$^{40}Ar/^{39}Ar$ GEOCHRONOLOGY RESULTS FOR THE LITTLE CREEK PEAK AND PANGUITCH NW QUADRANGLES, UTAH

by

Utah Geological Survey and
Nevada Isotope Geochronology Laboratory

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2018

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INTRODUCTION

This open-file report makes available raw analytical data from laboratory procedures completed to determine the age of rock samples collected during study of the Markagunt gravity slide (see Biek and others, 2015). Sample locations are given in table 1. This report was prepared by the Nevada Isotope Geochronology Laboratory (NIGL) under contract to Harry Filkorn. These data are highly technical in nature and proper interpretation requires considerable training in the applicable geochronologic techniques.

Table 1. *Samples and locations.*

Sample #	**7.5′ quadrangle**	**Northing**	**Easting**
Sandy Creek dike	Panguitch NW	4195862	369136
Sandy Peak	Little Creek Peak	4198836	364121
Little Creek Peak	Little Creek Peak	4193830	358241

Location data NAD83, UTM Zone 12S.

ACKNOWLEDGMENTS

These samples were collected by Harry F. Filkorn (Pierce College, CA) in 2016 and 2017 and submitted to NIGL in October 2017. We thank Harry for making the analyses available and Terry Spell and Kathleen Zanetti (NIGL) for running the analyses.

REFERENCE

Biek, R.F., Rowley, P.D., Anderson, J.J., Maldonado, F., Moore, D.W., Hacker, D.B., Eaton, J.G., Hereford, R., Filkorn, H.F., and Matyjasik, B., 2015, Geologic map of the Panguitch 30′ x 60′ quadrangle, Garfield, Iron, and Kane Counties, Utah: Utah Geological Survey Map 270DM, 162 p., 3 plates, scale 1:62,500.

Filkorn-Pierce College, Sandy Creek, Spherulitic Dike, 22.77 mg, J = 0.00160 ± 0.81%

4 amu discrimination = 1.0478 ± 0.08%, 40/39K = 0.012 ± 32.77%, 36/37Ca = 0.000266 ± 0.32%, 39/37Ca = 0.000736 ± 0.36%

