

## Supplemental File

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

Following the analytical methods described in Nagorsen-Rinke et al. (2013) and Dalrymple and Duffield (1988), we used  $^{40}\text{Ar}/^{39}\text{Ar}$  incremental heating techniques or a continuous CO<sub>2</sub> laser system to date eight samples collected from Oligocene to Miocene volcanic rocks from across the GVGR (Figs. S1, S2, and S3). The resulting age data provide us with timing of volcanism and faulting, and allows us to calculate fault slip rates across the GVGR.  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology samples were prepared and analyzed following the procedures outlined in Supplemental File 1 in Nagorsen-Rinke et al. (2013). Samples reported herein were irradiated at the U.S. Geological Survey, Denver, Colorado, USA, TRIGA (Training, Research, General Atomics) reactor using the Taylor Creek sanidine at 28.444 Ma (Fleck et al., 2019) as a neutron flux monitor. This standard age is equivalent to the Fish Canyon sanidine age of 28.198 Ma calibrated to the astronomical age of the Melilla tephra (Kuiper et al., 2008). Plateau ages are defined by a consecutive series of steps where  $\geq 50\%$  of  $^{39}\text{Ar}$  released is within error. Latitude and longitude recorded in the World Geodetic System 1984. Clean separates (either groundmass, groundmass plagioclase, sanidine, or anorthoclase), collected from three hornblende andesite lavas (OMI, Mlf, and Mal), one quartz latite (OMI), one rhyodacite to quartz latite (Mrc), one rhyolite (Mrl), one basalt (OMI), and one volcanic ash (Me) yield either plateau ages or weighted mean ages (Figs. S1, S2, and S3).

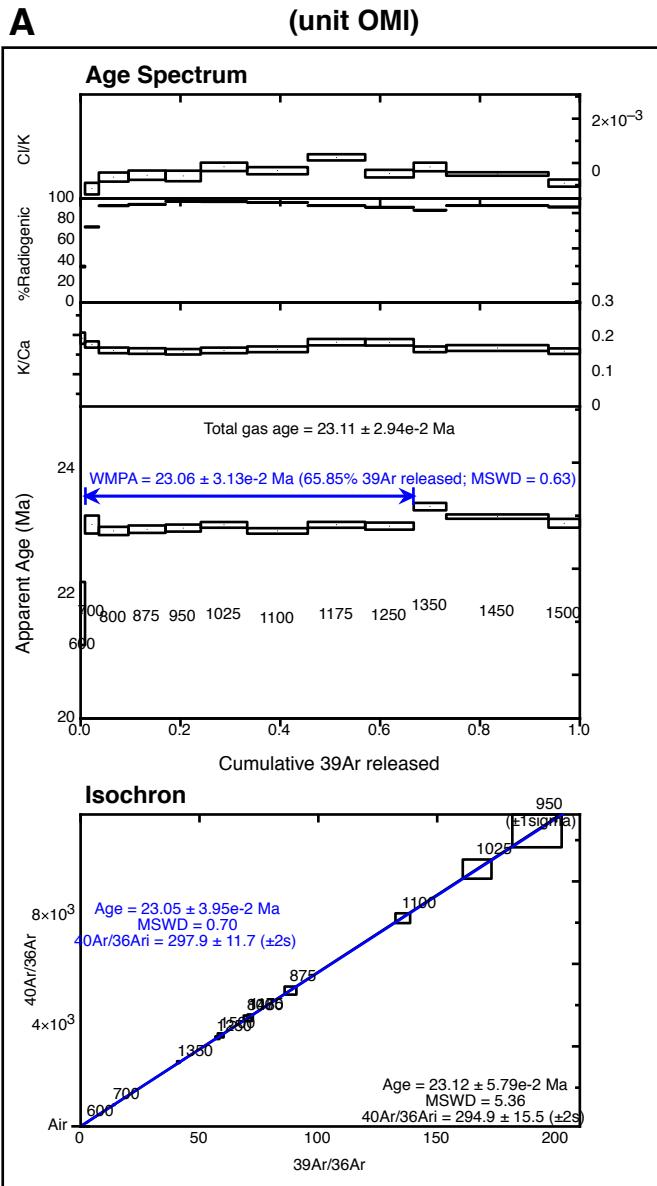
The Oligocene-Miocene unit, OMI, yields a plagioclase weighted mean plateau age of  $23.06 \pm 0.03$  Ma, a plagioclase weighted mean age of  $20.98 \pm 0.10$  Ma, and groundmass weighted mean plateau age of  $15.71 \pm 0.03$  Ma (Fig. S1). The oldest Miocene units, Mrc and Mrl, yield sanidine and anorthoclase weighted mean ages of  $22.95 \pm 0.04$  Ma and  $20.14 \pm 0.26$  Ma, respectively (Fig. S2). Three younger Miocene units, Mlf, Mal, and Me, yield a plagioclase weighted mean plateau age of  $18.91 \pm 0.03$  Ma, a plagioclase weighted mean plateau age of  $15.99 \pm 0.05$  Ma, and an anorthoclase weighted mean age of  $11.8 \pm 0.1$  Ma (Fig. S3).

## References Cited

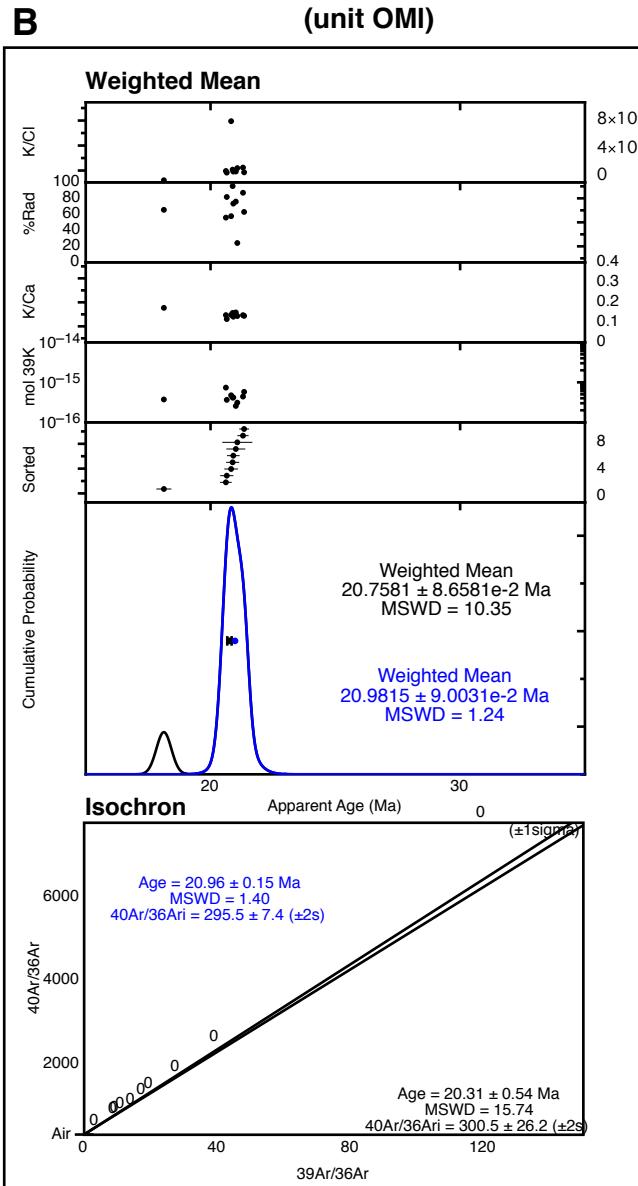
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deflection: *Geosphere*, v. 9, no. 1, p. 37–53.

