0.0105	30.75	34.4	48.7	51.3	25.8	37.63	0.25	10
AB	1050	16.82	0.0153	24.32	35.9	33.4	57.2	30.7	37.76	0.21	20
AC	1100	16.35	0.0180	22.56	52.4	28.3	59.2	37.8	37.98	0.18	10
AD	1100	15.30	0.0147	18.60	78.4	34.6	64.1	48.4	38.44	0.15	30
AE	1100	14.24	0.0139	14.47	74.5	36.8	70.0	58.6	39.05	0.13	60
AF	1100	13.83	0.0155	12.53	71.4	32.8	73.2	68.3	39.71	0.15	120
AG	1200	12.97	0.0096	9.039	104.1	52.9	79.4	82.4	40.35	0.10	10
AH	1250	13.87	0.0120	11.64	70.2	42.6	75.2	91.9	40.87	0.14	10
AI	1300	15.74	0.0291	17.07	12.1	17.5	68.0	93.6	41.92	0.25	10
AJ	1370	15.82	0.0629	16.51	11.9	8.1	69.2	95.2	42.86	0.25	10
AK	1470	14.81	0.0127	14.02	25.5	40.2	72.0	98.7	41.78	0.19	10
AL	1670	15.43	0.0194	15.99	9.92	26.4	69.4	100.0	41.93	0.30	10

Integrated age ± 1s n=38 K2O=10.13% Age – 39.39 ±0.14

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10 ⁻³)	³⁹ ArK (x 10 ⁻¹⁵ mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-006, K-Feldspar, 16.14 mg, J=0.0021686±0.11%, D=1.0014±0.001, NM-220L, Lab#=58610-01											
A	450	354.4	0.0301	1034.1	1.56	16.9	13.8	0.2	184.1	6.0	10
B	450	52.12	0.0043	137.1	2.38	117.5	22.3	0.5	45.5	1.4	20
C	500	27.04	0.0044	56.10	2.84	114.7	38.7	0.9	41.04	0.92	10
D	500	18.85	0.0074	29.36	4.17	69.3	54.0	1.4	39.92	0.55	20
E	500	16.53	0.0329	22.19	4.97	15.5	60.3	2.0	39.12	0.40	40
F	550	17.95	0.0245	22.39	3.84	20.8	63.1	2.5	44.43	0.58	10
G	550	13.48	0.0276	10.45	5.88	18.5	77.1	3.3	40.76	0.33	20
H	550	13.35	0.0220	9.638	2.90	23.1	78.7	3.7	41.18	0.60	20
I	550	13.24	0.0392	9.781	6.61	13.0	78.2	4.5	40.62	0.30	40
J	600	14.03	0.0352	10.18	5.22	14.5	78.5	5.2	43.19	0.35	10
K	600	11.97	0.0354	4.685	7.90	14.4	88.4	6.2	41.52	0.22	20
L	600	11.97	0.0355	4.842	10.4	14.4	88.1	7.5	41.33	0.19	40
M	650	12.19	0.0254	5.041	7.21	20.1	87.8	8.4	41.97	0.25	10
N	650	11.38	0.0405	2.600	10.7	12.6	93.3	9.8	41.63	0.18	20
O	700	11.55	0.0346	3.272	12.2	14.8	91.6	11.4	41.52	0.15	10
P	700	11.10	0.0296	1.518	15.3	17.2	96.0	13.3	41.79	0.14	20
Q	750	11.32	0.0292	2.079	14.5	17.5	94.6	15.2	41.97	0.13	10
R	750	11.07	0.0271	1.668	16.3	18.9	95.6	17.3	41.49	0.12	20
S	800	11.33	0.0300	2.316	12.9	17.0	94.0	18.9	41.77	0.14	10
T	800	11.22	0.0278	1.873	13.6	18.4	95.1	20.7	41.84	0.14	20
U	850	11.93	0.0197	4.060	10.3	25.8	90.0	22.0	42.09	0.18	10
V	850	11.57	0.0283	3.068	11.2	18.0	92.2	23.4	41.82	0.16	20
W	900	12.60	0.0256	6.521	9.21	20.0	84.7	24.6	41.84	0.26	10
X	900	12.15	0.0232	4.920	11.4	22.0	88.0	26.1	41.94	0.19	20
Y	950	13.41	0.0253	9.282	10.7	20.2	79.5	27.4	41.81	0.21	10
Z	950	12.86	0.0156	7.196	14.4	32.8	83.5	29.3	42.10	0.17	20
AA	1000	14.33	0.0171	11.70	15.0	29.8	75.9	31.2	42.65	0.20	10
AB	1000	13.53	0.0180	9.464	19.4	28.3	79.3	33.7	42.08	0.15	20
AC	1050	14.79	0.0190	13.37	23.7	26.8	73.3	36.7	42.48	0.18	10
AD	1050	14.19	0.0243	11.63	30.3	21.0	75.8	40.6	42.18	0.16	20
AE	1100	14.55	0.0215	12.47	33.8	23.7	74.7	44.9	42.59	0.17	10
AF	1100	14.11	0.0192	10.44	63.3	26.6	78.1	53.0	43.22	0.13	30
AG	1100	13.28	0.0158	7.360	72.4	32.3	83.6	62.3	43.54	0.11	60
AH	1100	12.88	0.0142	5.873	80.7	35.9	86.5	72.6	43.694	0.100	120
AJ	1250	12.59	0.0087	4.058	126.3	58.8	90.5	88.8	44.630	0.083	10
AK	1300	12.93	0.0164	4.812	23.3	31.0	89.0	91.8	45.10	0.14	10
AL	1470	12.96	0.0283	5.042	46.6	18.0	88.5	97.7	44.94	0.11	10
AM	1670	14.24	0.0172	8.318	17.6	29.6	82.7	100.0	46.13	0.19	10
Integrated age ± 1s n=38 K2O=8.57% Age – 43.51 ±0.10											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1\text{s}$ (Ma)	Time (min)
F08-TL-007, K-Feldspar, 15.26 mg, J=0.002168±0.11%, D=1.0014±0.001, NM-220L, Lab#=58609-01											
A	450	348.4	0.0477	1000.4	1.70	10.7	15.2	0.2	198.5	6.0	10
B	450	42.20	0.0379	102.7	1.71	13.5	28.1	0.4	46.4	1.5	20
C	500	30.80	0.0585	66.70	2.53	8.7	36.0	0.7	43.5	1.1	10
D	500	18.29	0.0104	27.99	3.27	49.0	54.8	1.0	39.32	0.73	20
E	500	15.97	0.0198	20.20	3.96	25.8	62.6	1.4	39.22	0.48	40
F	550	21.34	0.0133	33.59	3.14	38.2	53.5	1.8	44.72	0.69	10
G	550	13.43	0.0193	10.30	4.78	26.4	77.3	2.3	40.73	0.35	20
H	600	17.45	0.0349	22.22	7.05	14.6	62.4	3.1	42.68	0.38	10
I	600	12.17	0.0313	5.363	8.47	16.3	87.0	4.0	41.49	0.23	20
J	600	11.79	0.0299	4.549	10.4	17.0	88.6	5.2	40.98	0.18	40
K	650	12.77	0.0400	6.712	6.75	12.7	84.5	5.9	42.28	0.29	10
L	650	11.31	0.0313	2.278	9.90	16.3	94.1	7.0	41.72	0.20	20
M	700	12.33	0.0337	5.716	11.6	15.1	86.3	8.2	41.72	0.19	10
N	700	11.20	0.0329	2.279	15.3	15.5	94.0	9.9	41.28	0.13	20
O	750	11.71	0.0320	3.512	15.5	15.9	91.2	11.6	41.84	0.14	10
P	750	11.05	0.0243	1.310	18.1	21.0	96.5	13.6	41.80	0.11	20
Q	800	11.46	0.0262	2.804	14.2	19.4	92.8	15.1	41.69	0.15	10
R	800	11.13	0.0315	1.596	16.2	16.2	95.8	16.9	41.80	0.14	20
S	850	11.95	0.0329	4.447	12.9	15.5	89.0	18.3	41.71	0.16	10
T	850	11.36	0.0245	2.538	14.6	20.8	93.4	19.9	41.60	0.14	20
U	900	12.36	0.0252	5.881	11.7	20.3	85.9	21.2	41.64	0.18	10
V	900	11.64	0.0151	3.575	13.9	33.8	90.9	22.7	41.49	0.15	20
W	950	13.31	0.0156	9.383	12.2	32.8	79.2	24.1	41.33	0.21	10
X	950	12.56	0.0137	6.809	15.5	37.2	84.0	25.8	41.36	0.17	20
Y	1000	14.77	0.0190	14.16	18.3	26.8	71.7	27.8	41.50	0.21	10
Z	1000	13.71	0.0177	10.48	24.3	28.9	77.4	30.4	41.60	0.17	20
AA	1050	15.28	0.0207	15.75	28.3	24.7	69.5	33.5	41.65	0.20	10
AB	1050	14.67	0.0224	13.71	34.4	22.8	72.4	37.3	41.64	0.16	20
AC	1100	14.37	0.0208	12.72	31.0	24.6	73.8	40.7	41.59	0.16	10
AD	1100	13.76	0.0219	10.35	62.3	23.3	77.8	47.5	41.96	0.13	30
AE	1100	13.23	0.0176	8.354	67.0	28.9	81.3	54.9	42.19	0.11	60
AF	1100	12.82	0.0166	6.975	69.4	30.7	83.9	62.5	42.18	0.11	120
AG	1200	12.24	0.0087	4.470	151.2	58.9	89.2	79.0	42.785	0.081	10
AH	1250	12.59	0.0099	5.456	112.8	51.5	87.2	91.4	43.035	0.091	10
AI	1300	13.42	0.0294	8.236	20.1	17.4	81.9	93.6	43.07	0.16	10
AJ	1370	13.19	0.0331	6.912	14.2	15.4	84.5	95.1	43.69	0.18	10
AK	1470	12.60	0.0224	5.573	23.8	22.8	86.9	97.7	42.94	0.14	10
AL	1670	13.62	0.0147	8.816	20.9	34.7	80.9	100.0	43.15	0.15	10

Integrated age $\pm 1\text{s}$ n=38 K2O=10.60% Age = 42.56 ± 0.10

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
F08-TL-008, K-Feldspar, 14.86 mg, J=0.0021662±0.10%, D=1.0014±0.001, NM-220L, Lab#=58607-01											
A	450	231.2	0.0644	675.5	1.63	7.9	13.7	0.2	121.1	4.3	10
B	450	40.49	0.0543	101.9	1.72	9.4	25.6	0.4	40.7	1.3	20
C	500	26.36	0.0911	52.12	2.31	5.6	41.6	0.6	42.93	0.99	10
D	500	17.11	0.0282	24.69	2.90	18.1	57.3	0.9	38.47	0.63	20
E	500	15.56	0.0659	18.44	3.69	7.7	65.0	1.3	39.65	0.50	40
F	550	17.94	0.0962	23.61	3.21	5.3	61.1	1.7	42.95	0.64	10
G	550	12.96	0.0595	9.311	4.67	8.6	78.8	2.2	40.03	0.35	20
H	600	15.92	0.0481	16.20	7.22	10.6	69.9	2.9	43.58	0.33	10
I	600	11.75	0.0470	4.673	8.77	10.9	88.3	3.9	40.64	0.19	20
J	600	11.57	0.0383	3.929	10.8	13.3	90.0	5.0	40.79	0.18	40
K	650	12.02	0.0497	5.128	6.85	10.3	87.4	5.7	41.15	0.24	10
L	650	11.16	0.0383	2.507	9.94	13.3	93.4	6.8	40.84	0.16	20
M	700	11.47	0.0374	3.392	11.4	13.6	91.3	8.0	41.02	0.15	10
N	700	10.93	0.0419	1.379	14.8	12.2	96.3	9.6	41.22	0.12	20
O	750	11.18	0.0367	2.012	14.1	13.9	94.7	11.1	41.46	0.13	10
P	750	10.87	0.0307	1.271	15.7	16.6	96.6	12.8	41.12	0.11	20
Q	800	11.15	0.0369	2.205	12.0	13.8	94.2	14.1	41.13	0.13	10
R	800	10.94	0.0324	1.730	13.1	15.7	95.3	15.5	40.88	0.14	20
S	850	11.51	0.0441	3.329	9.82	11.6	91.5	16.5	41.25	0.17	10
T	850	11.30	0.0319	2.595	11.2	16.0	93.2	17.7	41.26	0.16	20
U	900	12.25	0.0418	6.081	8.98	12.2	85.3	18.7	40.97	0.21	10
V	900	11.78	0.0370	4.091	11.3	13.8	89.8	19.9	41.42	0.16	20
W	950	13.16	0.0214	8.874	10.5	23.9	80.1	21.0	41.28	0.20	10
X	950	12.46	0.0220	6.442	14.5	23.2	84.7	22.5	41.36	0.17	20
Y	1000	13.89	0.0266	11.39	15.4	19.2	75.8	24.2	41.25	0.20	10
Z	1000	12.95	0.0201	7.810	20.8	25.3	82.2	26.4	41.69	0.15	20
AA	1050	14.01	0.0219	11.63	26.6	23.3	75.5	29.2	41.42	0.18	10
AB	1050	13.10	0.0212	8.289	33.1	24.0	81.3	32.8	41.73	0.14	20
AC	1100	13.11	0.0231	8.087	48.7	22.1	81.8	38.0	41.97	0.12	10
AD	1100	12.61	0.0175	6.409	80.9	29.1	85.0	46.6	41.98	0.12	30
AE	1100	12.11	0.0142	4.341	80.9	35.9	89.4	55.2	42.394	0.095	60
AF	1100	11.96	0.0130	3.557	80.5	39.3	91.2	63.8	42.718	0.098	120
AG	1200	11.76	0.0079	2.710	134.4	64.9	93.2	78.2	42.901	0.070	10
AH	1250	11.91	0.0091	3.119	125.1	55.8	92.3	91.5	43.039	0.076	10
AI	1300	11.89	0.0204	3.095	24.6	25.0	92.3	94.2	42.99	0.13	10
AJ	1370	12.19	0.0276	3.493	10.1	18.5	91.5	95.2	43.71	0.16	10
AK	1470	12.01	0.0160	3.276	32.1	31.9	91.9	98.7	43.23	0.11	10
AL	1670	13.43	0.0155	7.802	12.6	32.9	82.8	100.0	43.54	0.19	10