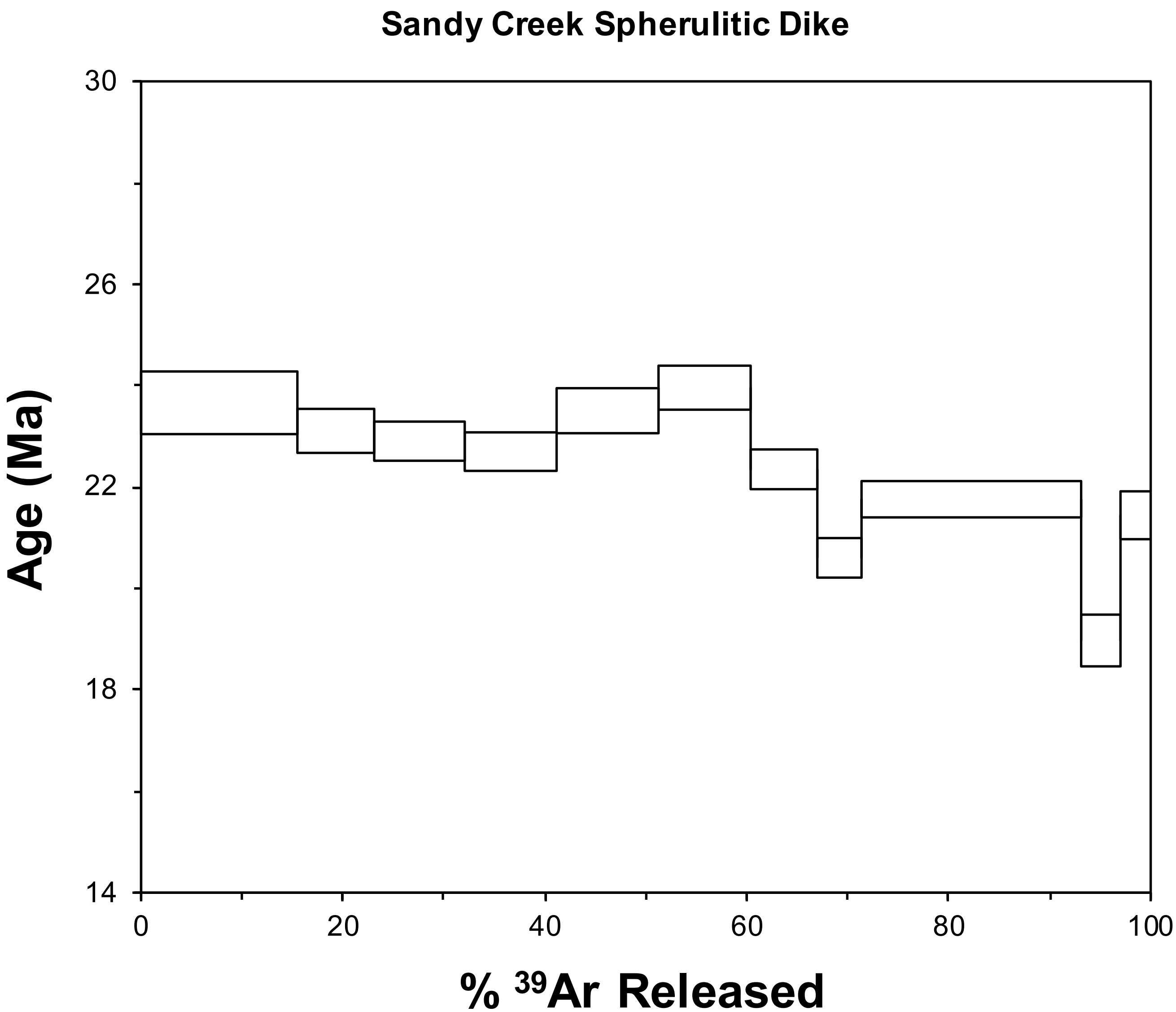
step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	600	12	1.806	8.065	2.470	42.946	858.023	41.2	15.5	1.630433846	8.251047	23.66	0.31
2	650	12	0.188	7.568	1.070	21.113	219.465	79.6	7.6	3.113570239	8.056617	23.11	0.22
3	710	12	0.212	12.632	1.252	24.871	252.879	80.2	9.0	4.413537347	7.985387	22.90	0.19
4	770	12	0.214	15.097	1.344	25.249	253.854	80.3	9.1	5.197124735	7.913113	22.70	0.19
5	840	12	0.245	18.286	1.638	27.997	290.956	80.1	10.1	5.677937272	8.196292	23.51	0.22
6	910	12	0.174	18.161	1.444	25.318	253.203	95.2	9.1	6.236935799	8.355657	23.96	0.22
7	980	12	0.152	14.458	1.068	18.320	180.045	82.0	6.6	6.863261127	7.790688	22.35	0.20
8	1060	12	0.141	12.040	0.620	12.150	122.759	75.1	4.4	8.622672458	7.178564	20.60	0.20
9	1150	12	0.612	63.454	3.401	60.348	608.536	75.8	21.8	9.150840729	7.583776	21.76	0.18
10	1220	12	0.182	16.960	0.583	10.809	119.366	66.0	3.9	13.67513674	6.607643	18.97	0.26
11	1400	12	0.226	12.265	0.445	8.303	123.352	55.7	3.0	12.87100861	7.472983	21.44	0.24
							Cumulative %39Ar rlsd =		100.0		Total gas age =	22.59	0.18

note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma

(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)

No plateau

No isochron



Sandy Creek Spherulitic Dike
Age (Ma)
30
26
22
18
14
0
20
40
60
80
100
% 39Ar Released