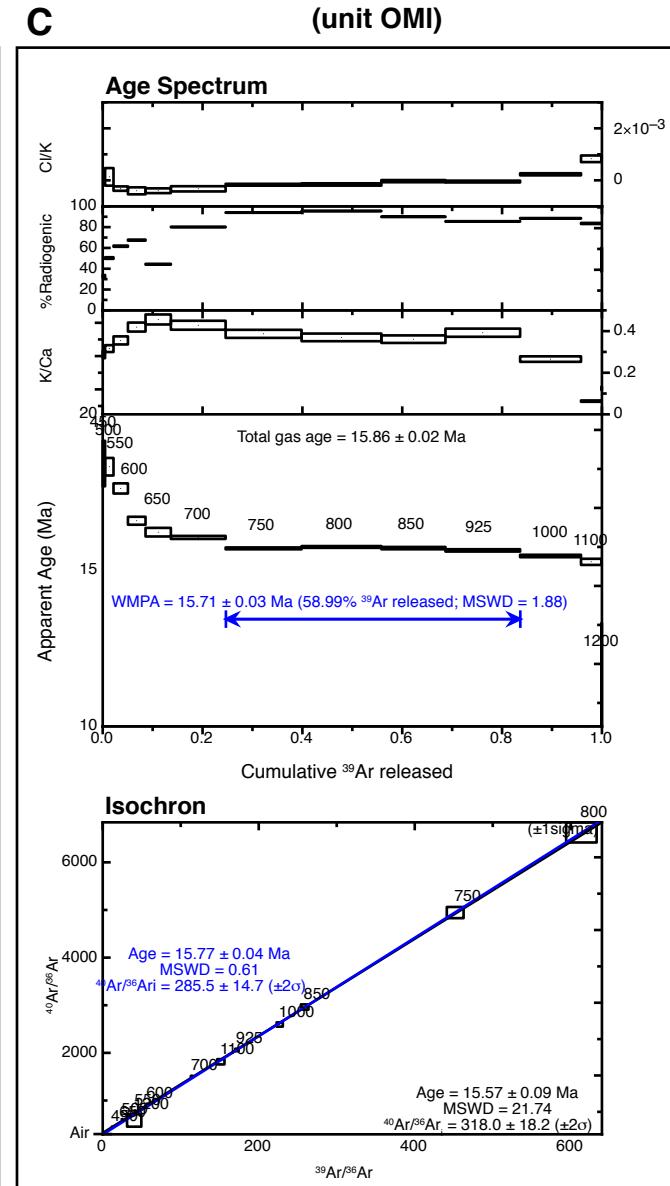
**Sample BS6 Plagioclase  
(unit OMI)**



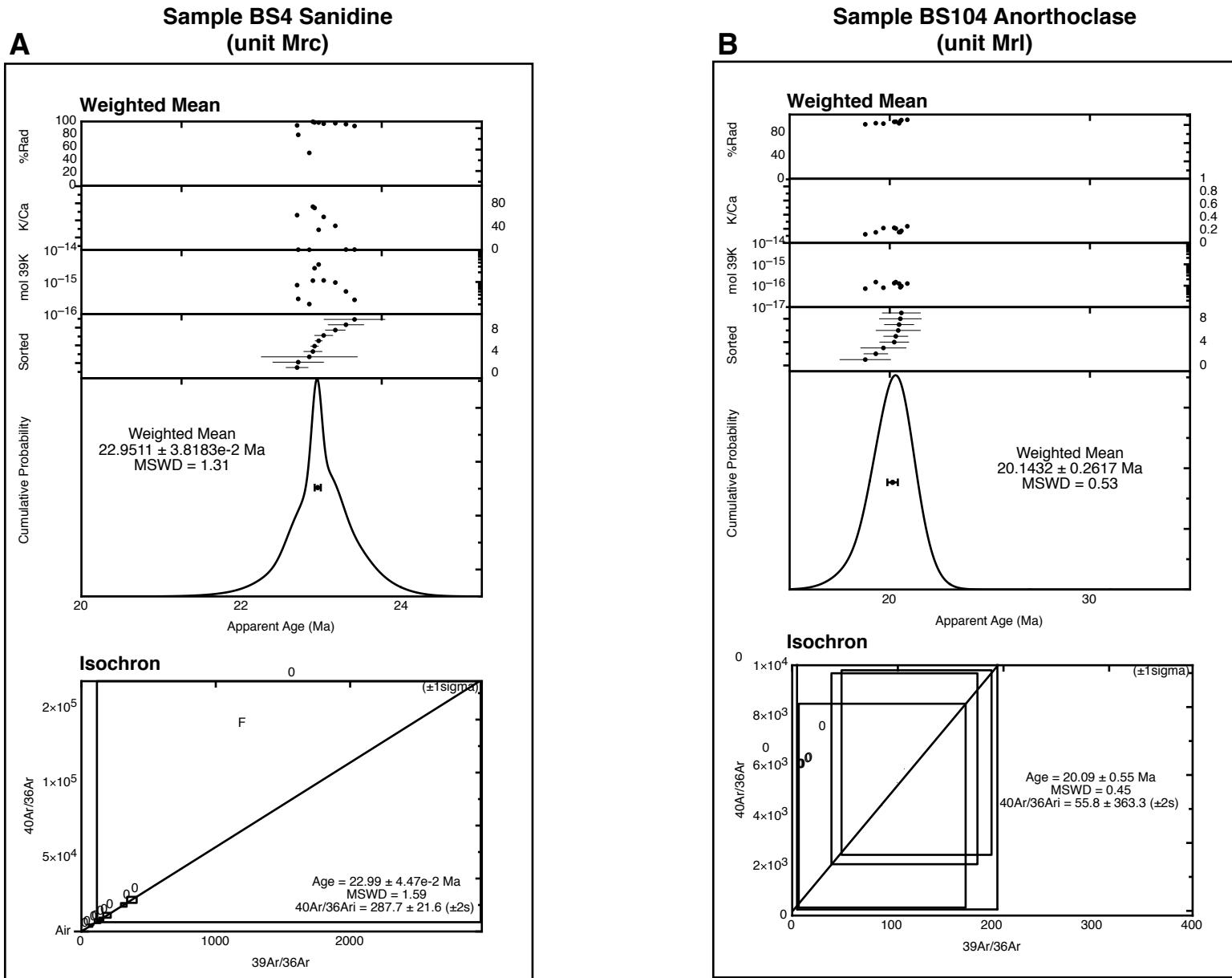
**Sample BS6 Anorthoclase  
(unit OMI)**