Integrated age ± 1s n=38 K2O=11.18% Age – 42.401 ±0.086

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-TL-009, K-Feldspar, 15.65 mg, J=0.0021658±0.10%, D=1.0014±0.001, NM-220L, Lab#=58604-01											
A	450	362.3	0.0689	1182.1	1.15	7.4	3.6	0.1	50.9	7.8	10
B	450	59.55	0.0987	168.5	1.63	5.2	16.4	0.3	38.2	2.1	20
C	500	33.40	0.0556	81.20	2.23	9.2	28.2	0.5	36.9	1.0	10
D	500	19.22	0.0501	32.94	2.82	10.2	49.3	0.8	37.19	0.77	20
E	500	17.16	0.0464	25.31	3.47	11.0	56.4	1.2	37.97	0.72	40
F	550	17.63	0.0444	23.00	2.75	11.5	61.4	1.5	42.43	0.71	10
G	550	13.59	0.0674	12.16	3.98	7.6	73.6	1.9	39.20	0.43	20
H	550	13.07	0.0363	11.20	5.37	14.1	74.7	2.5	38.26	0.37	40
I	600	13.04	0.0568	8.658	3.77	9.0	80.4	2.8	41.06	0.46	10
J	600	11.85	0.0530	5.315	5.76	9.6	86.8	3.5	40.28	0.31	20
K	650	12.36	0.0567	6.722	7.20	9.0	84.0	4.2	40.67	0.26	10
L	650	11.14	0.0426	2.971	9.51	12.0	92.1	5.2	40.22	0.17	20
M	700	11.14	0.0444	2.770	9.61	11.5	92.7	6.2	40.43	0.20	10
N	700	10.87	0.0314	1.944	11.3	16.3	94.7	7.4	40.32	0.16	20
O	750	11.06	0.0390	2.467	9.94	13.1	93.4	8.4	40.50	0.20	10
P	750	10.79	0.0322	1.731	9.36	15.8	95.3	9.4	40.29	0.19	20
Q	800	11.20	0.0373	2.599	7.24	13.7	93.2	10.2	40.88	0.23	10
S	850	12.27	0.0401	6.290	5.72	12.7	84.9	10.8	40.80	0.33	10
T	850	11.57	0.0322	4.141	8.73	15.8	89.4	11.7	40.53	0.21	20
U	900	14.07	0.0352	12.66	8.53	14.5	73.4	12.6	40.47	0.29	10
V	900	12.66	0.0193	7.544	11.4	26.5	82.4	13.8	40.85	0.19	20
W	950	14.69	0.0207	15.09	11.7	24.6	69.6	15.0	40.07	0.23	10
X	950	13.39	0.0131	10.48	15.0	38.9	76.9	16.6	40.34	0.22	20
Y	1000	14.94	0.0117	15.81	19.7	43.7	68.7	18.6	40.23	0.22	10
Z	1000	13.59	0.0126	11.10	13.7	40.6	75.9	20.1	40.38	0.19	10
AA	1050	14.22	0.0089	13.88	38.5	57.3	71.1	24.1	39.65	0.16	10
AB	1050	13.40	0.0117	10.85	55.3	43.5	76.1	29.9	39.95	0.13	20
AC	1100	13.09	0.0121	9.758	56.7	42.1	78.0	35.8	40.00	0.13	10
AD	1100	12.48	0.0105	7.531	101.8	48.7	82.2	46.5	40.157	0.096	30
AE	1100	11.87	0.0087	5.181	107.0	58.4	87.1	57.7	40.484	0.082	60
AF	1100	11.70	0.0112	4.524	105.1	45.7	88.6	68.8	40.593	0.083	120
AG	1150	11.47	0.0090	3.525	21.6	56.4	90.9	71.0	40.85	0.13	10
AH	1200	11.40	0.0074	3.082	106.2	69.3	92.0	82.1	41.070	0.073	10
AI	1250	11.69	0.0113	3.736	79.4	45.3	90.6	90.5	41.467	0.084	10
AJ	1300	11.82	0.0225	3.829	19.5	22.7	90.4	92.5	41.85	0.14	10
AK	1470	12.41	0.0364	6.041	31.4	14.0	85.6	95.8	41.61	0.13	10
AL	1670	12.42	0.0087	5.776	40.1	58.6	86.2	100.0	41.94	0.12	10

Integrated age $\pm 1s$ n=37 K2O=10.81% Age – 40.632 $\pm$ 0.092

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-TL-014, K-Feldspar, 15.3 mg, J=0.0021673 $\pm$ 0.10%, D=1.0014 $\pm$ 0.001, NM-220L, Lab#=58608-01											
A	450	779.3	0.0444	622.3	2.40	11.5	76.4	0.2	1517.0	5.2	10
B	450	42.69	0.0294	45.87	2.44	17.4	68.3	0.4	112.08	0.94	20
C	500	72.84	0.0220	25.84	4.45	23.2	89.5	0.8	241.92	0.84	10
D	500	17.90	0.0626	14.02	4.39	8.2	76.9	1.2	53.75	0.41	20
E	500	15.60	0.0507	10.94	4.56	10.1	79.3	1.6	48.38	0.40	40
F	550	33.30	0.0569	12.02	5.77	9.0	89.3	2.1	114.36	0.45	10
G	550	14.69	0.0657	7.361	3.77	7.8	85.2	2.5	48.99	0.44	10
H	550	14.77	0.0765	5.987	10.3	6.7	88.1	3.4	50.84	0.20	40
I	600	24.19	0.0445	7.386	10.6	11.5	91.0	4.3	85.29	0.23	10
J	600	13.11	0.0401	2.744	11.7	12.7	93.8	5.4	48.12	0.17	20
K	600	12.07	0.0332	2.354	14.1	15.4	94.3	6.6	44.54	0.15	40
L	650	16.33	0.0450	3.763	9.98	11.3	93.2	7.5	59.39	0.20	10
M	650	12.32	0.0364	1.887	13.9	14.0	95.5	8.8	46.04	0.13	20
N	700	14.70	0.0308	2.291	16.7	16.6	95.4	10.2	54.76	0.15	10
O	700	11.63	0.0290	1.203	18.6	17.6	97.0	11.9	44.17	0.11	20
P	750	12.64	0.0284	1.333	17.6	17.9	96.9	13.5	47.93	0.13	10
Q	750	11.29	0.0285	0.8044	19.2	17.9	97.9	15.2	43.31	0.10	20
R	800	11.97	0.0285	1.748	16.8	17.9	95.7	16.7	44.84	0.12	10
S	800	11.46	0.0251	1.171	17.9	20.3	97.0	18.3	43.53	0.11	20
T	850	12.41	0.0262	2.893	14.0	19.5	93.1	19.5	45.24	0.13	10
U	850	11.85	0.0179	1.379	16.1	28.6	96.6	21.0	44.80	0.12	20
V	900	12.84	0.0213	2.278	13.4	23.9	94.8	22.1	47.59	0.14	10
W	900	12.58	0.0199	1.519	16.9	25.6	96.4	23.6	47.48	0.13	20
X	950	14.20	0.0263	2.437	15.2	19.4	94.9	25.0	52.67	0.14	10
Y	950	14.01	0.0119	2.189	20.2	42.7	95.4	26.8	52.24	0.13	20
Z	1000	16.40	0.0158	2.888	20.1	32.3	94.8	28.6	60.61	0.14	10
AA	1000	15.65	0.0165	2.455	28.0	30.9	95.4	31.1	58.25	0.14	20
AB	1050	18.07	0.0134	3.155	34.3	38.1	94.8	34.1	66.72	0.14	10
AC	1050	16.62	0.0161	2.752	41.5	31.6	95.1	37.8	61.62	0.12	20
AD	1100	17.22	0.0188	2.719	26.6	27.1	95.3	40.2	63.95	0.14	10
AE	1100	16.83	0.0179	2.243	49.8	28.5	96.1	44.6	63.00	0.13	30
AF	1100	16.75	0.0182	2.037	53.7	28.0	96.4	49.4	62.95	0.11	60
AG	1100	17.37	0.0202	2.275	57.6	25.3	96.1	54.5	65.03	0.13	120
AH	1200	19.19	0.0112	1.351	97.4	45.4	97.9	63.2	73.04	0.11	10
AI	1250	18.81	0.0055	0.9331	269.1	93.6	98.5	87.2	72.04	0.11	10
AJ	1300	18.09	0.0245	1.244	68.0	20.8	98.0	93.2	68.97	0.12	10
AK	1370	17.79	0.0624	2.515	22.3	8.2	95.9	95.2	66.41	0.16	10
AL	1470	17.42	0.0193	1.267	34.1	26.4	97.9	98.3	66.36	0.14	10
AM	1670	18.20	0.0307	5.246	19.5	16.6	91.5	100.0	64.86	0.15	10

Integrated age $\pm 1s$ n=39 K2O=13.01% Age – 69.04 $\pm$ 0.11

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H07-HU-001, K-Feldspar, 12.52 mg, J=0.0022995±0.06%, D=1.0032±0.0012, NM-212E, Lab#=57443-01											
A	450	1171.7	0.1032	2203.6	0.461	4.9	44.4	0.0	1440.9	14.7	6
B	450	394.9	0.0204	741.8	0.475	25.1	44.5	0.1	621.3	8.5	20
C	500	195.7	0.1128	329.4	0.604	4.5	50.2	0.2	373.1	5.4	10
D	500	41.27	0.0719	63.14	0.363	7.1	54.8	0.2	92.8	6.1	17
E	550	103.0	-0.0102	138.8	0.769	-	60.2	0.3	243.9	3.8	7
F	550	23.75	0.0223	26.27	1.60	22.8	67.3	0.4	66.1	1.7	20
G	600	63.18	0.0342	77.98	4.92	14.9	63.5	1.0	161.6	1.1	10
H	600	11.10	0.0371	5.694	4.19	13.7	84.9	1.4	39.20	0.57	20
I	650	14.93	0.0506	8.214	5.79	10.1	83.8	2.0	51.87	0.41	10
J	650	9.442	0.0599	1.451	6.83	8.5	95.5	2.7	37.53	0.33	20
K	700	9.653	0.0578	0.9935	7.28	8.8	97.0	3.5	38.96	0.36	10
L	700	8.871	0.0495	0.3505	8.7	10.3	98.9	4.4	36.51	0.25	20
M	750	10.06	0.0482	2.024	10.9	10.6	94.1	5.6	39.38	0.23	10
N	750	8.737	0.0361	-0.1320	13.6	14.1	100.5	7.0	36.54	0.17	20
O	800	9.672	0.0371	1.243	16.1	13.7	96.2	8.7	38.73	0.16	10
P	800	8.749	0.0273	-0.0372	17.7	18.7	100.2	10.5	36.48	0.13	20
Q	850	9.774	0.0297	1.466	19.0	17.2	95.6	12.6	38.87	0.14	10
R	850	8.750	0.0214	-0.0626	21.1	23.9	100.2	14.8	36.51	0.12	20
S	900	9.237	0.0263	1.020	18.7	19.4	96.8	16.7	37.20	0.13	10
T	900	8.800	0.0243	-0.1207	20.4	21.0	100.4	18.9	36.79	0.12	20
U	950	9.489	0.0238	1.785	17.4	21.5	94.5	20.7	37.31	0.16	10
V	950	9.093	0.0140	0.8845	18.8	36.3	97.1	22.7	36.77	0.13	20
W	1000	10.12	0.0185	3.257	16.3	27.5	90.5	24.4	38.11	0.15	10
X	1000	9.935	0.0120	2.840	19.2	42.4	91.6	26.4	37.85	0.16	20
Y	1050	11.79	0.0136	7.448	22.8	37.5	81.3	28.8	39.88	0.18	10
Z	1050	11.22	0.0133	5.573	34.3	38.5	85.3	32.4	39.82	0.16	20
AA	1100	12.06	0.0119	6.824	55.6	42.9	83.3	38.3	41.74	0.12	10
AB	1100	11.00	0.0124	4.262	55.5	41.2	88.6	44.1	40.51	0.10	20
AC	1100	10.77	0.0167	3.665	45.0	30.5	89.9	48.8	40.30	0.11	30
AD	1100	10.86	0.0214	4.022	41.8	23.8	89.1	53.2	40.23	0.12	60
AE	1100	11.52	0.0276	5.858	39.4	18.5	85.0	57.4	40.73	0.13	120
AF	1100	12.75	0.0267	9.580	38.6	19.1	77.8	61.4	41.26	0.16	240
AG	1200	11.62	0.0190	2.826	71.3	26.8	92.8	68.9	44.793	0.096	10
AH	1300	11.40	0.0207	2.585	199.7	24.6	93.3	89.9	44.215	0.076	10
AI	1350	11.73	0.0619	3.514	32.3	8.2	91.2	93.3	44.45	0.15	10
AJ	1550	13.30	0.0160	10.11	59.5	31.9	77.5	99.6	42.86	0.14	10
AK	1700	136.3	0.0034	421.5	3.83	151.1	8.6	100.0	48.7	3.0	10

Integrated age ± 1s n=37 K2O=12.68% Age = 43.80 ±0.10

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H07-HU-002, K-Feldspar, 14.38 mg, J=0.0022964±0.07%, D=1.0032±0.0012, NM-212E, Lab#=57447-01											
A	450	761.8	-0.0007	1858.1	0.221	-	27.9	0.0	728.1	16.7	6
B	450	320.1	0.0207	745.9	0.407	24.6	31.1	0.1	377.3	8.4	20
C	500	208.2	-0.0240	389.9	0.554	-	44.7	0.1	354.3	5.1	10
D	500	40.49	0.0891	95.38	0.356	5.7	30.4	0.1	51.0	5.7	20
E	550	93.94	-0.0211	176.8	0.785	-	44.4	0.2	167.3	3.3	10
F	550	19.34	0.0001	28.99	1.17	3824.6	55.7	0.3	44.7	1.8	20
G	600	61.16	0.0347	105.0	2.10	14.7	49.3	0.5	122.5	1.7	7
H	600	10.59	0.0384	6.713	2.53	13.3	81.3	0.7	35.81	0.78	18
I	650	21.71	0.0660	27.53	6.64	7.7	62.5	1.3	56.20	0.47	10
J	650	9.239	0.0549	3.116	6.05	9.3	90.1	1.9	34.62	0.32	20
K	700	8.798	0.0602	0.5206	4.76	8.5	98.3	2.3	35.96	0.40	10
L	700	8.597	0.0535	0.3113	6.39	9.5	99.0	2.9	35.38	0.33	20
M	750	10.19	0.0433	4.435	8.1	11.8	87.2	3.6	36.94	0.28	10
N	750	8.733	0.0327	0.8792	11.3	15.6	97.1	4.7	35.24	0.18	20
O	800	9.887	0.0368	3.435	14.1	13.8	89.8	6.0	36.89	0.18	10
P	800	8.677	0.0282	0.4450	15.1	18.1	98.5	7.3	35.54	0.13	20
Q	850	9.128	0.0272	1.229	15.4	18.8	96.0	8.7	36.45	0.16	10
R	850	8.584	0.0236	0.3309	15.5	21.6	98.9	10.1	35.29	0.13	18
S	900	9.139	0.0260	1.700	14.8	19.7	94.5	11.5	35.92	0.15	10
T	900	8.639	0.0254	0.4562	13.9	20.1	98.5	12.7	35.37	0.15	20
U	950	9.391	0.0258	2.475	11.6	19.7	92.2	13.8	36.01	0.19	10
V	950	8.994	0.0205	1.361	12.1	24.9	95.5	14.9	35.73	0.18	20
W	1000	10.44	0.0250	6.218	11.6	20.4	82.4	16.0	35.76	0.22	10
X	1000	9.485	0.0169	3.137	13.4	30.2	90.2	17.2	35.59	0.18	20
Y	1050	11.60	0.0156	9.582	18.1	32.8	75.6	18.8	36.47	0.18	10
Z	1050	10.32	0.0126	5.394	22.2	40.5	84.6	20.9	36.28	0.15	20
AA	1100	11.40	0.0142	8.652	44.2	36.0	77.6	24.9	36.77	0.14	10
AB	1100	10.44	0.0077	5.560	58.7	66.0	84.3	30.2	36.57	0.10	20
AC	1100	10.46	0.0089	5.304	121.9	57.2	85.0	41.3	36.951	0.090	30
AD	1100	9.837	0.0127	3.401	85.7	40.1	89.8	49.1	36.720	0.082	60
AE	1100	10.03	0.0128	3.752	63.6	39.8	88.9	54.9	37.068	0.093	120
AF	1100	10.97	0.0114	6.781	50.5	44.6	81.7	59.5	37.26	0.12	240
AG	1200	9.880	0.0134	2.531	71.3	38.1	92.4	66.0	37.955	0.078	10
AH	1300	9.892	0.0094	2.200	253.5	54.1	93.4	89.0	38.406	0.069	10
AI	1350	10.21	0.0193	3.090	37.2	26.5	91.1	92.4	38.64	0.12	10
AJ	1550	11.60	0.0083	7.634	79.3	61.8	80.5	99.6	38.81	0.11	10
AK	1700	122.3	0.0070	382.1	4.30	73.2	7.7	100.0	39.1	2.7	10
Integrated age ± 1s n=37 K2O=12.79% Age – 38.217 ±0.091											