Filkorn-Pierce College, Sandy Peak, Amphibole, 35.35 mg, J = 0.00157 ± 0.93%

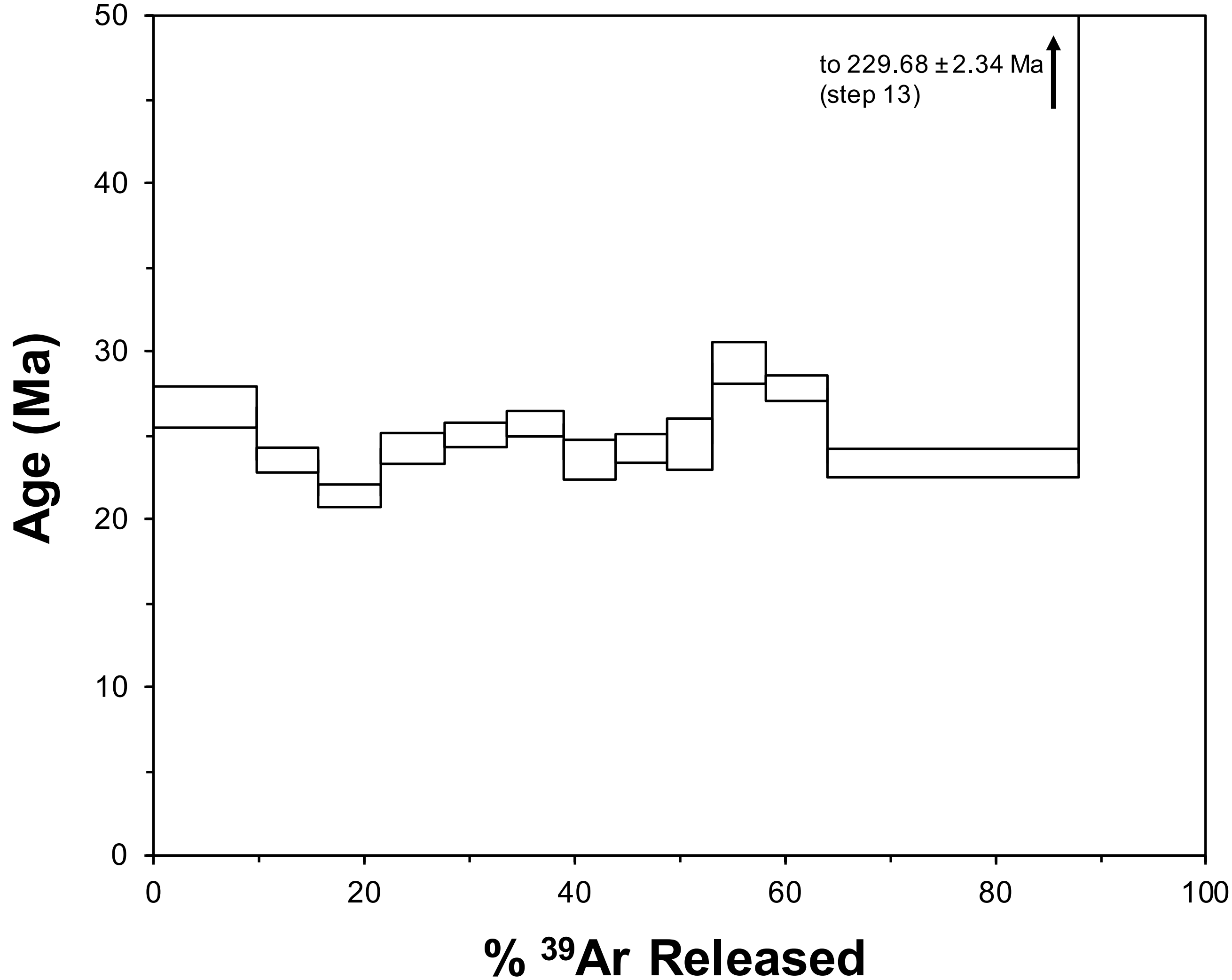
4 amu discrimination = 1.0478 ± 0.08%, 40/39K = 0.012 ± 32.77%, 36/37Ca = 0.000266 ± 0.32%, 39/37Ca = 0.000736 ± 0.36%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	700	12	0.417	5.877	0.219	5.158	164.412	30.8	9.8	10.12584903	9.496016	26.70	0.61
2	730	12	0.111	1.965	0.076	3.067	56.375	52.4	5.8	5.685784254	8.366143	23.54	0.37
3	760	12	0.061	1.630	0.070	3.134	40.600	72.5	6.0	4.614041649	7.605775	21.42	0.34
4	790	12	0.052	1.384	0.074	3.189	41.708	80.8	6.1	3.849180853	8.613357	24.23	0.46
5	820	12	0.058	1.272	0.082	3.106	43.609	77.0	5.9	3.631970022	8.901834	25.04	0.36
6	850	12	0.049	1.126	0.082	2.843	39.469	81.9	5.4	3.51238024	9.140301	25.71	0.38
7	880	12	0.056	1.065	0.081	2.595	37.273	73.7	4.9	3.639736291	8.374728	23.57	0.59
8	920	12	0.058	1.037	0.111	2.571	38.252	72.6	4.9	3.577055283	8.614431	24.24	0.43
9	960	12	0.069	0.928	0.149	2.262	38.959	63.0	4.3	3.638420302	8.705327	24.49	0.76
10	1020	12	0.097	1.333	0.250	2.672	54.793	58.9	5.1	4.425480449	10.438728	29.33	0.62
11	1090	12	0.129	2.858	0.370	3.077	65.863	51.9	5.9	8.249579931	9.898177	27.82	0.38
12	1180	12	0.536	41.786	1.679	12.556	243.174	44.2	23.9	29.76103825	8.301761	23.36	0.42
13	1400	12	1.709	484.515	2.681	6.339	777.500	56.2	12.1	864.3527832	86.476674	229.68	2.34
							Cumulative %39Ar rlsd =		100.0		Total gas age =	49.41	0.32
											Total gas age (step 13 age omitted) =	21.71	0.31
											No plateau		
											No isochron		