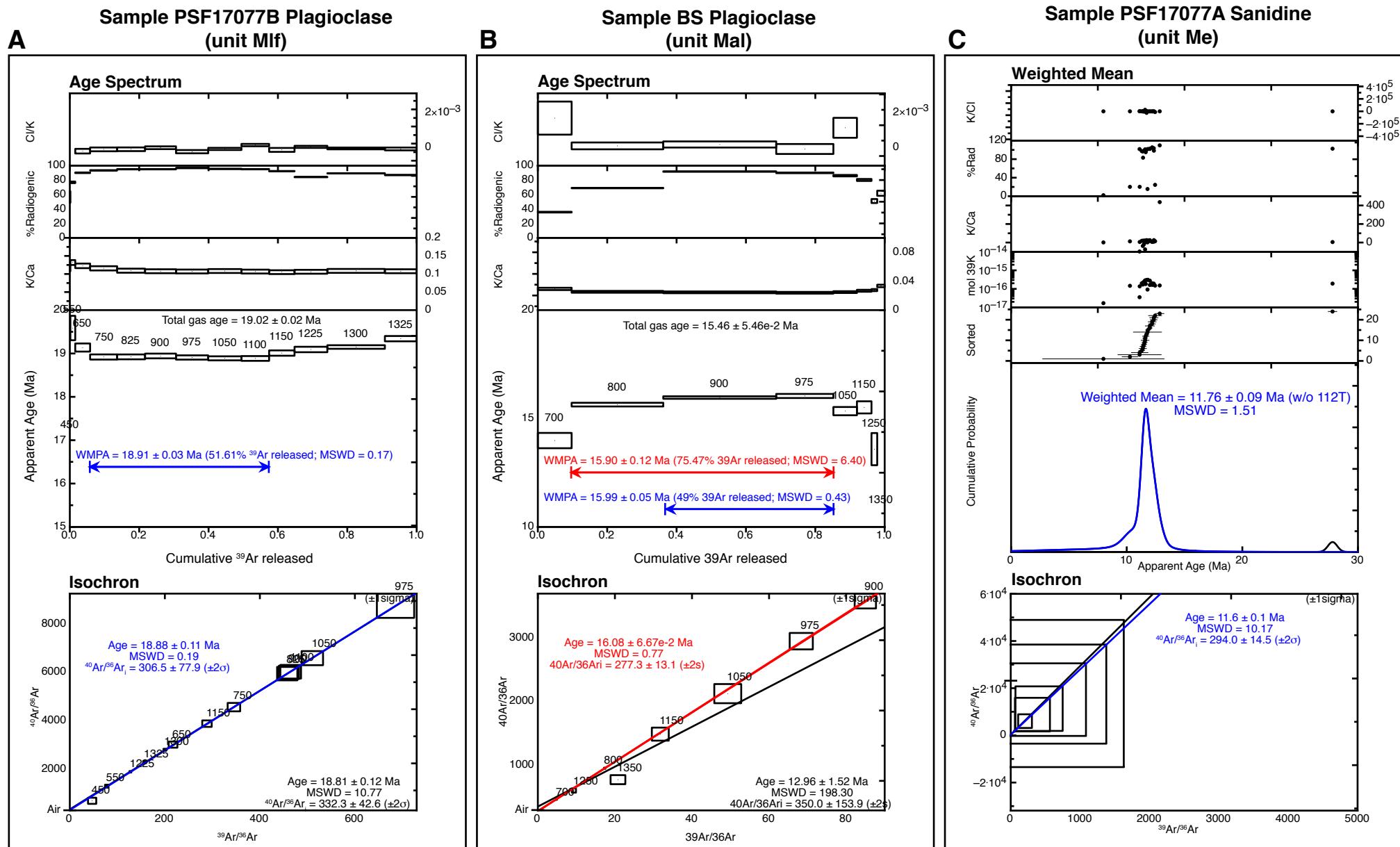
**Sample PSF17052 Groundmass  
(unit OMI)**



**Figure S1.**  $^{40}\text{Ar}/^{39}\text{Ar}$  age data from the Oligocene-Miocene unit OMI. (A) Age spectrum for plagioclase from a hornblende andesite lava. (B) age probability distribution plot for anorthoclase from a quartz latite, and (C) age spectrum for groundmass from a basalt lava. Summary of ages is shown in Table 1; analytical data are listed in the Supplemental File.



**Figure S2.**  $^{40}\text{Ar}/^{39}\text{Ar}$  age data from the oldest Miocene units, Mrc and Mrl. (A) Age probability distribution plot for sanidine from unit Mrc, and (B) age probability distribution plot for anorthoclase from unit Mrl. Summary of ages is shown in Table 1; analytical data are listed in the Supplemental File.



**Figure S3.**  $^{40}\text{Ar}/^{39}\text{Ar}$  age data from the youngest Miocene units, Mlf, Mal, and Me. (A) Age spectrum for plagioclase from unit Mlf, (B) age spectrum for plagioclase from unit Mal, and (C) age probability distribution plot for anorthoclase from unit Me. Summary of ages is shown in Table 1; analytical data are listed in the Supplemental File.

**Table 40Ar/39Ar tabulated data****BS10 Anorthoclase (unit Mrl)**

Grain	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles	40Ar*	$\Sigma$ 39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
A	19.30±0.61	95.17	0.16	-189	6.92E-15	0.14	0.049132±0.000056	0.001001±0.000009	-0.000008±0.000010	0.003178±0.000051	0.000009±0.000005	
B	19.68±1.15	94.43	0.23	-519	3.84E-15	0.21	0.027480±0.000055	0.000544±0.000009	0.000004±0.000010	0.001233±0.000040	0.000006±0.000005	
C	20.30±0.62	97.77	0.22	-871	7.24E-15	0.34	0.050008±0.000082	0.000994±0.000010	0.000009±0.000008	0.002318±0.000049	0.000004±0.000005	
D	20.47±0.75	94.96	0.17	-584	6.24E-15	0.46	0.044364±0.000071	0.000850±0.000011	0.000006±0.000009	0.002653±0.000043	0.000008±0.000005	
E	20.22±0.74	97.58	0.24	-3427	6.46E-15	0.58	0.044745±0.000065	0.000891±0.000010	0.000011±0.000012	0.001983±0.000040	0.000004±0.000005	
F	20.53±1.06	98.86	0.17	-551	4.21E-15	0.66	0.028803±0.000064	0.000573±0.000008	0.000003±0.000007	0.001782±0.000043	0.000002±0.000005	
G	20.58±0.97	100.56	0.19	-194	4.79E-15	0.74	0.032160±0.000064	0.000649±0.000009	-0.000006±0.000010	0.001805±0.000047	-0.000000±0.000005	
H	20.88±0.77	101.06	0.26	-258	6.39E-15	0.86	0.042700±0.000074	0.000853±0.000011	-0.000003±0.000010	0.001722±0.000042	-0.000001±0.000005	
I	18.78±1.28	93.27	0.13	-274	3.32E-15	0.93	0.024057±0.000050	0.000494±0.000007	-0.000000±0.000009	0.001930±0.000037	0.000006±0.000005	

Packet IRR348-LS, Experiment #16Z0067, xx g San, all errors ±1 sigma

J = 0.000229669620±0.000000247142

40Ar\* is radiogenic argon, isotopes in volts (1.48e-13 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca = 0.189 ± 5.509e-2, Calculated K2O = INF%wt., Calculated CaO = INF%wt., Calculated Cl = -INFppm