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
H07-HU-004, K-Feldspar, 15.96 mg, J=0.0023022±0.06%, D=1.0032±0.0012, NM-212E, Lab#=57439-01											
A	450	895.5	-0.3560	2322.5	0.330	-	23.4	0.0	719.4	15.8	6
B	450	445.2	-0.4360	1110.2	0.318	-	26.3	0.1	437.0	11.5	20
C	500	197.0	-0.3041	304.1	0.445	-	54.4	0.1	403.4	6.6	10
D	500	34.93	-0.2193	84.39	0.360	-	28.5	0.1	41.5	5.7	20
E	550	99.06	-0.0547	128.3	1.20	-	61.7	0.2	241.0	2.6	10
F	550	11.64	-0.0832	6.045	1.25	-	84.6	0.3	41.0	1.6	20
G	600	44.39	0.0062	53.61	5.04	82.0	64.3	0.8	116.48	0.82	10
H	600	9.779	0.0116	4.982	3.71	44.0	84.9	1.1	34.64	0.60	20
I	650	11.54	0.0218	4.113	7.16	23.4	89.5	1.7	42.96	0.35	10
J	650	8.378	0.0219	0.0720	7.25	23.3	99.8	2.3	34.85	0.30	20
K	700	7.870	0.0279	-1.6821	8.2	18.3	106.4	3.0	34.89	0.24	10
L	700	9.638	0.0380	-0.8374	9.0	13.4	102.6	3.7	41.2	1.7	20
M	750	9.819	0.0238	3.286	26.4	21.4	90.1	6.0	36.88	0.14	10
N	750	8.523	0.0144	1.128	26.4	35.5	96.1	8.2	34.15	0.10	20
O	800	8.653	0.0110	1.123	13.0	46.2	96.2	9.3	34.70	0.14	10
P	800	8.738	0.0100	1.693	15.9	50.9	94.3	10.6	34.35	0.11	20
Q	850	8.768	0.0138	1.360	16.2	37.0	95.4	12.0	34.89	0.11	10
R	850	8.773	0.0121	1.359	17.9	42.1	95.4	13.5	34.90	0.11	20
S	900	8.877	0.0176	1.964	15.0	29.0	93.5	14.8	34.60	0.11	10
T	900	8.938	0.0098	1.883	17.2	52.2	93.8	16.2	34.95	0.12	20
U	950	9.271	0.0143	2.824	15.3	35.7	91.0	17.5	35.18	0.13	10
V	950	9.235	0.0077	2.854	19.3	66.4	90.9	19.2	34.99	0.11	20
W	1000	9.824	0.0061	3.944	18.8	84.1	88.1	20.7	36.09	0.12	10
X	1000	9.736	0.0066	3.490	24.9	76.9	89.4	22.8	36.28	0.13	20
Y	1050	10.38	0.0066	5.054	28.8	77.8	85.6	25.3	37.03	0.15	10
Z	1050	10.10	0.0042	4.221	40.3	121.4	87.6	28.7	36.89	0.12	20
AA	1100	10.50	0.0075	4.886	26.9	68.1	86.2	31.0	37.74	0.15	10
AB	1100	9.949	0.0056	3.847	25.7	90.9	88.6	33.1	36.72	0.14	20
AC	1100	10.01	0.0072	3.784	29.4	71.3	88.8	35.6	37.07	0.14	30
AD	1100	10.07	0.0070	3.817	43.0	72.9	88.8	39.2	37.27	0.10	60
AE	1100	10.27	0.0081	4.404	56.9	63.0	87.3	44.1	37.361	0.091	120
AF	1100	10.72	0.0082	5.716	65.3	61.9	84.2	49.6	37.633	0.095	240
AG	1200	10.22	0.0101	2.534	104.7	50.4	92.7	58.4	39.449	0.076	10
AH	1300	9.655	0.0085	1.320	288.8	59.9	96.0	82.8	38.597	0.062	10
AI	1350	9.985	0.0129	2.389	50.5	39.4	92.9	87.1	38.655	0.088	10
AJ	1550	11.35	0.0043	7.074	138.9	118.8	81.6	98.8	38.56	0.10	10
AK	1700	54.60	0.0101	152.3	13.9	50.4	17.5	100.0	39.9	1.1	10

Integrated age $\pm 1s$ n=37 K2O=12.37% Age = 38.759 $\pm$ 0.090

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1\text{s}$ (Ma)	Time (min)
H07-HU-005, K-Feldspar, 15.04 mg, J=0.0022991±0.06%, D=1.0032±0.0012, NM-212E, Lab#=57451-01											
A	450	818.5	0.0645	2203.6	0.87	7.9	20.4	0.1	595.7	12.0	6
B	450	255.0	0.0940	652.4	0.92	5.4	24.4	0.2	244.8	5.5	20
C	500	110.5	0.0300	271.1	1.76	17.0	27.5	0.3	123.7	2.8	10
D	500	36.11	0.0941	92.14	1.30	5.4	24.6	0.4	37.0	1.9	20
E	550	33.53	0.0293	71.50	3.14	17.4	37.0	0.7	51.4	1.1	10
F	550	14.97	0.0434	23.59	3.91	11.7	53.4	1.1	33.33	0.63	20
G	600	32.30	0.0399	60.82	11.4	12.8	44.4	2.1	59.32	0.62	10
H	600	9.991	0.0447	8.500	9.4	11.4	74.9	3.0	31.19	0.23	20
I	650	11.39	0.0475	9.341	13.3	10.7	75.8	4.2	35.92	0.21	10
J	650	8.674	0.0364	3.256	10.1	14.0	88.9	5.1	32.14	0.19	20
K	700	8.078	0.0352	0.7229	7.36	14.5	97.4	5.7	32.77	0.25	9
L	700	8.451	0.0315	1.371	11.7	16.2	95.2	6.8	33.52	0.18	20
M	750	8.729	0.0306	2.001	13.8	16.7	93.2	8.0	33.90	0.15	10
N	750	8.366	0.0192	0.9994	17.2	26.6	96.5	9.6	33.62	0.12	19
O	800	9.962	0.0190	4.762	24.1	26.9	85.9	11.8	35.62	0.15	10
P	800	8.317	0.0151	0.6946	23.5	33.8	97.5	13.9	33.789	0.097	20
Q	850	8.711	0.0135	1.309	23.0	37.9	95.6	16.0	34.66	0.11	10
R	850	8.467	0.0148	0.7297	22.8	34.5	97.5	18.0	34.37	0.10	18
S	900	9.874	0.0144	5.268	24.2	35.4	84.2	20.2	34.64	0.15	10
T	900	8.945	0.0155	2.087	21.2	33.0	93.1	22.2	34.68	0.11	19
U	950	10.63	0.0125	7.123	22.8	40.9	80.2	24.2	35.51	0.16	10
V	950	9.496	0.0122	3.656	22.4	41.8	88.6	26.2	35.04	0.13	20
W	1000	11.38	0.0128	9.525	25.2	39.8	75.2	28.5	35.65	0.20	10
X	1000	10.65	0.0119	7.062	30.9	42.9	80.4	31.3	35.65	0.16	20
Y	1050	12.01	0.0086	10.88	44.6	59.3	73.2	35.3	36.61	0.14	10
Z	1050	11.10	0.0092	8.031	57.1	55.5	78.6	40.5	36.34	0.11	20
AA	1100	11.54	0.0098	8.912	81.7	52.0	77.2	47.9	37.07	0.12	10
AB	1100	10.79	0.0094	6.787	84.9	54.5	81.4	55.6	36.58	0.11	20
AC	1100	10.43	0.0106	5.274	69.3	48.1	85.0	61.8	36.909	0.100	30
AD	1100	10.21	0.0133	4.384	62.5	38.3	87.3	67.5	37.121	0.094	60
AE	1100	10.56	0.0157	4.985	48.4	32.6	86.1	71.9	37.82	0.11	120
AF	1100	11.75	0.0200	8.495	39.3	25.5	78.6	75.4	38.45	0.14	240
AG	1200	11.00	0.0181	4.984	35.1	28.1	86.6	78.6	39.64	0.13	10
AH	1300	11.06	0.0208	4.312	148.9	24.5	88.5	92.1	40.694	0.085	10
AI	1350	12.75	0.0962	8.414	20.8	5.3	80.6	93.9	42.70	0.19	10
AJ	1550	12.89	0.0264	10.46	58.9	19.3	76.0	99.3	40.74	0.14	10
AK	1700	60.63	0.0177	171.6	7.99	28.8	16.3	100.0	41.2	1.4	10

Integrated age $\pm 1\text{s}$ n=37 K2O=12.28% Age = 38.35 ± 0.11

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	37Ar/39Ar	36Ar/39Ar (x 10-3)	39ArK (x 10-15 mol)	K/Ca	40Ar (%)	39Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H07-HU-006, K-Feldspar, 13.65 mg, J=0.0023017±0.06%, D=1.0032±0.0012, NM-212E, Lab#=57437-01											
A	450	766.5	0.0052	1807.0	0.217	98.1	30.3	0.0	784.8	15.1	10
B	450	568.4	-0.1222	1898.1	0.068	-	1.3	0.0	31.5	36.3	17
C	500	359.5	0.1229	542.5	0.185	4.2	55.4	0.0	690.9	11.8	10
D	500	303.1	0.1274	431.4	0.421	4.0	57.9	0.1	621.5	6.1	20
E	550	207.7	0.0254	275.0	1.22	20.1	60.9	0.2	467.6	3.6	10
F	550	35.03	0.0401	62.50	1.16	12.7	47.3	0.3	68.5	2.1	20
G	600	47.32	0.0224	50.40	5.39	22.7	68.5	0.9	131.73	0.89	10
H	600	11.44	0.0272	12.76	4.39	18.7	67.0	1.4	32.01	0.50	20
I	650	11.19	0.0259	6.587	8.1	19.7	82.6	2.2	38.52	0.24	10
J	650	8.959	0.0263	5.408	5.82	19.4	82.2	2.8	30.72	0.36	20
K	700	8.238	0.0276	2.507	13.9	18.5	91.0	4.3	31.29	0.15	10
L	700	8.207	0.0247	2.119	16.7	20.6	92.4	6.0	31.63	0.14	20
M	750	8.549	0.0236	1.741	19.3	21.6	94.0	8.0	33.51	0.11	10
N	750	8.284	0.0155	1.909	18.6	33.0	93.2	9.9	32.20	0.11	20
O	800	8.661	0.0186	1.623	19.8	27.4	94.5	12.0	34.11	0.13	10
P	800	8.382	0.0145	1.806	18.6	35.1	93.6	13.9	32.74	0.12	20
Q	850	8.572	0.0210	2.421	15.6	24.3	91.7	15.6	32.77	0.13	10
R	850	8.716	0.0165	2.804	14.4	31.0	90.5	17.1	32.90	0.15	18
S	900	9.316	0.0130	3.955	16.2	39.3	87.5	18.7	33.97	0.15	10
T	900	9.206	0.0132	3.570	17.7	38.8	88.5	20.6	33.99	0.13	20
U	950	9.878	0.0106	4.742	20.6	48.0	85.8	22.7	35.33	0.14	10
V	950	9.655	0.0083	3.638	27.3	61.1	88.9	25.6	35.76	0.15	20
W	1000	10.25	0.0082	4.480	41.3	62.0	87.1	29.9	37.18	0.12	10
X	1000	9.812	0.0092	3.133	52.0	55.5	90.6	35.3	37.025	0.093	20
Y	1050	10.11	0.0117	2.921	58.8	43.7	91.5	41.4	38.517	0.082	10
Z	1050	9.900	0.0101	2.314	85.5	50.5	93.1	50.3	38.385	0.075	20
AA	1100	9.728	0.0083	1.820	104.8	61.2	94.5	61.2	38.280	0.068	10
AB	1100	10.11	0.0067	3.215	108.6	76.6	90.6	72.5	38.151	0.075	19
AC	1100	10.51	0.0068	4.377	96.0	74.9	87.7	82.5	38.382	0.086	30
AD	1100	11.20	0.0094	6.724	84.5	54.2	82.3	91.3	38.37	0.10	60
AE	1100	13.64	0.0149	14.88	54.4	34.3	67.8	97.0	38.51	0.16	120
AF	1100	23.46	0.0160	47.68	25.7	31.9	39.9	99.7	39.01	0.44	240
AG	1200	32.93	0.0199	79.94	3.20	25.6	28.2	100.0	38.8	1.0	10
Integrated age ± 1s n=33 K2O=11.74% Age – 38.948 ±0.093											

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10 ⁻³)	³⁹ ArK (x 10 ⁻¹⁵ mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H07-HU-008, K-Feldspar, 4.14 mg, J=0.0023012±0.06%, D=1.0032±0.0012, NM-212E, Lab#=57441-01											
A	450	7856.3	-0.1005	1292.6	0.167	-	95.1	0.0	5310.9	45.2	6
B	450	1709.7	0.0752	241.7	0.219	6.8	95.8	0.1	2859.9	26.4	20
C	500	1740.9	0.0126	111.5	0.552	40.5	98.1	0.2	2920.4	12.2	10
D	500	133.3	-0.1873	-4.2799	0.617	-	100.9	0.4	493.8	4.0	20
E	550	370.9	-0.1058	22.93	0.92	-	98.2	0.6	1113.9	5.0	7
F	550	81.85	-0.0003	-1.1615	1.79	-	100.4	1.1	317.1	1.5	20
G	600	531.3	-0.0088	27.01	3.24	-	98.5	1.9	1446.7	2.8	10
H	600	36.38	-0.0061	-5.3761	2.29	-	104.4	2.5	153.30	0.94	20
I	650	110.7	-0.0105	-2.3743	2.74	-	100.6	3.2	417.6	1.3	10
J	650	22.96	-0.0110	-7.0364	1.46	-	109.1	3.6	102.5	1.3	17
K	700	53.01	-0.0116	-7.0555	1.81	-	103.9	4.0	218.5	1.3	10
L	700	38.04	-0.0235	-7.0031	1.68	-	105.4	4.5	161.6	1.2	20
M	750	64.94	-0.0208	-8.7575	2.08	-	104.0	5.0	264.4	1.1	10
N	750	24.23	0.0006	-5.5390	2.82	790.8	106.8	5.7	105.78	0.71	20
O	800	56.25	-0.0205	-7.4186	2.32	-	103.9	6.3	230.9	1.0	10
P	800	21.75	-0.0188	-4.1662	3.38	-	105.7	7.2	94.28	0.59	20
Q	850	34.17	0.0085	-2.4368	4.69	60.2	102.1	8.4	141.31	0.53	10
R	850	18.80	0.0047	-1.5276	6.92	109.1	102.4	10.2	79.33	0.31	20
S	900	31.41	0.0064	-0.6064	7.24	79.9	100.6	12.0	128.42	0.40	10
T	900	22.35	0.0014	0.6297	8.9	358.9	99.2	14.3	91.00	0.30	20
U	950	34.59	0.0075	0.0060	9.3	68.3	100.0	16.7	140.16	0.42	10
V	950	25.37	0.0010	-0.3368	9.7	534.6	100.4	19.2	104.20	0.31	20
W	1000	48.87	0.0049	-1.1333	8.5	105.2	100.7	21.3	196.30	0.53	10
X	1000	39.97	-0.0029	1.127	10.8	-	99.2	24.1	159.76	0.37	20
Y	1050	78.15	0.0055	12.57	10.3	92.7	95.2	26.7	289.38	0.60	10
Z	1050	60.54	0.0009	2.060	14.3	597.6	99.0	30.4	236.44	0.43	20
AA	1100	97.44	0.0107	2.889	16.8	47.6	99.1	34.7	367.35	0.56	10
AB	1100	86.27	0.0027	3.089	21.7	187.3	98.9	40.3	328.23	0.54	20
AC	1100	82.65	0.0016	3.512	20.4	310.1	98.7	45.5	315.01	0.47	30
AD	1100	75.55	0.0041	4.548	21.9	123.0	98.2	51.1	288.56	0.47	60
AE	1100	75.85	0.0029	7.969	20.2	173.7	96.9	56.3	285.99	0.48	120
AF	1100	84.69	0.0039	18.00	16.0	131.8	93.7	60.4	307.05	0.59	239
AG	1200	100.4	0.0067	1.625	26.5	76.5	99.5	67.2	378.67	0.55	10
AH	1300	92.48	0.0023	1.887	74.7	218.1	99.4	86.3	351.22	0.54	10
AI	1350	79.09	0.0033	3.812	17.4	155.2	98.6	90.8	302.04	0.46	10
AJ	1550	75.01	0.0120	14.63	31.5	42.7	94.2	98.8	275.84	0.54	10
AK	1700	159.1	-0.0024	368.0	4.53	-	31.6	100.0	200.5	2.7	10