Total Gas Age = 20.15 ± 0.26 Ma

**Weighted Mean Plateau Age = 20.14 ± 0.26 Ma (±1 sigma, including ±J), 100.00% 39Ar released**

Weighted Mean Plateau Age = 20.14 ± 0.26 Ma (A priori, including ±J), 100.00% 39Ar released

Weighted Mean Plateau Age = 20.14 ± 0.44 Ma (95% confidence, including ±J)

MSWD = 0.53 (Good fit, MSWD &lt; 2.11)

Grains 10 of 10

Isochron Age = 20.1 ± 0.6 Ma (±1 sigma, including ±J)

Isochron Age = 20.1 ± 0.6 Ma (A Priori Errors, including ±J)

Isochron Age = 20.1 ± 1.3 Ma (95% confidence, including ±J)

MSWD = 0.45 (Good fit, MSWD &lt; 2.19)

40Ar/36Ar intercept = 55.8 ± 153.6 (±1 sigma)

40Ar/36Ar intercept = 55.8 ± 153.6 (A Priori)

40Ar/36Ar intercept = 55.8 ± 363.3 (95% confidence)

Grains 10 of 10

**BS4 Sanidine (unit Mrc)**

Grain	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles	40Ar*	$\Sigma$ 39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
A	22.85±0.60	51.07	0.17	576	1.15E-14	0.02	0.151435±0.000163	0.001385±0.000020	0.000075±0.000009	0.004268±0.000077	0.000252±0.000006	
B	23.41±0.38	92.99	0.53	-1547	1.59E-14	0.04	0.115523±0.000129	0.001874±0.000016	0.000025±0.000010	0.001856±0.000043	0.000028±0.000005	
C	23.17±0.13	97.34	41.92	2027	5.45E-14	0.13	0.378482±0.000241	0.006488±0.000024	0.000105±0.000009	0.000081±0.000024	0.000034±0.000005	
D	23.03±0.12	96.58	57.51	2126	6.30E-14	0.22	0.441000±0.000286	0.007548±0.000026	0.000124±0.000009	0.000069±0.000022	0.000051±0.000005	
E	23.30±0.23	95.88	0.52	-40032	2.89E-14	0.27	0.203506±0.000176	0.003419±0.000021	0.000050±0.000012	0.003433±0.000071	0.000029±0.000005	
F	22.89±0.12	99.66	75.36	3047	6.19E-14	0.36	0.419323±0.000276	0.007450±0.000030	0.000109±0.000010	0.000052±0.000025	0.000005±0.000004	
G	22.71±0.32	79.23	0.33	2186	1.65E-14	0.39	0.140864±0.000117	0.002008±0.000012	0.000049±0.000012	0.003190±0.000067	0.000100±0.000005	
H	22.91±0.05	98.62	73.15	13168	1.50E-13	0.62	1.030433±0.000472	0.018099±0.000032	0.000253±0.000015	0.000130±0.000028	0.000048±0.000005	
I	22.69±0.14	93.94	60.53	1227	4.42E-14	0.69	0.318106±0.000179	0.005374±0.000023	0.000102±0.000009	0.000047±0.000032	0.000065±0.000005	
J	22.96±0.05	98.36	35.01	3014	1.97E-13	1	1.353322±0.000556	0.023656±0.000040	0.000359±0.000014	0.000355±0.000024	0.000075±0.000005	

Packet IRR348-MA, Experiment #16Z0069, xx g San, all errors ±1 sigma

J = 0.000227632520±0.000000211219

40Ar\* is radiogenic argon, isotopes in volts (1.48e-13 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca = 3.008 ± 1.138, Calculated K2O = INF%wt., Calculated CaO = INF%wt., Calculated Cl = INFppm

Total Gas Age =  $22.97 \pm 3.95\text{e-}2$  Ma

**Weighted Mean Age =  $22.95 \pm 4.24\text{e-}2$  Ma ( $\pm 1$  sigma, including  $\pm J$ ), 100.00% 39Ar released**

Weighted Mean Age =  $22.95 \pm 3.65\text{e-}2$  Ma (A priori, including  $\pm J$ ), 100.00% 39Ar released

Weighted Mean Age =  $22.95 \pm 9.78\text{e-}2$  Ma (95% confidence, including  $\pm J$ )

MSWD = 1.35 (Good fit, MSWD < 2.11)

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Isochron Age =  $22.99 \pm 0.04$  Ma ( $\pm 1$  sigma, including  $\pm J$ )

Isochron Age =  $23.0 \pm 0.05$  Ma (A Priori Errors, including  $\pm J$ )

Isochron Age =  $23.0 \pm 0.1$  Ma (95% confidence, including  $\pm J$ )

MSWD = 1.59 (Good fit, MSWD < 2.19)

$^{40}\text{Ar}/^{36}\text{Ar}$  intercept =  $287.7 \pm 9.1$  ( $\pm 1$  sigma)

$^{40}\text{Ar}/^{36}\text{Ar}$  intercept =  $287.7 \pm 7.2$  (A Priori)

$^{40}\text{Ar}/^{36}\text{Ar}$  intercept =  $287.7 \pm 21.6$  (95% confidence)

10 of 10 grains

**BS6 Anorthoclase (quartz latite flow in unit OMI)**

Grain	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles	40Ar*	$\Sigma^{39}\text{Ar}$	40Ar	39Ar	38Ar	37Ar	36Ar
A	$21.01 \pm 0.38$	75.91	0.15	488		$1.32\text{E-}14$	0.06	$0.117304 \pm 0.000083$	$0.001741 \pm 0.000012$	$0.000056 \pm 0.000012$	$0.006103 \pm 0.000076$	$0.000097 \pm 0.000005$
B	$21.35 \pm 0.20$	63.01	0.13	375		$3.01\text{E-}14$	0.19	$0.322966 \pm 0.000188$	$0.003918 \pm 0.000016$	$0.000172 \pm 0.000012$	$0.015490 \pm 0.000099$	$0.000409 \pm 0.000006$
C	$20.65 \pm 0.26$	81.69	0.12	338		$1.84\text{E-}14$	0.27	$0.152129 \pm 0.000141$	$0.002474 \pm 0.000015$	$0.000082 \pm 0.000009$	$0.011126 \pm 0.000086$	$0.000097 \pm 0.000005$
D	$20.91 \pm 0.25$	73.43	0.13	484		$2.14\text{E-}14$	0.37	$0.196438 \pm 0.000165$	$0.002835 \pm 0.000015$	$0.000096 \pm 0.000009$	$0.011571 \pm 0.000072$	$0.000180 \pm 0.000005$
E	$21.30 \pm 0.22$	86.96	0.14	1028		$2.29\text{E-}14$	0.47	$0.177845 \pm 0.000150$	$0.002983 \pm 0.000016$	$0.000067 \pm 0.000011$	$0.011494 \pm 0.000111$	$0.000082 \pm 0.000005$
F	$20.62 \pm 0.23$	55.89	0.14	557		$3.71\text{E-}14$	0.64	$0.448552 \pm 0.000249$	$0.004997 \pm 0.000021$	$0.000230 \pm 0.000015$	$0.019209 \pm 0.000111$	$0.000675 \pm 0.000009$
G	$20.89 \pm 0.26$	95.32	0.15	742		$2.12\text{E-}14$	0.74	$0.150056 \pm 0.000095$	$0.002814 \pm 0.000014$	$0.000058 \pm 0.000014$	$0.010014 \pm 0.000099$	$0.000027 \pm 0.000006$
H	$20.82 \pm 0.27$	57.69	0.14	7409		$2.41\text{E-}14$	0.84	$0.281910 \pm 0.000184$	$0.003209 \pm 0.000016$	$0.000120 \pm 0.000012$	$0.012254 \pm 0.000103$	$0.000407 \pm 0.000007$
I	$18.13 \pm 0.30$	65.62	0.17	-715		$1.65\text{E-}14$	0.93	$0.169690 \pm 0.000111$	$0.002524 \pm 0.000015$	$0.000055 \pm 0.000012$	$0.007665 \pm 0.000032$	$0.000200 \pm 0.000006$
J	$21.07 \pm 0.60$	24.15	0.13	954		$1.60\text{E-}14$	1	$0.446438 \pm 0.000294$	$0.002102 \pm 0.000017$	$0.000251 \pm 0.000011$	$0.008364 \pm 0.000067$	$0.001148 \pm 0.000010$

Packet IRR348-MC, Experiment #16Z0070, xx g San, all errors  $\pm 1$  sigma

$J = 0.000228489670 \pm 0.000000232521$

$40\text{Ar}^*$  is radiogenic argon, isotopes in volts ( $1.48\text{e-}13$  moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca =  $0.137 \pm 4.530\text{e-}2$ , Calculated K<sub>2</sub>O = INF%wt., Calculated CaO = INF%wt., Calculated Cl = INFppm

Total Gas Age =  $20.70 \pm 0.09$  Ma

**Weighted Mean Age =  $20.98 \pm 0.10$  Ma ( $\pm 1$  sigma, including  $\pm J$ ), 91.47% 39Ar released**

Weighted Mean Age =  $20.98 \pm 8.97\text{e-}2$  Ma (A priori, including  $\pm J$ ), 91.47% 39Ar released

Weighted Mean Age =  $20.98 \pm 0.23$  Ma (95% confidence, including  $\pm J$ )

MSWD = 1.25 (Good fit, MSWD < 2.19)

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Isochron Age =  $20.96 \pm 0.15$  Ma ( $\pm 1$  sigma, including  $\pm J$ )

Isochron Age =  $21.0 \pm 0.1$  Ma (A Priori Errors, including  $\pm J$ )

Isochron Age =  $21.0 \pm 0.3$  Ma (95% confidence, including  $\pm J$ )

MSWD = 1.40 (Good fit, MSWD < 2.29)

$^{40}\text{Ar}/^{36}\text{Ar}$  intercept =  $295.5 \pm 3.1$  ( $\pm 1$  sigma)

$^{40}\text{Ar}/^{36}\text{Ar}$  intercept =  $295.5 \pm 2.6$  (A Priori)

$^{40}\text{Ar}/^{36}\text{Ar}$  intercept =  $295.5 \pm 7.4$  (95% confidence)

9 of 10 grains

**BS8 Plagioclase (unit Ma)**

Temp(°C)	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles	40Ar*	Σ39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
700	13.98±0.35	35.6	0.03	614		3.48E-14	0.1	0.660408±0.000900	0.007052±0.000147	0.000413±0.000027	0.124489±0.000504	0.001474±0.000011
800	15.64±0.09	68.91	0.03	11024		1.06E-13	0.36	1.035334±0.000289	0.019161±0.000058	0.000472±0.000015	0.390821±0.000687	0.001199±0.000010
900	15.97±0.06	91.73	0.02	5902		1.33E-13	0.69	0.978562±0.000321	0.023623±0.000042	0.000390±0.000016	0.496134±0.000598	0.000413±0.000008
975	16.04±0.09	89.96	0.02	-12386		6.76E-14	0.85	0.507422±0.000247	0.011963±0.000036	0.000191±0.000014	0.257328±0.000559	0.000245±0.000007
1050	15.34±0.19	86.07	0.02	916		2.66E-14	0.92	0.208939±0.000174	0.004926±0.000023	0.000108±0.000011	0.102129±0.000434	0.000127±0.000007
1150	15.51±0.28	80.12	0.03	308		1.66E-14	0.96	0.140247±0.000123	0.003040±0.000018	0.000101±0.000012	0.058711±0.000262	0.000111±0.000006
1250	13.59±0.74	50.97	0.03	37		5.73E-15	0.98	0.075943±0.000117	0.001196±0.000012	0.000177±0.000013	0.022328±0.000198	0.000132±0.000007
1350	9.51±0.55	61.74	0.03	204		5.22E-15	1	0.057140±0.000104	0.001555±0.000012	0.000067±0.000011	0.024120±0.000214	0.000081±0.000007

Packet IRR348-LV, Experiment #16Z0109, 0.0858 g Sanidine, all errors ±1 sigma

J = 0.000230468333±0.000000253305

40Ar\* is radiogenic argon, isotopes in volts (1.48e-13 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca = 2.540e-2 ± 1.199e-2, Calculated K2O = 0.21%wt., Calculated CaO = 9.92%wt., Calculated Cl = 0.2ppm

Total Gas Age = 15.46 ± 5.46e-2 Ma

Weighted Mean Plateau Age = 15.90 ± 0.12 Ma (±1 sigma, including ±J), 75.47% 39Ar released

Weighted Mean Plateau Age = 15.90 ± 4.59e-2 Ma (A priori, including ±J), 75.47% 39Ar released

Weighted Mean Plateau Age = 15.90 ± 0.28 Ma (95% confidence, including ±J)

MSWD = 6.40 (Poor fit, MSWD > 3.69)

Steps 3 of 8 (800,900,975°C)

Isochron Age = 16.08 ± 0.07 Ma (±1 sigma, including ±J)

Isochron Age = 16.08 ± 0.07 Ma (A Priori Errors, including ±J)

Isochron Age = 16.1 ± 0.2 Ma (95% confidence, including ±J)

MSWD = 0.77 (Good fit, MSWD < 5.02)

40Ar/36Ar intercept = 277.3 ± 5.1 (±1 sigma)

40Ar/36Ar intercept = 277.3 ± 5.1 (A Priori)

40Ar/36Ar intercept = 277.3 ± 13.1 (95% confidence)

Steps 3 of 8 (800,900,975°C)

**Weighted Mean Plateau Age = 15.99 ± 0.05 Ma (±1 sigma, including ±J), 49.0% 39Ar released**

Weighted Mean Plateau Age = 15.99 ± 0.05 Ma (A priori, including ±J), 49.0% 39Ar released

Weighted Mean Plateau Age = 15.87 ± 0.62 Ma (95% confidence, including ±J)

MSWD = 0.43 (Good fit, MSWD < 2.77)

Steps 2 of 8 (900,975°C)