Integrated age ± 1s n=37 K2O=15.74% Age – 320.47 ±0.45

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$ (x 10-3)	^{39}ArK (x 10-15 mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
H07-TL-001, K-Feldspar, 13.64 mg, J=0.0022969±0.06%, D=1.0032±0.0012, NM-212E, Lab#=57445-01											
C	450	594.1	0.1586	500.4	0.220	3.2	75.1	0.0	1291.6	16.9	8
D	450	444.3	0.1825	275.6	0.476	2.8	81.7	0.1	1109.9	7.6	20
E	500	369.5	0.0827	152.6	1.02	6.2	87.8	0.2	1019.3	4.2	10
F	500	42.87	0.0949	73.08	0.498	5.4	49.6	0.2	87.4	4.0	20
G	550	153.6	0.0193	58.40	1.23	26.4	88.8	0.4	498.6	2.9	7
H	550	23.58	0.0512	27.06	1.42	10.0	66.1	0.5	64.4	1.4	17
I	600	80.39	0.0535	36.22	7.58	9.5	86.7	1.3	271.76	0.75	10
J	600	10.53	0.0864	6.341	4.56	5.9	82.3	1.8	36.04	0.41	20
K	650	14.71	0.1029	7.209	7.77	5.0	85.6	2.7	52.16	0.29	10
L	650	9.987	0.0845	4.666	7.38	6.0	86.3	3.5	35.83	0.24	20
M	700	10.78	0.0833	5.041	8.6	6.1	86.2	4.4	38.65	0.24	10
N	700	9.605	0.0823	3.146	10.2	6.2	90.4	5.5	36.11	0.20	20
O	750	10.86	0.0714	2.976	11.4	7.1	91.9	6.8	41.48	0.18	9
P	750	9.331	0.0575	1.588	14.2	8.9	95.0	8.3	36.86	0.14	19
Q	800	11.60	0.0555	3.520	19.7	9.2	91.1	10.4	43.83	0.17	10
R	800	9.431	0.0556	1.771	15.5	9.2	94.5	12.1	37.05	0.14	20
S	850	9.529	0.0503	1.076	14.1	10.1	96.7	13.6	38.30	0.14	10
T	850	9.523	0.0392	2.059	13.8	13.0	93.6	15.1	37.08	0.16	20
U	900	10.03	0.0477	2.833	11.7	10.7	91.7	16.4	38.23	0.19	10
V	900	9.705	0.0398	2.232	12.9	12.8	93.2	17.8	37.62	0.15	20
W	950	10.63	0.0394	3.942	11.7	13.0	89.1	19.1	39.33	0.20	10
X	950	10.14	0.0274	2.227	13.5	18.6	93.5	20.5	39.42	0.16	19
Y	1000	11.04	0.0272	3.309	14.3	18.8	91.2	22.1	41.78	0.15	10
Z	1000	10.83	0.0210	2.972	17.7	24.3	91.9	24.0	41.34	0.15	20
AA	1050	12.05	0.0237	3.489	18.3	21.5	91.5	26.0	45.72	0.17	10
AB	1050	11.65	0.0225	3.411	23.4	22.7	91.4	28.5	44.17	0.16	20
AC	1100	13.17	0.0254	3.591	28.1	20.1	92.0	31.6	50.17	0.16	10
AD	1100	12.37	0.0254	3.437	31.9	20.1	91.8	35.0	47.09	0.14	20
AE	1100	12.55	0.0259	3.606	31.2	19.7	91.5	38.4	47.62	0.15	30
AF	1100	13.17	0.0257	4.151	40.0	19.8	90.7	42.7	49.50	0.13	60
AG	1100	14.18	0.0230	6.176	41.3	22.1	87.1	47.2	51.18	0.14	120
AH	1100	15.58	0.0210	9.308	42.2	24.2	82.3	51.8	53.12	0.15	240
AI	1200	14.63	0.0221	1.711	40.1	23.1	96.6	56.1	58.41	0.12	10
AJ	1300	14.55	0.0227	1.349	283.2	22.5	97.3	86.8	58.500	0.090	10
AK	1350	14.89	0.0899	2.526	60.7	5.7	95.0	93.4	58.50	0.11	10
AL	1550	16.17	0.0413	8.781	58.3	12.3	84.0	99.7	56.19	0.15	10
AM	1700	247.0	0.0717	799.6	2.81	7.1	4.4	100.0	44.6	5.6	10

Integrated age $\pm 1s$ n=37 K2O=11.32% Age = 56.59 ± 0.11

ID	Temp (°C)	⁴⁰ Ar/ ³⁹ Ar	³⁷ Ar/ ³⁹ Ar	³⁶ Ar/ ³⁹ Ar (x 10-3)	³⁹ ArK (x 10-15 mol)	K/Ca	⁴⁰ Ar (%)	³⁹ Ar (%)	Age (Ma)	±1s (Ma)	Time (min)
H08-HU-10, Kspar, 1.87 mg, J=0.011843±0.11%, D=1.004±0.001, NM-218D, Lab#=57961-01											
B	450	388.0	0.0444	43.28	0.449	11.5	96.7	0.1	3101.8	9.6	10
C	450	50.12	0.0307	3.112	0.243	16.6	98.2	0.1	840.3	11.6	20
D	500	35.82	0.1166	0.2432	0.457	4.4	99.8	0.2	646.3	6.3	10
E	500	12.78	0.2198	1.078	0.546	2.3	97.6	0.3	252.1	6.1	20
F	500	8.858	0.2818	3.621	0.532	1.8	88.2	0.4	161.8	6.7	30
G	550	16.49	0.2497	-0.5081	0.82	2.0	101.0	0.5	329.5	4.1	10
H	550	5.429	0.1542	0.3185	1.20	3.3	98.5	0.7	112.2	3.3	20
I	550	6.009	0.1010	3.137	1.31	5.0	84.7	0.9	107.0	3.4	30
J	600	11.21	0.0721	-0.2070	1.80	7.1	100.6	1.2	229.3	2.3	10
K	600	3.996	0.0426	0.3837	2.46	12.0	97.2	1.7	82.2	1.6	20
L	600	4.207	0.0261	0.8798	2.43	19.5	93.9	2.1	83.5	1.5	30
M	650	9.177	0.0147	0.5216	2.64	34.6	98.3	2.5	185.7	1.5	10
N	650	4.241	0.0145	0.4023	3.27	35.1	97.2	3.1	87.1	1.2	20
O	700	7.064	0.0129	0.2969	4.13	39.4	98.8	3.8	145.14	0.96	10
P	700	4.903	0.0112	0.2603	4.93	45.5	98.4	4.6	101.56	0.83	20
Q	750	5.711	0.0120	0.3207	6.31	42.5	98.4	5.7	117.69	0.69	10
R	750	4.684	0.0090	0.3161	8.2	56.7	98.0	7.0	96.71	0.54	20
S	800	5.319	0.0098	0.2015	9.3	51.9	98.9	8.6	110.43	0.46	10
T	800	5.555	0.0084	0.1570	11.0	60.7	99.2	10.5	115.50	0.40	20
U	850	9.428	0.0083	0.1791	11.4	61.6	99.4	12.4	192.55	0.40	10
V	850	8.893	0.0062	0.2310	14.9	82.3	99.2	14.9	181.76	0.40	20
W	900	14.52	0.0078	0.2714	15.6	65.6	99.5	17.6	288.72	0.44	10
X	900	16.57	0.0042	0.3255	20.5	120.7	99.4	21.0	326.03	0.53	20
Y	950	29.43	0.0046	0.4006	19.3	110.3	99.6	24.3	545.35	0.82	10
Z	950	27.12	0.0034	0.3679	23.7	149.1	99.6	28.3	507.86	0.85	20
AA	1000	45.00	0.0043	0.4879	22.0	119.4	99.7	32.0	779.8	1.2	10
AB	1000	41.97	0.0035	0.6365	28.0	144.0	99.6	36.7	735.74	0.92	20
AC	1050	64.33	0.0047	0.5681	29.7	108.7	99.7	41.8	1034.5	1.2	10
AD	1050	54.96	0.0040	1.009	36.4	128.8	99.5	47.9	913.6	1.1	20
AE	1100	67.68	0.0043	0.9032	30.7	119.9	99.6	53.1	1074.2	1.2	10
AF	1100	59.52	0.0046	0.9064	35.2	110.3	99.6	59.1	973.0	1.1	20
AG	1100	56.33	0.0043	0.9655	32.8	119.1	99.5	64.6	931.8	1.1	30
AH	1100	55.86	0.0036	1.643	35.1	141.9	99.1	70.5	922.9	1.1	60
AI	1100	58.66	0.0032	2.375	33.1	157.9	98.8	76.1	956.5	1.2	120
AJ	1200	65.20	0.0031	0.9857	37.0	164.3	99.6	82.4	1043.8	1.3	10
AK	1300	69.19	0.0022	1.822	54.2	226.8	99.2	91.5	1089.0	1.2	10
AL	1350	57.47	0.0020	3.518	47.6	255.3	98.2	99.6	936.7	1.1	10
AM	1550	117.2	0.0037	196.5	2.07	136.8	50.5	99.9	971.8	6.5	10
AN	1700	1219.5	0.0079	3939.8	0.337	64.2	4.5	100.0	922.1	77.7	10
AO	1700	3223.5	0.0306	10894.0	0.142	16.7	0.1	100.0	92.5	339.9	10

Integrated age ± 1s n=40 K2O=10.27% Age – 800.8 ±1.1

Notes:

Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.

Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.

Integrated age calculated by summing isotopic measurements of all steps.

Integrated age error calculated by quadratically combining errors of isotopic measurements of all steps.

Plateau age is inverse-variance-weighted mean of selected steps.

Plateau age error is inverse-variance-weighted mean error (Taylor, 1982) times root MSWD where MSWD>1.

Plateau error is weighted error of Taylor (1982).

Decay constants and isotopic abundances after Min et al. (2000).

Weight percent K₂O calculated from ³⁹Ar signal, sample weight, and instrument sensitivity.

Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.201 Ma (Kuiper et al., 2008).

Decay Constant (LambdaK (total)) = 5.46e-10/a

Correction factors:

(³⁹Ar/³⁷Ar)Ca = 0.0007 ± 5e-05

(³⁶Ar/³⁷Ar)Ca = 0.00028 ± 2e-05

(³⁸Ar/³⁹Ar)K = 0.013

(⁴⁰Ar/³⁹Ar)K = 0.01 ± 0.002

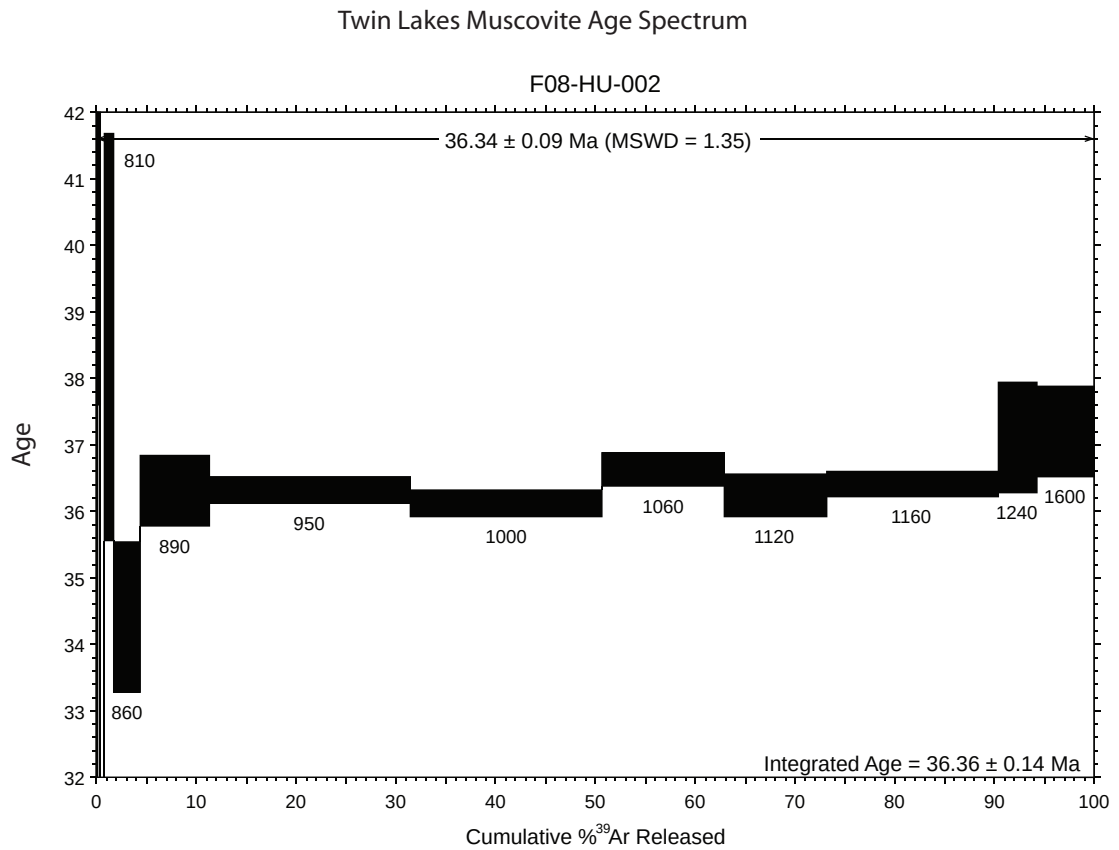


Figure C.7: Muscovite age spectrum from Proterozoic basement at the contact with the Winfield pluton, which is 40 Ma.