**BS5 Plagioclase (hornblende andesite lava in unit OMI)**

Temp(°C)	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles	40Ar*	Σ39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
600	21.68±0.51	34.53	0.2	-122		2.65E-14	0.01	0.519015±0.000226	0.003414±0.000052	0.000140±0.000027	0.009078±0.000584	0.001153±0.000011
700	23.11±0.14	72.64	0.18	-1609		8.92E-14	0.04	0.829745±0.000248	0.010772±0.000043	0.000257±0.000010	0.031541±0.000316	0.000777±0.000010
800	23.01±0.07	93	0.16	-5672		1.90E-13	0.1	1.383132±0.000377	0.023097±0.000051	0.000349±0.000017	0.074696±0.000527	0.000349±0.000008
875	23.03±0.06	94.35	0.16	-9597		2.38E-13	0.17	1.704621±0.000472	0.028844±0.000056	0.000429±0.000022	0.094391±0.000898	0.000352±0.000009
950	23.05±0.06	97.32	0.16	-7481		2.26E-13	0.24	1.572171±0.000406	0.027420±0.000053	0.000373±0.000024	0.090944±0.000321	0.000168±0.000008

1025	23.10±0.05	96.94	0.16	4614	2.99E-13	0.33	2.083755±0.000700	0.036116±0.000057	0.000551±0.000025	0.116882±0.000346	0.000249±0.000008
1100	23.01±0.04	96.24	0.16	14690	3.89E-13	0.46	2.730868±0.000550	0.047189±0.000080	0.000702±0.000028	0.149806±0.000859	0.000390±0.000008
1175	23.10±0.05	93.12	0.19	1715	3.70E-13	0.57	2.683664±0.000964	0.044668±0.000074	0.000818±0.000023	0.126036±0.000421	0.000660±0.000010
1250	23.08±0.06	91.6	0.19	-22375	3.12E-13	0.67	2.302963±0.000708	0.037739±0.000078	0.000614±0.000023	0.106726±0.001087	0.000685±0.000009
1350	23.40±0.06	88.76	0.16	4706	2.12E-13	0.73	1.615186±0.000398	0.025311±0.000050	0.000472±0.000018	0.080382±0.000359	0.000637±0.000008
1450	23.24±0.03	93.11	0.17	-17303	6.63E-13	0.94	4.808718±0.001079	0.079592±0.000102	0.001241±0.000023	0.247044±0.000517	0.001190±0.000011
1500	23.13±0.07	91.8	0.16	-2453	2.02E-13	1	1.487622±0.000411	0.024390±0.000059	0.000357±0.000014	0.079999±0.000320	0.000435±0.000008

Packet IRR348-LT, Experiment #16Z0127, 0.1051 g Plagioclase, all errors ±1 sigma

J = 0.000229914529±0.000000245114

40Ar\* is radiogenic argon, isotopes in volts (1.48e-13 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca = 0.168 ± 5.660e-2, Calculated K2O = 0.91%wt., Calculated CaO = 6.64%wt., Calculated Cl = -5.1e-2ppm

Total Gas Age = 23.11 ± 0.02 Ma

### Weighted Mean Plateau Age = 23.06 ± 3.13e-2 Ma (±1 sigma, including ±J), 65.85% 39Ar released

Weighted Mean Plateau Age = 23.06 ± 3.13e-2 Ma (A priori, including ±J), 65.85% 39Ar released

Weighted Mean Plateau Age = 23.06 ± 5.53e-2 Ma (95% confidence, including ±J)

MSWD = 0.63 (Good fit, MSWD < 2.29)

Steps 8 of 12 (700,800,875,950,1025,1100,1175,1250°C)

Isochron Age = 23.05 ± 0.04 Ma (±1 sigma, including ±J)

Isochron Age = 23.05 ± 0.0 Ma (A Priori Errors, including ±J)

Isochron Age = 23.05 ± 0.1 Ma (95% confidence, including ±J)

MSWD = 0.70 (Good fit, MSWD < 2.40)

40Ar/36Ar intercept = 297.9 ± 5.2 (±1 sigma)

40Ar/36Ar intercept = 297.9 ± 5.2 (A Priori)

40Ar/36Ar intercept = 297.9 ± 11.7 (95% confidence)

Steps 8 of 12 (700,800,875,950,1025,1100,1175,1250°C)

### PSF17077A Sanidine (unit Me)

Grain	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles	40Ar*	Σ39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
A	11.12 ± 0.75	20.3	5.8	2201	3.63E-15	0.03	0.251974±0.000201	0.001920±0.000023	0.000155±0.000020	0.000173±0.000144	0.000673±0.000011	
B	10.28 ± 0.70	20.2	12.8	-174	3.59E-15	0.06	0.249562±0.000213	0.002052±0.000019	0.000101±0.000014	0.000084±0.000075	0.000667±0.000011	
C	11.80 ± 1.24	15.6	2.0	-405	2.58E-15	0.08	0.233282±0.000190	0.001288±0.000018	0.000127±0.000019	0.000336±0.000135	0.000660±0.000013	
D	7.98 ± 5.28	2.1	1.3	-239	3.22E-16	0.09	0.213452±0.000215	0.000238±0.000011	0.000130±0.000018	0.000098±0.000237	0.000700±0.000010	
E	12.45 ± 0.59	24.5	14.0	-11683	4.46E-15	0.12	0.254123±0.000260	0.002092±0.000021	0.000147±0.000017	0.000078±0.000117	0.000643±0.000010	
F	12.00 ± 0.42	102.1	25.4	-522	4.68E-15	0.16	0.064375±0.000123	0.002292±0.000025	0.000010±0.000018	0.000047±0.000200	-0.000005±0.000007	
G	11.59 ± 0.37	101.0	4.5	-631	5.21E-15	0.2	0.072478±0.000129	0.002643±0.000023	0.000016±0.000018	0.000307±0.000214	-0.000002±0.000008	
H	11.11 ± 1.90	101.7	-96.8	677	9.44E-16	0.21	0.013041±0.000067	0.000499±0.000012	0.000010±0.000016	-0.000003±0.000258	-0.000001±0.000008	
I	11.83 ± 0.23	101.9	22.8	-1412	8.70E-15	0.28	0.119899±0.000164	0.004321±0.000031	0.000042±0.000017	0.000099±0.000215	-0.000008±0.000007	
J	12.35 ± 0.39	98.3	25.6	-581	5.02E-15	0.32	0.071704±0.000212	0.002388±0.000020	0.000014±0.000017	0.000049±0.000129	0.000004±0.000007	
K	11.55 ± 0.25	98.0	21.7	-4651	7.05E-15	0.37	0.101081±0.000176	0.003590±0.000027	0.000045±0.000013	0.000087±0.000301	0.000007±0.000007	
L	11.49 ± 0.25	98.3	-18.6	1108	6.55E-15	0.43	0.093625±0.000128	0.003350±0.000026	0.000058±0.000011	-0.000094±0.000166	0.000005±0.000006	
M	11.59 ± 0.22	100.3	-73.9	24065	7.91E-15	0.49	0.110820±0.000112	0.004014±0.000033	0.000053±0.000010	-0.000029±0.000126	-0.000001±0.000007	
N	12.00 ± 0.23	102.4	16.9	-1020	7.94E-15	0.56	0.108975±0.000140	0.003892±0.000026	0.000033±0.000009	0.000120±0.000090	-0.000009±0.000007	
O	11.72 ± 0.21	100.5	25.9	-24205	8.49E-15	0.62	0.118709±0.000210	0.004258±0.000028	0.000055±0.000014	0.000086±0.000121	-0.000002±0.000007	
P	12.19 ± 0.32	104.9	9.2	-262	5.81E-15	0.67	0.077774±0.000117	0.002800±0.000023	-0.000011±0.000016	0.000159±0.000199	-0.000013±0.000007	
Q	12.20 ± 0.37	105.3	6.5	-888	4.78E-15	0.71	0.063414±0.000120	0.002289±0.000025	0.000017±0.000016	0.000184±0.000228	-0.000011±0.000006	
R	12.85 ± 0.39	109.8	436.5	-178	4.68E-15	0.74	0.059895±0.000103	0.002139±0.000020	-0.000027±0.000016	0.000003±0.000127	-0.000020±0.000006	
S	12.34 ± 0.33	103.6	8.8	-399	5.65E-15	0.78	0.076670±0.000130	0.002693±0.000028	0.000005±0.000016	0.000160±0.000184	-0.000009±0.000007	