Table C.4: Muscovite $^{40}\text{Ar}/^{39}\text{Ar}$ analytical data

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	37Ar/39Ar	36Ar/39Ar (x 10-3)	39ArK (x 10-15 mol)	K/Ca	40Ar (%)	39Ar (%)	Age (Ma)	$\pm 1s$ (Ma)	Time (min)
F08-HU-002, Muscovite, .78 mg, J=0.012131 $\pm$ 0.11%, D=1.0014 $\pm$ 0.001, NM-218F, Lab#=57976-01											
A	580	22.91	0.1312	72.71	0.314	3.9	6.2	0.1	31.4	23.7	5
B	630	4.234	0.0191	4.634	0.254	26.7	67.7	0.3	62.5	20.8	5
C	680	2.611	-0.0137	0.7823	0.408	-	91.1	0.5	52.1	14.5	5
D	740	2.403	0.0016	4.956	0.90	309.5	39.0	0.9	20.7	6.3	5
E	810	2.167	0.0101	1.392	2.08	50.4	81.0	1.8	38.6	3.1	5
F	860	2.439	0.0005	2.966	5.66	1070.7	64.1	4.5	34.4	1.1	5
G	890	1.828	-0.0017	0.6035	15.0	-	90.2	11.5	36.28	0.53	5
H	950	1.711	-0.0013	0.2060	43.2	-	96.4	31.6	36.29	0.20	5
I	1000	1.682	-0.0004	0.1382	41.1	-	97.6	50.7	36.09	0.20	5
J	1060	1.711	-0.0016	0.1577	26.5	-	97.3	63.1	36.60	0.25	5
K	1120	1.725	-0.0006	0.2642	21.9	-	95.5	73.3	36.21	0.32	5
L	1160	1.678	-0.0013	0.0776	36.9	-	98.6	90.5	36.38	0.19	5
M	1240	1.693	-0.0101	0.0221	8.2	-	99.6	94.3	37.07	0.82	5
N	1600	2.117	-0.0001	1.443	12.3	-	79.9	100.0	37.17	0.68	5

Integrated age $\pm 1s$ n=14 K2O=8.72% Age – 36.34 $\pm$ 0.14

Plateau $\pm 1s$ steps A-N n=14 MSWD=1.35 Age – 36.32 $\pm$ 0.12

Notes:

Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.

Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.

Integrated age calculated by summing isotopic measurements of all steps.

Integrated age error calculated by quadratically combining errors of isotopic measurements of all steps.

Plateau age is inverse-variance-weighted mean of selected steps.

Plateau age error is inverse-variance-weighted mean error (Taylor, 1982)) times root MSWD where MSWD>1.

Plateau error is weighted error of Taylor (1982).

Decay constants and isotopic abundances after Min et al. (2000).

X symbol preceding sample ID denotes analyses excluded from plateau age calculations.

Weight percent K2O calculated from 39Ar signal, sample weight, and instrument sensitivity.

Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.201 Ma (Kuiper et al., 2008).

Decay Constant (LambdaK (total)) = 5.463e-10/a

Correction factors:

(39Ar/37Ar)Ca = 0 $\pm$ 0

(36Ar/37Ar)Ca = 0 $\pm$ 0

(38Ar/39Ar)K = 0.0122

($^{40}\text{Ar}/^{39}\text{Ar}$)K = 0 $\pm$ 0

APPENDIX D

APATITE FISSION-TRACK

D.1 Methods

Apatite fission track analysis was conducted on five samples. To prepare the first set of samples, concentrated apatite separates were poured onto quick-release paper, and covered in epoxy and a 1-cm² glass slide. The second set of samples was prepared by picking 40 apatite grains and placing them in a 4x10 grid on tape. These samples were also covered with epoxy and a glass slide, and the tape was removed after the epoxy cured. All samples were then polished with 400 grit paper, 6 μ m diamond, and 0.3 μ m alumina polishing wheels, and etched with a 5 molar solution of nitric acid for 25 seconds to reveal the fission tracks. The external detector method was used for determining ages, which requires attaching 1-cm² sheets of muscovite to the top of the polished slides. The samples were packaged in stacks that included U-glass and Durango apatite standards, and irradiated at a nominal fluence of 1×10^{16} neutrons/cm² at the Texas A&M nuclear Science Center. After cooling for three months, small holes were drilled in the corner of each sample through the glass slide and muscovite detector as a reference point, and the muscovite detectors were etched in a solution of 48% HF for 13 minutes for unknowns, and 45 minutes for glasses. The grain mounts and corresponding muscovite detectors were then mounted on a glass slide in epoxy, and spontaneous and induced tracks 20 were counted in 20 grains per sample. Zeta calibrations for each irradiation were determined by counting spontaneous and induced tracks in Durango apatite and CN-5 uranium-doped

glass included in the irradiation packages. Counting and track length measurement were conducted on a Nikon petrographic microscope with a 100x objective. Track lengths were measured with a SumaSketch digitizing tablet attached to a PC running an in-house program written by S. Kelley. Age data were reduced using an Excel template also created by Kelley (with an error of $\pm 0.2 \mu\text{m}$), and HeFTy by Ketcham (2007) was used to model cooling histories.

APPENDIX E

(U-TH)/HE

E.1 Methods

(U-Th)/He in apatite low temperature thermochronometry analysis was conducted at the University of Kansas Isotope Geochemistry Laboratory (IGL). Samples were picked from apatite-concentrate separates at the New Mexico Institute of Mining and Technology with a Nikon high power stereoscope with polarizing lenses. The polarization was necessary for picking inclusion-free grains in two steps: during the first step the concentrate separate was poured onto a glass slide and acceptable grains were picked and placed onto another clean glass slide, and during the second phase several drops of isopropyl alcohol were placed onto the slide and the grains were re-examined for inclusions, cracks, and overgrowths. Finally three aliquots per sample were picked (containing three grains per aliquot), and the grains were digitally imaged and measured for alpha-ejection age corrections before being loaded into 1 mm platinum tubes. The samples were heated to 1070°C for 5 minutes each and analyzed for He on a Balzers Prisma QMS-200 quadrupole mass spectrometer. Helium was measured using the isotope dilution method where ^4He of a known concentration and amount is mixed with the radiogenic helium from the samples in an ultra high vacuum all-metal extraction line equipped with a cryogenic gas purification system to separate He from the other gasses in the system. Measuring the $^3\text{He}/^4\text{He}$ ratio on the quadrupole mass spectrometer allows for very low blank and high precision He measurements (~0.3 – 0.5%). Aliquots are then retrieved from the He extraction line

and the U, Th, and Sm are analyzed. The grains are dissolved in a 30% HNO₃ solution at 90 °C for an hour and spiked in a solution of ²³⁰Th, ²³⁵U, and ¹⁴⁹Sm. The spiked aliquots are then analyzed for U, Th, and Sm with a VG PlasmaQuad IIXS ICP-MS, fitted with a micro-concentric nebulizer and an auto-sampling device. Data reduction takes place at the University of Kansas with in-house software programmed on Visual-Basic and Excel macros.

Uncertainties include He measurement error (0.3 – 0.5%); U, Th, and Sm measurement error (<1 – 2%); alpha-ejection calculation errors; and errors associated with non-uniform U and Th distribution. The latter two sources of error are difficult to quantify, and propagated analytical uncertainty (3 – 4%) typically underestimate aliquot reproducibility. IGL therefore typically assigns a percentage error to an aliquot analysis based on the standard deviation of the population derived from analyzing standards.

Table E.1: (U-Th)/He data table. Produced by D. Stockli of the IGL at the University of Kansas.

Sample	Age [Ma]	[Ma]	U [ppm]	Th [ppm]	Sm [ppm]	Th/U	He [nmol/g]	mass [mg]	Ft	stddev
F08HU007-1	7.8	0.5	0.9	1.3	3.2	1.5	0.04	95.5	0.86	
F08HU007-2	7.0	0.4	1.2	2.4	3.7	2.1	0.06	67.9	0.83	
F08HU007-3	8.6	0.5	2.0	4.1	7.1	2.1	0.12	62.9	0.83	
F08HU007	7.8	0.5	1.3	2.6	4.7	1.9	0.07	75.4	0.84	0.8
F08LP001-1	20.0	1.2	1.4	1.9	8.3	1.4	0.18	141.7	0.87	
F08LP001-2	16.1	1.0	2.4	2.2	10.7	0.9	0.22	88.9	0.85	
F08LP001-3	17.4	1.0	1.7	2.3	8.8	1.4	0.19	142.4	0.87	
F08LP001	17.8	1.1	1.8	2.1	9.3	1.2	0.19	124.3	0.86	2.0
F08LP002A-1	17.7	1.1	2.3	2.6	13.0	1.2	0.26	123.5	0.89	
F08LP002A-2	15.9	1.0	1.5	2.3	7.9	1.5	0.15	39.4	0.81	
F08LP002A-3	15.9	1.0	2.0	2.8	11.6	1.4	0.20	45.9	0.82	
F08LP002A	16.5	1.0	1.9	2.6	10.8	1.4	0.20	69.6	0.84	1.0
F08LP002B-1	15.7	0.9	1.7	2.3	8.1	1.3	0.16	58.2	0.83	
F08LP002B-2	19.1	1.1	1.5	1.7	6.4	1.2	0.17	140.8	0.87	
F08LP002B-3	17.4	1.0	1.8	2.4	6.4	1.3	0.18	37.1	0.81	
F08LP002B	17.4	1.0	1.7	2.1	7.0	1.3	0.17	78.7	0.84	1.7
F08LP003-1	9.0	0.5	1.6	3.0	8.6	1.9	0.09	38.1	0.81	
F08LP003-2	12.6	0.8	0.9	1.4	19.2	1.7	0.08	89.2	0.85	
F08LP003-3	8.1	0.5	1.3	2.3	8.0	1.8	0.07	63.1	0.84	
F08LP003	9.9	0.6	1.2	2.3	11.9	1.8	0.08	63.5	0.83	2.4
F08LP007-1	12.6	0.8	1.3	1.6	12.8	1.2	0.11	164.0	0.88	
F08LP007-2	17.0	1.0	2.4	3.2	19.8	1.3	0.25	50.7	0.82	
F08LP007-3	17.1	1.0	1.4	1.6	17.3	1.2	0.14	42.0	0.81	
F08LP007	15.6	0.9	1.7	2.1	16.7	1.2	0.17	85.6	0.84	2.6
F08LP008-1	7.8	0.5	1.1	2.8	9.1	2.6	0.06	36.6	0.80	
F08LP008-2	8.5	0.5	1.4	3.1	9.3	2.3	0.08	42.1	0.81	
F08LP008-3	9.4	0.6	1.2	3.2	9.8	2.6	0.09	57.4	0.83	
F08LP008	8.6	0.5	1.2	3.0	9.4	2.5	0.08	45.3	0.81	0.8
H07HU001-1	13.7	0.8	1.5	3.0	5.2	2.0	0.14	51.2	0.82	
H07HU001-2	12.1	0.7	2.2	5.4	7.7	2.4	0.19	40.0	0.81	
H07HU001-3	11.7	0.7	1.1	2.3	3.8	2.1	0.08	29.7	0.79	
H07HU001	12.5	0.7	1.6	3.6	5.6	2.2	0.14	40.3	0.81	1.0

APPENDIX F

ELECTRON MICROPROBE

F.1 Methods

Four samples were analyzed with a Cameca SX-100 microprobe at New Mexico Tech. Basic thin section petrography was used to characterize the samples before they were carbon-coated and loaded into the microprobe for analysis. Backscatter electron imaging was used for qualitative analysis of the samples, and quantitative analyses were run on hornblende, plagioclase, k-feldspar, and biotite grains. Data are summarized in appendix M. For quantitative analysis, a 10 nA beam current and a 20 μm beam diameter were used. Count times of 20 seconds were used for all major elements except for F (60 s), Al (80 s), and Cl (40 s). ZAF matrix corrections were used for data reduction. The purpose of the microprobe was to run Al-in-hornblende geobarometry on the samples. Of the four samples, two contained hornblende phenocrysts, and one of these had the proper mineral assemblage of plagioclase, quartz, hornblende, biotite, orthoclase, magnetite, and titanite (Hollister et al., 1987). WinAmphCal was used to reduce the geobarometry data for both hornblende-bearing samples (Yavuz, 2007).

Table F.1: Microprobe Quantitative Analysis Tables: Amphibole, Feldspar, and Oxide

Sample	kak-04	orth-01	orth-02	orth-03	orth-04	anorth-01	anorth-02	anorth-03	anorth-04	H07-HU-001-01	H07-HU-001-02	H07-HU-001-03	H07-HU-001-04
Specie	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole
Beam Size (mM)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	—	—	—	—	—	—	—	—	—	—	—	—	—
SiO2	40.046	65.009	65.01	65.153	65.158	44.109	44.076	44.062	44.044	43.048	43.809	43.656	44.247
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	4.664	—	—	—	—	—	—	—	—	1.028	0.964	0.932	0.77
Al2O3	14.746	16.566	16.666	16.654	16.623	34.113	34.288	34.437	34.017	9.066	8.612	9.378	8.443
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	12.571	—	—	—	—	—	—	—	—	10.456	10.846	10.481	10.957
CaO	10.185	0	0.006	—	0.003	18.795	18.522	18.847	18.502	11.598	11.497	11.82	11.497
MnO	0.119	—	—	—	—	—	—	—	—	1.367	1.398	1.442	1.541
FeO	11.068	1.752	1.821	1.822	1.89	0.41	0.396	0.397	0.423	17.815	17.573	17.802	17.906
SrO	—	0	0	0	0.043	0.04	0.033	0.024	0.097	—	—	—	—
BaO	—	0	0.109	0.079	0.054	0.03	0.044	0.014	0.093	—	—	—	—
H2O	1.947	0	0	0	0	0	0	0	0	1.701	1.749	1.759	1.749
Na2O	2.612	0.954	0.884	0.918	0.834	0.698	0.743	0.721	0.718	1.359	1.462	1.176	1.401
K2O	2.113	15.606	15.609	15.531	15.457	0.027	0.008	0.008	0.004	1.034	1.013	1.141	0.941
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	0.166	—	—	—	—	—	—	—	—	0.501	0.427	0.425	0.453
Cl	0.019	—	—	—	—	—	—	—	—	0.011	0.018	0.024	0.006
Total	100.257	99.888	100.104	100.157	100.061	98.223	98.109	98.51	97.898	98.985	99.367	100.037	99.911

Sample	H07-HU-001-05	H07-HU-001-06	H07-HU-001-07	H07-HU-001-08	H07-HU-001-09	H07-HU-001-010	H07-HU-001-011	H07-HU-001-012	H07-HU-001-013	H07-HU-001-014	H07-HU-001-015	H07-HU-001-016	H07-HU-001-017
Specie	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole
Beam Size (nm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	—	—	—	—	—	—	—	—	—	—	—	—	—
SiO2	44.527	43.39	42.463	42.657	42.95	62.068	62.573	60.968	46.355	44.462	43.854	48.005	42.63
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	0.601	0.973	1.206	1.27	1.108	—	—	—	0.504	0.717	0.876	0.388	1.173
Al2O3	8.694	9.002	9.576	9.535	9.234	22.96	22.678	23.487	7.037	8.738	8.898	5.875	9.644
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	10.546	10.546	10.226	10.404	10.456	—	—	—	11.743	10.979	10.83	12.214	10.151
CaO	11.527	11.616	11.461	11.457	11.494	4.995	4.273	5.411	12.029	11.766	11.549	12.044	11.695
MnO	1.425	1.439	1.408	1.375	1.433	—	—	—	1.531	1.556	1.501	1.58	1.516
FeO	18.19	18.012	18.396	18.044	18.046	0.112	0.084	0.09	16.987	17.92	18.029	17.096	18.579
SrO	—	—	—	—	—	0.103	0.103	0.225	—	—	—	—	—
BaO	—	—	—	—	—	0.03	0.049	0	—	—	—	—	—
H2O	1.744	1.744	1.724	1.711	1.747	0	0	0	1.783	1.754	1.743	1.812	1.757
Ni2O	1.134	1.367	1.515	1.495	1.558	8.566	8.872	8.422	1.024	1.343	1.398	0.821	1.316
K2O	0.915	1.057	1.181	1.139	1.11	0.254	0.29	0.181	0.699	0.96	0.993	0.51	1.198
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	0.463	0.44	0.456	0.483	0.415	—	—	—	0.406	0.47	0.467	0.378	0.402
Cl	0.009	0.007	0.023	0.036	0.025	—	—	—	0.051	0.014	0.009	0.073	0.027
Total	99.775	99.593	99.633	99.606	99.576	99.089	98.922	98.784	100.15	100.679	100.148	100.797	100.089

Sample	H07-HU-001-018	H07-HU-001-019	H07-HU-001-020	H07-HU-001-021	H07-HU-001-022	H07-HU-001-023	H07-HU-001-024	H07-HU-001-025	H07-HU-001-026	H07-HU-001-027	H07-HU-001-028	H07-HU-001-029	H07-HU-001-030
Specie	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar
Beam Size (mM)	10	10	10	10	10	10	10	10	10	10	10	10	10
P205	—	—	—	—	—	—	—	—	—	—	—	—	—
SiO2	52.028	44.758	44.814	44.121	42.288	43.396	44.629	43.285	44.232	43.553	43.425	63.169	63.374
SiO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	0.017	0.66	0.637	0.601	1.133	0.94	0.719	1.189	0.703	1.084	1.148	—	—
Al2O3	2.276	8.561	8.717	8.993	10.255	9.392	8.485	9.522	8.994	9.159	9.349	22.906	22.929
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	12.751	11.092	10.807	10.739	9.7	10.643	10.998	10.375	10.769	10.596	10.44	—	—
CaO	12.581	11.681	11.904	11.582	11.629	11.67	11.716	11.585	11.841	11.715	11.574	4.37	4.202
MnO	2.283	1.607	1.55	1.565	1.581	1.586	1.492	1.63	1.535	1.568	1.438	—	—
FeO	16.029	17.729	17.936	18.232	18.981	18.09	17.686	18.4	18.268	18.305	18.592	0.195	0.156
FeO	—	—	—	—	—	—	—	—	—	—	—	0.216	0.163
BaO	—	—	—	—	—	—	—	—	—	—	—	0.022	0.03
H2O	1.916	1.803	1.783	1.779	1.764	1.758	1.789	1.759	1.767	1.803	1.745	0	0
Ni2O	0.255	1.305	0.999	1.351	1.466	1.339	1.339	1.423	1.297	1.271	1.572	9	9.166
K2O	0.164	0.946	0.921	0.933	1.214	1.063	0.89	1.176	0.998	0.999	1.091	0.337	0.18
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	0.245	0.375	0.39	0.405	0.407	0.436	0.383	0.439	0.445	0.344	0.468	—	—
Cl	0	0.012	0.055	0.004	0	0.011	0.023	0.018	0.008	0.022	0.023	—	—
Total	100.545	100.53	100.513	100.305	100.417	100.324	100.15	100.802	100.858	100.419	100.865	100.214	100.2

Sample	H07-HU-001-031	H07-HU-001-032	H07-HU-001-033	H07-HU-001-034	H07-HU-001-035	H07-HU-001-036	H07-HU-001-037	H07-HU-001-038	H07-HU-001-039	H07-HU-001-040	H07-HU-001-041	H07-HU-001-042	H07-HU-001-043
Specie	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole
Beam Size (mM)	10	10	10	10	10	10	10	10	10	10	10	10	10
P205	62.788	71.239	44.598	44.104	44.737	44.112	44.312	43.214	42.284	43.018	42.41	42.364	43.947
SiO2	—	—	0.706	0.993	0.659	0.902	0.767	1.065	1.249	1.011	1.29	1.273	0.515
SO2	—	—	8.481	8.964	8.29	8.581	8.591	9.109	9.872	10.176	10.177	10.268	8.449
Al2O3	22.93	26.185	—	—	—	—	—	—	—	—	—	—	—
Ce2O3	—	—	11.061	10.753	11.156	10.679	10.829	10.098	9.832	10.185	10.11	10.171	10.693
MgO	—	—	11.444	11.557	11.78	11.523	11.386	11.483	11.469	11.429	11.519	11.435	11.647
CaO	4.513	5.208	1.406	1.489	1.527	1.529	1.475	1.475	1.267	1.249	1.229	1.222	1.433
MnO	—	—	17.703	17.858	17.416	17.933	17.728	18.331	18.139	18.33	18.176	18.435	18.36
FeO	0.111	0.166	—	—	—	—	—	—	—	—	—	—	—
FeO	0.235	0.199	—	—	—	—	—	—	—	—	—	—	—
SiO	0.081	0.03	—	—	—	—	—	—	—	—	—	—	—
BaO	—	—	1.708	1.765	1.78	1.767	1.724	1.737	1.785	1.703	1.723	1.716	1.769
H2O	0	0	1.382	1.316	1.147	1.336	1.395	1.367	1.514	1.602	1.623	1.678	1.146
Ni2O	8.864	10.074	0.959	1.041	0.935	0.966	0.954	1.09	1.221	1.226	1.244	1.318	0.919
K2O	0.285	0.339	—	—	—	—	—	—	—	—	—	—	—
Ag2O	—	—	0.543	0.422	0.402	0.4	0.491	0.406	0.295	0.52	0.467	0.478	0.383
F	—	—	—	—	—	—	—	—	—	—	—	—	—
Cl	—	—	0.015	0.033	0.006	0.023	0.022	0.07	0.059	0.065	0.044	0.065	0.004
Total	99.807	113.439	100.006	100.295	99.836	99.751	99.674	99.444	98.986	100.514	100.012	100.424	99.266

Sample	H07-HU-001-044	H07-HU-001-045	H07-HU-001-046	H07-HU-001-047	H07-HU-001-048	H07-HU-001-049	H07-HU-001-050	H07-HU-001-051	H07-HU-001-052	H07-HU-001-053	H07-HU-001-054	H07-HU-001-055	H07-HU-001-056
Specie	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole
Beam Size (mM)	10	10	10	10	10	10	10	10	10	10	10	10	10
P205	44.733	43.134	42.226	42.289	43.14	42.638	64.466	62.941	62.534	44.306	43.503	42.704	42.255
SiO2	—	—	—	—	—	—	—	—	—	—	—	—	—
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	0.641	0.355	1.078	0.848	0.904	0.902	—	—	—	0.868	1.089	0.998	0.532
Al2O3	7.588	9.265	9.4	9.413	8.84	8.968	22.618	22.383	22.861	8.744	9.35	9.503	10.412
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	11.36	10.282	10.126	10.166	10.574	10.488	—	—	—	11.137	10.603	10.216	9.734
CaO	11.5	11.682	11.569	11.639	11.471	11.456	1.543	4.307	4.422	11.52	11.511	11.487	11.992
MnO	1.467	1.247	1.435	1.422	1.606	1.482	—	—	—	1.463	1.465	1.458	1.568
FeO	17.274	18.518	18.355	18.153	17.807	18.014	0.073	0.065	0.072	17.517	17.758	17.977	19.185
SiO	—	—	—	—	—	—	0.229	0.131	0.189	—	—	—	—
BaO	—	—	—	—	—	—	0.073	0.043	0.019	—	—	—	—
H2O	1.747	1.714	1.697	1.731	1.734	1.723	0	0	0	1.691	1.743	1.746	1.735
Ni2O	1.164	1.279	1.544	1.222	1.297	1.388	11.824	8.935	9.014	1.543	1.416	1.389	1.398
K2O	0.847	0.951	1.167	1.131	0.992	1.037	1.115	0.292	0.221	1.087	1.089	1.149	1.111
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	0.432	0.466	0.477	0.386	0.416	0.434	—	—	—	—	—	—	—
Cl	0.004	0.013	0.036	0.047	0.034	0.005	—	—	—	0.582	0.463	0.385	0.4
Total	98.757	98.907	99.11	98.448	98.816	98.535	101.942	99.098	99.331	100.487	99.998	99.062	100.433

Sample	H07-HU-001-057	H07-HU-001-058	H07-HU-001-059	H07-HU-001-060	H07-HU-001-061	H07-HU-001-062	H07-HU-001-063	H07-HU-001-064	H07-HU-001-065	H07-HU-006-01	H07-HU-006-02	H07-HU-006-03	kaer-05
Specie	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Oxide	Oxide	Oxide	Amphibole
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	—	—	—	—	—	—	—	—	—	0.022	0.047	—	—
SiO2	44.281	44.683	44.167	43.885	45.137	43.144	65.095	62.896	61.821	29.791	30.121	30.344	38.696
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	0.656	0.728	0.944	0.859	0.814	1.049	—	—	—	0.898	0.943	0.894	4.328
Al2O3	8.837	8.507	8.69	8.816	8.213	9.515	22.05	23.07	23.992	14.178	13.96	14.425	15.819
Ce2O3	—	—	—	—	—	—	—	—	—	10.203	10.288	10.146	—
MgO	10.69	11.173	10.644	10.914	11.292	10.179	—	—	—	1.188	1.229	1.19	14.176
CaO	11.672	11.631	11.433	11.526	11.803	11.46	3.105	4.488	5.529	11.692	11.585	11.939	12.74
MnO	1.481	1.539	1.528	1.421	1.551	1.52	—	—	—	0.514	0.49	0.44	0.075
FeO	18.322	17.66	18.17	17.972	17.496	18.411	0.158	0.245	0.22	15.289	15.236	14.998	8.731
FeO	—	—	—	—	—	—	0.259	0.24	0.295	—	—	—	—
BaO	—	—	—	—	—	—	—	0.022	0.041	—	—	—	—
H2O	1.779	1.763	1.779	1.759	1.807	1.756	0	0	0	0	0	0	1.898
Na2O	1.33	1.276	1.395	1.418	1.16	1.404	9.892	8.819	8.256	0.069	0.04	0.013	2.279
K2O	0.983	0.954	1.021	1.007	0.885	1.189	0.094	0.323	0.339	0.015	0	0.004	1.306
Ag2O	—	—	—	—	—	—	—	—	—	0.061	0.01	0.069	—
F	0.402	0.452	0.376	0.428	0.381	0.411	—	—	—	—	—	—	0.291
Cl	0.018	0.008	0.047	0.018	0.004	0.033	—	—	—	—	—	—	0.019
Total	100.452	100.374	100.194	100.023	100.543	100.069	100.653	100.101	100.492	83.92	83.95	84.462	100.558

Sample	kaer-06	kak-05	kak-06	orth-05	orth-06	orth-07	anorth-05	anorth-06
Specie	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar
Beam Size (mM)	10	10	10	10	10	10	10	10
P2O5	—	—	—	—	—	—	—	—
SiO2	38.617	40.482	40.134	64.801	75.063	63.393	44.415	44.125
SO2	—	—	—	—	—	—	—	—
TiO2	4.111	4.736	4.65	—	—	—	—	—
Al2O3	15.848	14.867	14.81	16.477	19.375	16.37	34.526	34.372
Ce2O3	—	—	—	—	—	—	—	—
MgO	14.522	12.531	12.668	—	—	—	—	—
CaO	12.579	10.153	10.29	0.02	0	0.004	18.845	18.773
MnO	0.096	0.127	0.105	—	—	—	—	—
FeO	8.655	10.958	10.922	1.822	2.021	1.752	0.451	0.379
SrO	—	—	—	0.012	0.009	0	0.021	0.026
BaO	—	—	—	0.157	0.118	0.153	0.114	0
H2O	2.002	1.941	1.971	0	0	0	0	0
Na2O	7.038	2.58	2.536	0.956	1.098	0.924	0.721	0.666
K2O	1.293	2.136	2.088	15.499	18.467	15.529	0.021	0.014
Ag2O	—	—	—	—	—	—	—	—
F	0.198	0.2	0.117	—	—	—	—	—
Cl	0.023	0.029	0.037	—	—	—	—	—
Total	104.98	100.738	100.329	99.745	116.15	98.124	99.113	98.354

Samples	kaer-01	kaer-02	kaer-03	kaer-04	kak-01	kak-02	kak-03	kak-04	orth-01	orth-02	orth-03	orth-04	anorth-01
Specie	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	—	—	—	—	—	—	—	—	—	—	—	—	—
SiO2	39.706	39.616	39.892	39.699	40.846	40.712	40.735	40.693	65.406	64.844	64.7	64.429	43.923
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	4.138	4.109	4.163	4.157	4.813	4.74	4.595	4.637	—	—	—	—	—
Al2O3	15.564	15.417	15.463	15.439	14.653	14.551	14.746	14.722	16.67	16.651	16.548	16.657	34.004
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	14.108	14.132	14.134	14.078	12.621	12.593	12.707	12.83	—	—	—	—	—
CaO	12.287	12.27	12.126	12.288	9.975	10.126	10.18	10.144	0	0.018	0	0.035	18.384
MnO	0.068	0.099	0.083	0.095	0.125	0.15	0.132	0.084	—	—	—	—	—
FeO	8.758	8.744	8.724	8.563	11.215	10.844	10.823	11.022	1.806	1.768	1.828	1.815	0.344
SrO	—	—	—	—	—	—	—	—	0	0.02	0	0.006	0.078
BaO	—	—	—	—	—	—	—	—	0.03	0.071	0.079	0.117	0.063
H2O	1.207	1.882	1.892	1.97	1.939	1.937	1.909	1.976	0	0	0	0	0
Na2O	2.214	2.288	2.216	2.334	2.654	2.603	2.598	2.549	0.996	0.904	0.909	0.907	0.737
K2O	1.26	1.283	1.261	1.285	2.139	2.099	2.085	2.092	15.535	15.342	15.397	15.314	0.013
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	1.704	0.33	0.326	0.157	0.22	0.209	0.274	0.143	—	—	—	—	—
Cl	0.022	0.018	0.013	0.02	0.032	0.021	0.024	0.026	—	—	—	—	—
O=F, Cl	0.722	0.143	0.14	0.07	0.1	0.093	0.121	0.066	0	0	0	0	0
Total	100.312	100.046	100.153	100.014	101.132	100.491	100.688	100.85	100.442	99.618	99.459	99.281	97.547