T	27.80 ± 0.40	102.6	5.2	-538	1.28E-14	0.83	0.175404±0.000177	0.002695±0.000024	0.000011±0.000017	0.000270±0.000118	-0.000015±0.000007
U	11.39 ± 0.34	96.6	-36.9	2989	4.65E-15	0.86	0.067110±0.000122	0.002381±0.000024	0.000036±0.000015	-0.000034±0.000206	0.000008±0.000006
V	11.64 ± 0.31	95.1	13.5	-687	5.12E-15	0.91	0.075680±0.000113	0.002585±0.000021	0.000020±0.000015	0.000101±0.000128	0.000013±0.000006
W	11.41 ± 0.28	83.1	20.0	-3373	5.97E-15	0.96	0.100904±0.000148	0.003075±0.000026	0.000047±0.000016	0.000081±0.000127	0.000057±0.000007
X	11.30 ± 0.28	97.4	18.2	354	5.34E-15	1	0.076561±0.000144	0.002760±0.000027	0.000071±0.000015	0.000080±0.000154	0.000007±0.000006

Packet IRR371-FZ, Experiment #18Z0112, 0.0017 g Sanidine, all errors ±1 sigma

J = 0.00023263423819052±2.857E-07 9/20/18

40Ar\* is radiogenic argon, isotopes in volts (7.17e-14 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca = 13.375 ± 3.876, Calculated K2O = 4.32%wt., Calculated CaO = 0.40%wt., Calculated Cl = -5.1ppm

Total Gas Age = 12.4 ± 8.2e-2 Ma

Weighted Mean Age = 11.8 ± 8.5e-2 Ma (±1 sigma, including ±J), 95.7% 39Ar released

Weighted Mean Age = 11.8 ± 6.9e-2 Ma (a priori, including ±J), 95.7% 39Ar released

Weighted Mean Age = 11.8 ± 0.2 Ma (95% confidence, including ±J)

MSWD = 1.51 (Good fit, MSWD < 1.67)

23 of 24 grains

Isochron Age = 11.6 ± 0.1 Ma (±1 sigma, including ±J)

Isochron Age = 11.6 ± 0.0 Ma (a priori, including ±J)

Isochron Age = 11.6 ± 0.3 Ma (95% confidence, including ±J)

MSWD = 10.17 (Poor fit, MSWD > 1.69)

40Ar/36Ar intercept = 294.0 ± 7.0 (±1 sigma)

40Ar/36Ar intercept = 294.0 ± 2.2 (a priori)

40Ar/36Ar intercept = 294.0 ± 14.5 (95% confidence)

Steps 23 of 24 grains

#### PSF17077B Plagioclase (unit Mf)

temp(°C)	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles 40Ar*	Σ39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
450	12.72±1.81	56.52	0.12	-329	1.20E-15	0	0.029756±0.000160	0.002041±0.000024	0.000009±0.000015	0.009185±0.000507	0.000046±0.000008
550	19.59±0.28	76.85	0.13	-880	1.66E-14	0.02	0.304382±0.000340	0.018389±0.000061	0.000198±0.000010	0.073036±0.001012	0.000256±0.000011
650	19.14±0.09	90.07	0.12	-4970	4.97E-14	0.06	0.775243±0.000423	0.056194±0.000085	0.000744±0.000031	0.239889±0.003507	0.000325±0.000011
750	18.92±0.06	93.44	0.12	-9764	8.91E-14	0.14	1.340223±0.000646	0.101975±0.000158	0.001361±0.000046	0.461044±0.004707	0.000424±0.000011
825	18.92±0.06	94.97	0.11	-10390	9.22E-14	0.22	1.364555±0.000544	0.105530±0.000169	0.001398±0.000046	0.505578±0.006959	0.000372±0.000010
900	18.94±0.05	95.01	0.11	-87893	1.02E-13	0.31	1.513046±0.000672	0.116943±0.000179	0.001592±0.000038	0.568192±0.005429	0.000412±0.000011
975	18.91±0.05	96.58	0.11	-4359	1.06E-13	0.4	1.535263±0.000644	0.120845±0.000189	0.001516±0.000046	0.590804±0.003585	0.000342±0.000009
1050	18.89±0.05	95.46	0.11	-12961	1.09E-13	0.49	1.611571±0.000611	0.125504±0.000154	0.001668±0.000032	0.606362±0.003562	0.000415±0.000010
1100	18.89±0.06	95.04	0.11	7366	9.12E-14	0.57	1.339420±0.000615	0.103867±0.000159	0.001479±0.000029	0.508898±0.002938	0.000366±0.000010
1150	19.01±0.06	92.29	0.11	-7609	8.43E-14	0.65	1.283207±0.000479	0.096000±0.000136	0.001281±0.000044	0.477674±0.003193	0.000466±0.000011
1225	19.09±0.06	84.14	0.11	26580	1.09E-13	0.74	1.825524±0.000623	0.123968±0.000165	0.001845±0.000030	0.610659±0.006514	0.001141±0.000015
1300	19.15±0.04	89.31	0.11	-19918	1.92E-13	0.91	3.025262±0.000912	0.217390±0.000259	0.003037±0.000045	1.047256±0.003050	0.001378±0.000014
1325	19.34±0.06	86.9	0.11	-12813	1.07E-13	1	1.734071±0.000658	0.120037±0.000147	0.001693±0.000039	0.583170±0.005767	0.000925±0.000014

Packet IRR367-CG, Experiment #18Z0051, 0.0879 g Plagioclase, all errors ±1 sigma

J = 0.0 6/19/18

40Ar\* is radiogenic argon, isotopes in volts (7.12e-14 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca = 0.109 ± 3.453e-2, Calculated K2O = 0.48%wt., Calculated CaO = 5.34%wt., Calculated Cl = -4.6e-2ppm