Samples	anorth-02	anorth-03	anorth-04	F08-TL-009-01	F08-TL-009-02	F08-TL-009-03	F08-TL-009-04	F08-TL-009-05	F08-TL-009-06	F08-TL-009-07	F08-TL-009-08	F08-TL-009-09	F08-TL-009-10
Specie	Feldspar	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	—	—	—	—	—	—	—	—	—	—	—	—	—
SiO2	43.97	44.038	44.4	32.867	33.449	35.235	36.686	35.222	36.396	35.943	34.528	31.602	33.368
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	—	—	—	0.473	0.438	0.369	0.288	0.315	0.218	0.24	0.348	0.537	0.333
Al2O3	33.897	34.031	34.275	3.774	3.702	1.822	1.206	1.563	1.196	1.361	2.788	4.249	2.771
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	—	—	—	12.85	12.984	14.625	14.788	14.835	15.259	15	13.662	12.383	13.269
CaO	18.296	18.188	18.542	9.987	9.773	9.308	9.757	9.605	9.684	9.606	9.897	9.499	9.478
MnO	—	—	—	1.004	0.969	1.033	1.002	1	1.133	1.177	1.029	1.014	1.049
FeO	0.408	0.435	0.424	11.901	12.043	10.527	9.7	9.773	9.637	10.093	11.311	12.693	11.297
SrO	0.068	0.042	0.023	—	—	—	—	—	—	—	—	—	—
BaO	0	0	0	—	—	—	—	—	—	—	—	—	—
H2O	0	0	0	1.218	1.187	1.201	1.298	1.195	1.257	1.249	1.233	1.121	1.187
Na2O	0.743	0.731	0.678	1.052	1.088	0.773	0.536	0.57	0.43	0.518	0.728	1.125	0.913
K2O	0.002	0.014	0.006	0.444	0.394	0.38	0.3	0.232	0.218	0.258	0.34	0.47	0.306
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	—	—	0.556	0.649	0.637	0.469	0.625	0.549	0.562	0.572	0.69	0.582
Cl	—	—	—	0.026	0.024	0.021	0.034	0.021	0.033	0.014	0.021	0.041	0.015
O=F, Cl	0	0	0	0.24	0.279	0.273	0.205	0.268	0.239	0.24	0.246	0.3	0.249
Total	97.384	97.478	98.348	75.912	76.42	75.658	75.86	74.688	75.771	75.78	76.212	75.124	74.319

Samples	F08-TL-009-011	F08-TL-009-012	F08-TL-009-013	F08-TL-009-014	F08-TL-009-015	F08-TL-009-016	F08-TL-009-017	F08-TL-009-018	F08-TL-009-019	F08-TL-009-020	F08-TL-009-021	F08-TL-009-022	F08-TL-009-023
Specie	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole
P2O5	-	-	-	-	-	-	-	-	-	-	-	-	-
SiO2	32.393	43.329	43.053	66.164	41.409	47.649	48.499	48.662	48.604	48.901	48.713	49.97	46.811
SO2	-	-	-	-	-	-	-	-	-	-	-	-	-
TiO2	0.442	-	-	-	-	0.497	0.467	0.447	0.432	0.492	0.483	0.386	0.686
Al2O3	3.877	15.036	15.589	0.02	15.876	3.973	3.982	3.934	4.325	4.66	4.691	3.679	5.775
Ce2O3	-	-	-	-	-	-	-	-	-	-	-	-	-
MgO	12.6	-	-	-	-	15.172	15.574	15.205	14.961	14.793	14.815	15.578	13.682
CaO	9.5	2.14	2.853	0.049	3.217	11.275	11.39	11.447	11.588	11.447	11.339	11.441	11.248
MnO	1.008	-	-	-	-	0.963	0.905	0.944	0.989	1.068	1.1	1.087	1.032
FeO	12.171	0.145	0.161	0.014	0.104	12.261	12.154	12.372	12.457	13.037	12.785	12.249	14.6
SrO	-	0.022	0.025	0.009	0.253	-	-	-	-	-	-	-	-
BaO	-	0.038	0.005	-	0.022	-	-	-	-	-	-	-	-
H2O	1.245	0	0	0	0	1.641	1.701	1.728	1.647	1.651	1.739	1.766	1.623
Nu2O	1.167	9.191	8.63	0.007	8.215	1.061	1.062	0.977	0.887	0.964	1.139	0.78	1.359
K2O	0.438	0.191	0.227	0.004	0.268	0.378	0.365	0.341	0.412	0.428	0.449	0.372	0.548
Ag2O	-	-	-	-	-	-	-	-	-	-	-	-	-
F	0.477	-	-	-	-	0.614	0.545	0.5	0.67	0.71	0.535	0.49	0.723
Cl	0.006	-	-	-	-	0.046	0.06	0.034	0.041	0.024	0	0.03	0.004
O=F, Cl	0.202	0	0	0	0	0.269	0.243	0.218	0.291	0.305	0.225	0.213	0.305
Total	75.122	70.092	70.543	66.266	69.362	95.26	96.461	96.372	96.72	97.87	97.564	97.616	97.784

Samples	F08-TL-009-024	F08-TL-009-025	F08-TL-009-026	F08-TL-009-027	F08-TL-009-028	F08-TL-009-029	F08-TL-009-030	F08-TL-009-031	F08-TL-009-032	F08-TL-009-033	F08-TL-009-034	F08-TL-009-035	F08-TL-009-036
Specie	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole
P2O5	—	—	—	—	—	—	—	—	0.01	—	—	—	—
SiO2	47.323	47.766	48.099	65.559	64.033	63.759	59.046	59.442	0.115	46.91	45.078	43.968	48.96
SO2	—	—	—	—	—	—	—	—	0.006	—	—	—	—
TiO2	0.597	0.564	0.621	—	—	—	—	—	0.161	0.865	1.082	1.084	0.567
Al2O3	4.986	4.981	5.164	20.108	20.604	20.704	22.106	22.715	0.062	6.876	8.226	8.664	5.128
Ce2O3	—	—	—	—	—	—	—	—	0	—	—	—	—
MgO	14.322	14.029	13.978	1.824	2.545	2.767	4.942	5.491	0.006	13.155	12.405	11.632	14.624
CaO	11.04	11.205	11.218	—	—	—	—	—	0.038	11.493	11.672	11.397	11.585
MnO	1.174	1.155	1.144	—	0.205	0.163	0.175	0.189	0.106	0.989	0.969	1.043	1.077
FeO	14.028	13.98	14.176	0.084	0.061	0.021	0.144	0.168	93.647	14.546	15.396	15.757	13.477
SrO	—	—	—	0.078	0.046	0.005	0.065	0.081	—	—	—	—	—
BaO	—	—	—	0.033	0.046	0.005	0.065	0.081	—	—	—	—	—
H2O	1.658	1.683	1.66	0	0	0	0	0	—	1.705	1.706	1.672	1.722
Nu2O	1.336	1.336	1.349	10.493	9.83	9.692	8.379	8.222	0.012	1.439	1.447	1.508	1.191
K2O	0.49	0.537	0.536	0.121	0.209	0.283	0.218	0.271	0.005	0.73	0.9	1.019	0.504
Ag2O	—	—	—	—	—	—	—	—	0	—	—	—	—
F	0.647	0.606	0.687	—	—	—	—	—	—	—	—	—	—
Cl	0.004	0.017	0.011	—	—	—	—	—	—	0.595	0.549	0.548	0.619
O=F, Cl	0.274	0.259	0.292	0	0	0	0	0	—	0.034	0.064	0.078	0.006
Total	97.333	97.599	98.349	98.3	97.534	97.396	95.075	96.58	94.168	99.079	99.248	98.121	99.199

Samples	F08-TL-009-037	F08-TL-009-038	F08-TL-009-039	F08-TL-009-040	F08-TL-009-041	F08-TL-009-042	F08-TL-009-043	F08-TL-009-044	F08-TL-009-045	F08-TL-009-046	F08-TL-009-047	F08-TL-009-048	F08-TL-014-01
Specie	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar
P2O5	—	—	—	—	—	—	—	—	—	—	—	—	—
SiO2	51.811	50.166	51.521	66.033	49.896	50.636	49.812	49.59	64.859	64.033	60.703	61.231	63.437
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	0.341	0.598	0.499	0	0.696	0.507	0.559	0.601	—	—	—	—	—
Al2O3	3.437	5.298	3.63	18.636	4.573	3.829	4.779	4.76	20.991	21.409	23.195	23.128	18.743
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	15.925	14.565	15.789	0	14.732	15.486	14.882	14.652	2.608	3.322	5.374	5.141	0.001
CaO	12.363	11.707	11.614	0	11.916	12.155	11.448	11.571	—	—	—	—	—
MnO	0.925	1.046	1.026	0.015	1.017	0.95	1.112	1.077	0.471	0.261	0.19	0.154	0.025
FeO	11.969	12.961	12.014	0.137	13.086	12.267	13.395	13.269	0.057	0.049	0.141	0.081	0.129
SrO	—	—	—	—	—	—	—	—	0.068	0.071	0.005	0.008	0.457
BaO	—	—	—	—	—	—	—	—	—	—	—	—	—
H2O	1.836	1.775	1.837	2.289	1.754	1.749	1.736	1.756	0	0	0	0	0
Na2O	0.518	0.916	0.838	0.667	0.919	0.765	1.188	1.057	10.087	9.501	8.24	8.466	0.852
K2O	0.35	0.488	0.37	15.572	0.502	0.384	0.449	0.468	0.107	0.269	0.247	0.13	15.587
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	0.455	0.543	0.43	0	0.56	0.584	0.626	0.557	—	—	—	—	—
Cl	0.032	0.049	0.046	0.008	0.044	0.031	0	0.009	—	—	—	—	—
O=F, Cl	0.199	0.24	0.191	0.002	0.246	0.253	0.264	0.237	0	0	0	0	0
Total	99.762	99.873	99.423	103.355	99.449	99.091	99.723	99.129	99.246	98.915	98.095	98.339	99.231

Samples	F08-TL-014-02	F08-TL-014-03	F08-TL-014-04	F08-TL-014-05	F08-TL-014-06	F08-TL-014-07	F08-TL-014-08	F08-TL-014-09	F08-TL-014-10	F08-TL-014-11	F08-TL-014-12	F08-TL-014-13	F08-TL-014-14
Specie	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar	Feldspar
—	—	—	—	—	—	—	—	—	—	—	—	—	—
P2O5	69.556	63.278	65.368	64.646	68.643	66.216	62.879	64.141	63.896	63.385	63.536	64.287	63.622
SiO2	—	—	—	—	—	—	—	—	—	—	—	—	—
SO2	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO2	—	—	—	—	—	—	—	—	—	—	—	—	—
Al2O3	17.18	18.855	21.721	19.141	19.31	17.97	18.897	19.105	19.099	19.229	19.22	19.093	18.936
Ce2O3	—	—	—	—	—	—	—	—	—	—	—	—	—
MgO	—	—	—	—	—	—	—	—	—	—	—	—	—
CaO	0.431	0	2.627	0.001	0.535	0.091	0	0.078	0.045	0.047	0.179	0.021	0.041
MnO	—	—	—	—	—	—	—	—	—	—	—	—	—
FeO	0.124	0.044	0.009	0.05	0.081	0.08	0.035	0.03	0.06	0.027	0.003	0.039	0.046
SrO	0.08	0.147	0.218	0.159	0.115	0.153	0.13	0.174	0.173	0.252	0.181	0.163	0.145
BaO	0.206	0.437	0.024	0.559	0.003	0.465	0.746	0.794	1.324	1.413	1.4	0.816	1.261
H2O	0	0	0	0	0	0	0	0	0	0	0	0	0
Na2O	1.922	0.859	9.526	1.604	9.946	0.6	0.775	2.006	1.706	1.836	1.572	1.154	1.544
K2O	8.108	15.385	0.107	14.493	0.285	11.909	15.412	13.786	13.882	13.701	14.144	15.069	14.337
Ag2O	—	—	—	—	—	—	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—	—	—	—	—	—	—
Cl	—	—	—	—	—	—	—	—	—	—	—	—	—
O=F, Cl	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	97.608	99.006	99.602	100.653	98.918	97.485	98.873	100.113	100.184	99.89	100.234	100.642	99.932

Samples	F08-TL-014-015	kaer-05	kaer-06	kak-05	kak-06	orth-05	orth-06	anorth-05	anorth-06
Specie	Feldspar	Amphibole	Amphibole	Amphibole	Amphibole	Feldspar	Feldspar	Feldspar	Feldspar
—	—	—	—	—	—	—	—	—	—
P2O5	—	—	—	—	—	—	—	—	—
SiO2	64.789	39.371	39.459	40.611	40.468	64.621	64.61	43.857	44.333
SO2	—	—	—	—	—	—	—	—	—
TiO2	—	4.192	4.154	4.665	4.691	—	—	—	—
Al2O3	19.45	15.647	15.696	14.784	14.869	16.64	16.61	34.297	34.201
Ce2O3	—	—	—	—	—	—	—	—	—
MgO	—	14.076	14.082	12.782	12.686	—	—	—	—
CaO	0.107	12.441	12.266	10.177	10.297	0.027	0.005	18.502	18.371
MnO	—	0.07	0.084	0.103	0.083	—	—	—	—
FeO	0	8.716	8.598	11.074	10.986	1.914	1.844	0.429	0.356
SrO	0.232	—	—	—	—	0.036	0.02	0.012	0.053
BaO	0.881	—	—	—	—	0.159	0.051	0.06	0
H2O	0	1.903	1.899	1.949	1.937	0	0	0	0
Na2O	3.841	2.164	2.214	2.566	2.549	0.879	0.895	0.7	0.714
K2O	11.161	1.283	1.316	2.061	2.063	15.144	15.24	0	0.004
Ag2O	—	—	—	—	—	—	—	—	—
F	—	0.286	0.302	0.196	0.219	—	—	—	—
Cl	—	0.021	0.009	0.029	0.016	—	—	—	—
O=F, Cl	0	0.125	0.129	0.089	0.096	0	0	0	0
Total	100.461	100.045	99.949	100.908	100.769	99.421	99.275	97.856	98.033

Table F.2: Microprobe Quantitative Analysis: Apatite

Sample	kaer-01		kaer-02		kaer-03		kaer-04		kak-01		kak-02		kak-03		kak-04		dur-ap-01		dur-ap-02		dur-ap-03		dur-ap-04		bee-ap-01	
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5																	43.894	40.221	40.735	40.51	40.739					
SiO2	39.324	39.278	39.564	39.163	39.307	39.104	39.322	40.238									0.37	0.334	0.322	0.319	0.102					
SO2																	0.359	0.364	0.379	0.357	0.348					
TiO2	4.171	4.122	4.193	4.163	6.403	6.466	6.367	4.678																		
Al2O3	15.657	15.732	15.678	15.549	15.272	15.409	15.034	14.771																		
MgO	14.092	14.039	13.923	14.002	13.406	13.31	13.204	12.48																		
CaO	12.173	12.216	12.241	12.151	11.38	11.358	11.257	10.095									56.891	52.856	52.87	52.512	53.308					
MnO	0.132	0.104	0.117	0.124	0.043	0.031	0.069	0.118									0.03	0.011	0	0.02	0.044					
FeO	9.07	9.07	8.91	8.896	8.381	8.448	8.548	11.427									0.101	0.057	0.032	0	0.048					
SrO																	0.047	0.049	0.066	0.091	0.433					
H2O	1.876	1.898	1.899	1.894	1.892	1.854	1.857	1.89									0.097	0	0.009	0.035	0.16					
Na2O	2.288	2.301	2.168	2.258	1.893	1.831	1.936	2.497									0.26	0.218	0.229	0.214	0.207					
K2O	1.266	1.262	1.235	1.261	2.439	2.415	2.282	2.053																		
F	0.341	0.3	0.296	0.283	0.333	0.399	0.372	0.286									3.411	3.603	3.305	3.233	3.195					
Cl	0.026	0.016	0.026	0.024	0.003	0.011	0.026	0.03									0.334	0.334	0.355	0.351	0					
O=F, Cl	0.15	0.13	0.131	0.125	0.141	0.171	0.163	0.127									1.512	1.593	1.472	1.441	1.345					
Total	100.267	100.209	100.119	99.643	100.612	100.467	100.11	100.437									104.28	96.456	96.832	96.202	97.238					

Sample	bee-ap-02	bee-ap-03	bee-ap-04	H07-HU-001-01	H07-HU-001-02	H07-HU-001-03	H07-HU-001-04	H07-HU-001-05	H07-HU-001-06	H07-HU-001-07	H07-HU-001-08	H07-HU-001-09	H07-HU-001-10
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	40.564	40.87	40.977	40.817	41.662	41.642	41.29	41.215	42.014	41.39	41.456	41.584	41.308
SiO2	0.082	0.093	0.087	0.141	0.167	0.183	0.18	0.178	0.13	0.171	0.205	0.126	0.103
SO2	0.371	0.325	0.358	0.096	0.098	0.098	0.116	0.116	0.107	0.108	0.131	0.133	0.118
TiO2													
Al2O3													
MgO	53.205	53.34	53.572	53.832	53.908	53.81	54.06	53.509	54.093	54.169	53.581	53.508	53.673
CaO	0.03	0.056	0.065	0.118	0.085	0.098	0.173	0.08	0.131	0.136	0.118	0.078	0.102
MnO	0.051	0.004	0.01	0.078	0.036	0.035	0.018	0.035	0.006	0.024	0.06	0.06	0.04
SrO	0.443	0.425	0.427	0.029	0.045	0.075	0.072	0.072	0.059	0.055	0.035	0.108	0.101
H2O	0	0.126	0.142	0.298	0.277	0.102	0.112	0	0.01	0.092	0.242	0.001	0
Na2O	0.209	0.2	0.209	0.04	0.019	0.062	0.06	0.004	0.028	0.022	0.034	0.06	0.071
K2O													
F	3.536	3.268	3.251	2.877	2.959	3.314	3.289	3.653	3.544	3.329	3.02	3.505	3.57
Cl	0.006	0.001	0	0.072	0.083	0.08	0.072	0.038	0.046	0.081	0.076	0.084	0.09
O=F, Cl	1.49	1.376	1.369	1.228	1.265	1.414	1.401	1.547	1.503	1.42	1.289	1.495	1.523
Total	97.007	97.334	97.729	97.17	98.075	98.085	98.04	97.354	98.665	98.158	97.669	97.751	97.653

Sample	H07-HU-001-11	H07-HU-001-12	H07-HU-001-13	H07-HU-001-14	H07-HU-001-15	H07-HU-001-16	H07-HU-001-17	H07-HU-001-18	H07-HU-001-19	H07-HU-001-20	H07-HU-001-21	H07-HU-001-22	H07-HU-001-23
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	41.748	41.786	41.804	41.27	41.134	41.345	47.012	41.294	41.797	41.835	41.18	41.343	41.664
SiO2	0.114	0.115	0.119	0.255	0.123	0.131	0.247	0.178	0.119	0.197	0.177	0.128	0.185
SO2	0.115	0.117	0.119	0.145	0.124	0.132	0.117	0.073	0.126	0.137	0.14	0.133	0.16
TiO2													
Al2O3													
MgO													
CaO	54.135	53.906	53.79	53.644	53.796	53.437	61.749	53.455	53.753	54.224	53.323	54.264	53.804
MnO	0.136	0.09	0.104	0.123	0.128	0.092	0.161	0.141	0.102	0.117	0.136	0.136	0.071
FeO	0.012	0.04	0.029	0.082	0.039	0.031	0.032	0.007	0.061	0.071	0.071	0.009	0.03
SiO	0.065	0.053	0.059	0.04	0.034	0.059	0.084	0.041	0.022	0.059	0.046	0.034	0.019
H2O	0	0.033	0.278	0.318	0.318	0.34	0.42	0.006	0	0.008	0.22	0.218	0
Ni2O	0.028	0.038	0.051	0.056	0.015	0.038	0.042	0.029	0.044	0.036	0.05	0.033	0.075
K2O													
F	3.747	3.441	2.965	2.86	2.85	2.791	3.158	3.473	3.568	3.531	3.004	3.047	3.516
Cl	0.109	0.118	0.077	0.081	0.075	0.105	0.079	0.093	0.093	0.074	0.149	0.13	0.095
O=F, Cl	1.602	1.476	1.266	1.222	1.217	1.199	1.348	1.483	1.524	1.504	1.299	1.312	1.502
Total	98.608	98.264	98.13	97.651	97.419	97.303	111.753	97.306	98.162	98.785	97.198	98.162	98.115

Sample	H07-HU-001-24	H07-HU-001-25	H07-HU-001-26	H07-HU-001-27	H07-HU-001-28	H07-HU-001-29	H07-HU-001-30	H07-HU-001-31	H07-HU-001-32	H07-HU-001-33	H07-HU-001-34	H07-HU-001-35	H07-HU-001-36
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	41.168	42.12	41.77	41.436	41.8	41.83	41.558	41.313	41.694	41.674	42.182	41.515	41.518
SiO2	0.184	0.123	0.162	0.165	0.171	0.088	0.096	0.194	0.199	0.099	0.102	0.237	0.245
SO2	0.178	0.111	0.129	0.103	0.099	0.107	0.095	0.114	0.16	0.041	0.06	0.337	0.406
TiO2													
Al2O3													
MgO	53.548	54.065	53.941	54.303	54.086	54.274	54.085	53.582	54.151	54.208	54.52	54.042	53.99
CaO	0.141	0.14	0.113	0.148	0.126	0.093	0.115	0.122	0.09	0.174	0.095	0.158	0.094
MnO	0.047	0.004	0.026	0.021	0.013	0.012	0.045	0.035	0.027	0.025	0.036	0.007	0.058
FeO	0.053	0.031	0.079	0.073	0.056	0.097	0.062	0.03	0.043	0.036	0.036	0.052	0.053
SiO	0.054	0	0	0.207	0.261	0.358	0.132	0.173	0.24	0	0.094	0.366	0.091
H2O	0.062	0.043	0.032	0.037	0.018	0.005	0.013	0.028	0.903	0.026	0.016	0.097	0.385
Ni2O													
K2O													
F	3.376	3.72	3.847	3.124	3.031	2.811	3.246	3.151	3.062	3.887	3.408	2.8	3.366
Cl	0.097	0.071	0.079	0.04	0.031	0.082	0.091	0.075	0.093	0.016	0.01	0.069	0.067
O=F, Cl	1.444	1.582	1.638	1.325	1.283	1.202	1.387	1.344	1.31	1.64	1.437	1.194	1.433
Total	97.464	98.845	98.54	98.333	98.409	98.556	98.151	97.473	99.353	98.545	99.123	98.485	98.842

Sample	H07-HU-001-37	H07-HU-001-38	H07-HU-001-39	H07-HU-001-40	H07-HU-005-01	H07-HU-005-02	H07-HU-005-03	H07-HU-005-04	H07-HU-005-05	H07-HU-005-06	H07-HU-005-07	H07-HU-005-08	H07-HU-005-09
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	41.786	41.693	41.781	41.948	41.398	42.229	42.29	42.415	41.859	42.123	42.219	41.105	41.953
SiO2	0.167	0.177	0.123	0.076	0.175	0.123	0.177	0.188	0.167	0.157	0.194	0.238	0.195
SO2	0.198	0.183	0.118	0.131	0.103	0.121	0.108	0.123	0.121	0.121	0.076	0.082	0.102
TiO2													
Al2O3													
MgO	54.567	54.013	54.203	54.577	53.883	54.269	54.286	53.659	53.761	53.696	54.135	53.669	53.338
CaO	0.117	0.093	0.144	0.114	0.109	0.171	0.107	0.149	0.16	0.146	0.146	0.177	0.116
MnO	0.046	0.028	0.05	0.041	0.063	0.056	0.034	0	0.046	0.072	0.025	0.039	0.031
FeO	0.051	0.029	0.074	0.032	0.035	0.026	0.056	0.04	0.055	0.053	0.068	0.03	0.038
SiO	0.075	0.021	0.094	0.161	0.276	0.328	0.317	0.239	0.242	0.216	0.421	0.153	0.291
H2O	0.071	0.868	0.065	0.079	0.07	3.85	0.041	0.036	0.067	0.048	0.015	0.046	0.035
Ni2O													
K2O													
F	3.389	3.505	3.352	3.218	2.982	3.024	2.957	3.106	3.067	3.136	2.736	3.207	2.964
Cl	0.104	0.088	0.07	0.097	0.022	0.013	0.02	0.019	0.033	0.025	0.021	0.034	0.029
O=F, Cl	1.45	1.496	1.427	1.377	1.261	1.276	1.25	1.312	1.299	1.326	1.157	1.358	1.254
Total	99.119	99.201	98.647	99.098	97.854	102.935	99.142	98.662	98.28	98.468	98.901	97.421	97.836

Sample	H07-HU-005-010	H07-HU-005-011	H07-HU-005-012	H07-HU-005-013	H07-HU-005-014	H07-HU-005-015	H07-HU-005-016	H07-HU-005-017	H07-HU-005-018	H07-HU-005-019	H07-HU-005-020	H07-HU-005-021	H07-HU-005-022
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	47.629	42.157	42.101	42.397	42.091	42.089	41.738	42.702	41.573	41.994	42.679	41.755	41.967
SiO2	0.172	0.169	0.126	0.129	0.157	0.15	0.125	0.149	0.217	0.096	0.081	0.155	0.15
SO2	0.105	0.128	0.125	0.114	0.103	0.1	0.072	0.106	0.119	0.056	0.044	0.095	0.113
TiO2													
Al2O3													
MgO													
CaO	60.977	53.455	54.259	53.831	54.078	54.536	54.271	54.011	53.686	54.367	54.229	53.909	53.748
MnO	0.11	0.155	0.119	0.182	0.139	0.12	0.084	0.119	0.164	0.159	0.152	0.149	0.126
FeO	0.01	0.06	0.057	0.071	0.034	0.022	0.016	0.034	0.041	0.04	0	0.003	0.041
SrO	0.024	0.048	0.057	0.072	0.094	0.022	0.039	0.023	0.019	0.041	0.06	0.023	0.047
H2O	0.443	0.01	0	0	0	0.144	0.169	0	0.023	0	0	0.195	0.257
Na2O	0.045	0.916	0.039	0.042	3.877	0.035	0.022	0.066	0.085	1.019	0.035	0.047	1.396
K2O													
F	3.158	3.572	3.668	4.134	3.823	3.308	3.225	3.969	3.486	3.892	3.65	3.171	3.079
Cl	0.005	0.022	0.014	0.025	0.026	0.007	0.017	0.034	0.053	0.02	0.018	0.008	0.02
O=F, Cl	1.331	1.509	1.548	1.747	1.616	1.395	1.362	1.679	1.48	1.644	1.541	1.337	1.301
Total	111.347	99.183	99.017	99.251	102.806	99.138	98.437	99.533	97.985	100.04	99.408	98.173	99.642

Sample	H07-HU-005-023	H07-HU-005-024	H07-HU-005-025	H07-HU-005-026	H07-HU-005-027	H07-HU-005-028	H07-HU-005-029	H07-HU-005-030	H07-HU-005-031	H07-HU-005-032	H07-HU-005-033	H07-HU-005-034	H07-HU-005-035
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	41.381	41.341	42.388	41.575	41.836	41.671	41.455	41.681	42.152	41.645	41.877	40.729	41.874
SiO2	0.15	0.248	0.101	0.249	0.149	0.181	0.179	0.175	0.155	0.131	0.161	0.42	0.089
SO2	0.105	0.123	0.111	0.122	0.119	0.117	0.113	0.104	0.126	0.103	0.121	0.104	0.15
TiO2													
Al2O3													
MgO	53.689	53.382	54.078	53.517	54.071	53.857	53.782	53.375	54.131	53.458	54.151	52.306	53.869
CaO	0.137	0.151	0.149	0.103	0.152	0.145	0.173	0.176	0.141	0.193	0.104	0.116	0.178
MnO	0.05	0.024	0.003	0.01	0.016	0.058	0	0.056	0.014	0.044	0.034	0.012	0.01
FeO	0.058	0.032	0.072	0.052	0.048	0.027	0.069	0.039	0.068	0	0.049	0.031	0.04
H2O	0.301	0.256	0	0	0.083	0.142	0.265	0.253	0	0	0.193	0.238	0
Na2O	0.032	0.057	0.072	0.069	0.064	0.057	0.065	0.043	0.028	0.033	0.066	0.095	0.075
K2O													
F	2.924	3.002	4.117	3.838	3.402	3.266	3.002	3.03	3.875	3.625	3.181	2.984	3.694
Cl	0.022	0.04	0.007	0.029	0.019	0.03	0.03	0.024	0.025	0	0.026	0.044	0.019
O=F, Cl	1.236	1.273	1.735	1.623	1.437	1.382	1.271	1.282	1.637	1.526	1.345	1.266	1.56
Total	97.611	97.382	99.361	97.942	98.522	98.167	97.862	97.673	99.077	97.705	98.617	95.813	98.438

Sample	H07-HU-005-036	H07-HU-005-037	H07-HU-005-038	H07-HU-005-039	H07-HU-005-040	kaer-05	kaer-06	kak-05	kak-06	dur-ap-05	dur-ap-06	bee-ap-05	bee-ap-06
Beam Size (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10
P2O5	41.824	41.95	41.509	41.565	42.027					41.006	40.817	40.914	40.952
SiO2	0.157	0.176	0.192	0.133	0.127	39.259	38.415	40.345	39.381	0.319	0.336	0.122	0.108
SO2	0.124	0.115	0.094	0.09	0.1					0.334	0.37	0.359	0.341
TiO2						4.178	4.116	4.673	6.292				
Al2O3						15.46	15.921	14.668	15.349				
MgO						14.015	14.017	12.326	13.291				
CaO	53.556	54.053	53.756	53.899	53.576	12.144	12.048	9.791	11.374	52.029	52.256	53.499	53.503
MnO	0.182	0.154	0.143	0.11	0.098	0.082	0.08	0.109	0.078	0	0.016	0.061	0.02
FeO	0	0.056	0.009	0.019	0.016	9.039	8.926	11.296	8.593	0.033	0.067	0	0.037
SrO	0.044	0.035	0.049	0.017	0					0.035	0.044	0.4	0.455
H2O	0.057	0	0	0.219	0.141	1.837	1.833	1.927	1.884	0.046	0	0.149	0
Na2O	0.079	0.046	0.059	0.047	0.03	2.323	2.258	2.559	1.952	0.239	0.215	0.224	0.189
K2O						1.208	1.201	2.036	2.245				
F	3.438	3.633	3.614	3.107	3.283	0.406	0.391	0.198	0.354	3.228	3.465	3.233	3.552
Cl	0.027	0.028	0.006	0.015	0.008	0.019	0	0.025	0	0.343	0.369	0	0.01
O=F, Cl	1.454	1.536	1.523	1.312	1.384	0.175	0.164	0.089	0.149	1.436	1.542	1.361	1.498
Total	98.034	98.71	97.908	97.91	98.021	99.793	99.042	99.863	100.643	96.175	96.411	97.6	97.668

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