Total Gas Age = 19.02 ± 2.21e-2 Ma

**Weighted Mean Plateau Age = 18.91 ± 2.57e-2 Ma (±1 sigma, including ±J), 51.61% 39Ar released**

Weighted Mean Plateau Age =  $18.91 \pm 2.57\text{e-}2$  Ma (A priori, including  $\pm J$ ), 51.61% 39Ar released  
 Weighted Mean Plateau Age =  $18.91 \pm 2.33\text{e-}2$  Ma (95% confidence, including  $\pm J$ )  
 MSWD = 0.17 (Good fit, MSWD < 2.56)  
 Steps 6 of 13 (750,825,900,975,1050,1100°C)

Isochron Age =  $18.9 \pm 0.1$  Ma ( $\pm 1$  sigma, including  $\pm J$ )  
 Isochron Age =  $18.9 \pm 0.1$  Ma (A Priori Errors, including  $\pm J$ )  
 Isochron Age =  $18.9 \pm 0.3$  Ma (95% confidence, including  $\pm J$ )  
 MSWD = 0.19 (Good fit, MSWD < 2.77)  
 40Ar/36Ar intercept =  $306.5 \pm 35.0$  ( $\pm 1$  sigma)  
 40Ar/36Ar intercept =  $306.5 \pm 35.0$  (A Priori)  
 40Ar/36Ar intercept =  $306.5 \pm 77.9$  (95% confidence)  
 Steps 6 of 13 (750,825,900,975,1050,1100°C)

### PSF17052 Basalt (unit OMI)

temp(°C)	Age(Ma)	%40Ar*	K/Ca	K/Cl	moles 40Ar*	$\Sigma$ 39Ar	40Ar	39Ar	38Ar	37Ar	36Ar
450	$18.42 \pm 0.73$	32.69	0.29	-421	5.60E-15	0	$0.240910 \pm 0.000208$	$0.006532 \pm 0.000038$	$0.000121 \pm 0.000024$	$0.011902 \pm 0.000426$	$0.000546 \pm 0.000010$
500	$18.32 \pm 0.28$	50.28	0.32	7493	1.99E-14	0.02	$0.555012 \pm 0.000331$	$0.023269 \pm 0.000061$	$0.000493 \pm 0.000034$	$0.038584 \pm 0.000617$	$0.000935 \pm 0.000014$
550	$17.62 \pm 0.16$	61.67	0.36	-3142	3.27E-14	0.05	$0.745827 \pm 0.000317$	$0.039873 \pm 0.000086$	$0.000650 \pm 0.000014$	$0.058812 \pm 0.001348$	$0.000974 \pm 0.000014$
600	$16.59 \pm 0.13$	67.5	0.42	-2478	3.76E-14	0.09	$0.782139 \pm 0.000361$	$0.048627 \pm 0.000109$	$0.000715 \pm 0.000028$	$0.060765 \pm 0.000874$	$0.000868 \pm 0.000013$
650	$16.22 \pm 0.14$	44.33	0.46	-2499	5.29E-14	0.14	$1.677114 \pm 0.000627$	$0.070022 \pm 0.000125$	$0.001386 \pm 0.000027$	$0.080494 \pm 0.001448$	$0.003150 \pm 0.000021$
700	$16.05 \pm 0.05$	80.11	0.43	-3059	1.13E-13	0.25	$1.983796 \pm 0.000604$	$0.151259 \pm 0.000158$	$0.002027 \pm 0.000065$	$0.185134 \pm 0.001584$	$0.001374 \pm 0.000015$
750	$15.70 \pm 0.03$	93.96	0.39	-5890	1.53E-13	0.4	$2.294720 \pm 0.000584$	$0.209852 \pm 0.000235$	$0.002698 \pm 0.000032$	$0.284297 \pm 0.001938$	$0.000544 \pm 0.000011$
800	$15.75 \pm 0.03$	95.5	0.37	-6283	1.62E-13	0.56	$2.379862 \pm 0.000879$	$0.220557 \pm 0.000203$	$0.002822 \pm 0.000042$	$0.312524 \pm 0.001180$	$0.000447 \pm 0.000011$
850	$15.71 \pm 0.04$	89.92	0.36	-32239	1.30E-13	0.69	$2.024705 \pm 0.000670$	$0.177116 \pm 0.000189$	$0.002438 \pm 0.000031$	$0.256909 \pm 0.002053$	$0.000756 \pm 0.000013$
925	$15.64 \pm 0.04$	85.52	0.39	-21349	1.50E-13	0.84	$2.468500 \pm 0.000682$	$0.206306 \pm 0.000211$	$0.002900 \pm 0.000030$	$0.275551 \pm 0.001707$	$0.001275 \pm 0.000015$
1000	$15.46 \pm 0.04$	88.5	0.27	4315	1.21E-13	0.96	$1.923286 \pm 0.000666$	$0.168360 \pm 0.000174$	$0.002526 \pm 0.000029$	$0.332136 \pm 0.001632$	$0.000834 \pm 0.000013$
1100	$15.27 \pm 0.10$	83.53	0.06	1207	4.00E-14	1	$0.673173 \pm 0.000419$	$0.056559 \pm 0.000127$	$0.001023 \pm 0.000030$	$0.464623 \pm 0.002931$	$0.000502 \pm 0.000011$
1200	$10.74 \pm 2.56$	48.69	0.12	79	7.47E-16	1	$0.021573 \pm 0.000119$	$0.001500 \pm 0.000032$	$0.000108 \pm 0.000019$	$0.006295 \pm 0.000217$	$0.000039 \pm 0.000008$

Packet IRR367-Cl, Experiment #18Z0046, 0.0386 g Basalt, all errors  $\pm 1$  sigma

J = 0.0      6/4/18

40Ar\* is radiogenic argon, isotopes in volts (7.12e-14 moles/volt), corrected for blank, background, discrimination, and decay

Calculated bulk K/Ca =  $0.305 \pm 0.109$ , Calculated K2O = 1.15%wt., Calculated CaO = 4.61%wt., Calculated Cl = -9.7e-2ppm

Total Gas Age =  $15.86 \pm 2.06\text{e-}2$  Ma

### Weighted Mean Plateau Age = $15.71 \pm 2.74\text{e-}2$ Ma ( $\pm 1$ sigma, including $\pm J$ ), 58.99% 39Ar released

Weighted Mean Plateau Age =  $15.71 \pm 2.00\text{e-}2$  Ma (A priori, including  $\pm J$ ), 58.99% 39Ar released

Weighted Mean Plateau Age =  $15.71 \pm 6.02\text{e-}2$  Ma (95% confidence, including  $\pm J$ )

MSWD = 1.88 (Good fit, MSWD < 3.12)

Steps 4 of 13 (750,800,850,925°C)

Isochron Age =  $15.8 \pm 0.04$  Ma ( $\pm 1$  sigma, including  $\pm J$ )  
 Isochron Age =  $15.8 \pm 0.04$  Ma (A Priori Errors, including  $\pm J$ )  
 Isochron Age =  $15.8 \pm 0.1$  Ma (95% confidence, including  $\pm J$ )  
 MSWD = 0.61 (Good fit, MSWD < 3.69)  
 40Ar/36Ar intercept =  $285.5 \pm 6.6$  ( $\pm 1$  sigma)  
 40Ar/36Ar intercept =  $285.5 \pm 6.6$  (A Priori)  
 40Ar/36Ar intercept =  $285.5 \pm 14.7$  (95% confidence)

Steps 4 of 13 (750,800,850,925°C)