note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma

(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)

Sandy Peak Amphibole



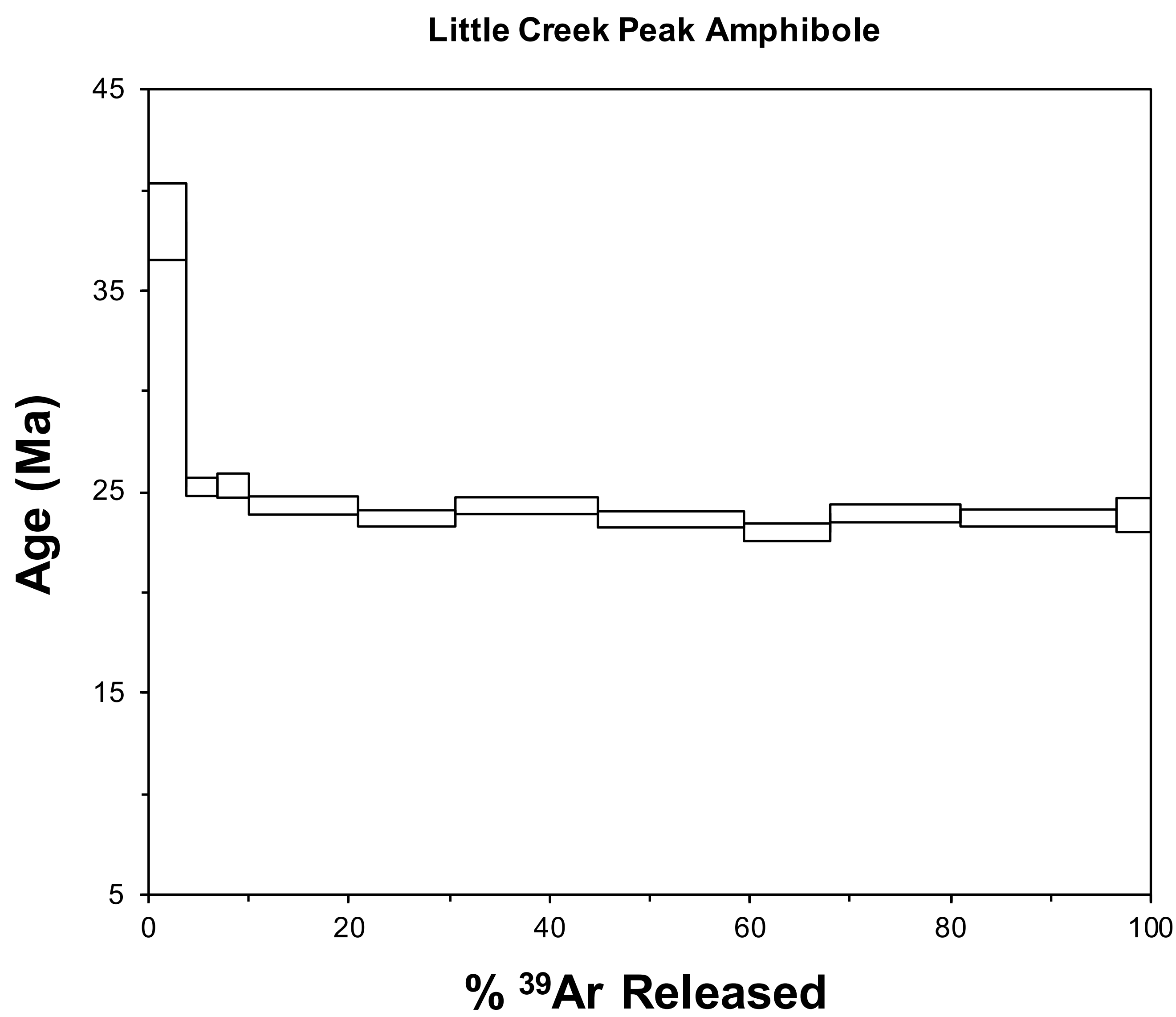
Filkorn-Pierce College, Little Creek Peak, Amphibole, 20.77 mg, J = 0.00152 ± 0.84%

4 amu discrimination = 1.0501 ± 0.01%, 40/39K = 0.012 ± 32.77%, 36/37Ca = 0.000266 ± 0.32%, 39/37Ca = 0.000736 ± 0.36%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	Ca/K	40Ar*/39ArK	Age (Ma)	1s.d.
1	1030	12	1.319	2.648	0.527	6.931	467.135	21.0	3.8	5.331023704	14.160914	38.42	0.95
2	1080	12	0.114	5.165	0.490	5.700	82.115	69.3	3.1	12.67364407	9.273423	25.25	0.23
3	1100	12	0.086	5.597	0.520	5.802	75.077	78.0	3.2	13.49576152	9.295612	25.31	0.30
4	1110	12	0.147	20.992	1.693	20.018	208.045	87.5	10.9	14.67628958	8.931435	24.33	0.23
5	1115	12	0.118	19.090	1.401	17.898	177.962	89.6	9.7	14.92861319	8.696028	23.69	0.20
6	1120	12	0.118	27.522	2.045	26.159	251.542	94.8	14.2	14.72477607	8.928109	24.32	0.21
7	1125	12	0.118	28.699	1.987	26.842	251.205	95.0	14.6	14.96493922	8.677184	23.64	0.20
8	1130	12	0.085	17.222	1.108	15.843	148.696	94.2	8.6	15.21612151	8.439650	23.00	0.22
9	1150	12	0.102	25.751	1.559	23.915	224.775	95.8	13.0	15.07167572	8.787298	23.94	0.22
10	1200	12	0.227	31.077	2.648	28.659	296.143	85.5	15.6	15.1785633	8.703048	23.71	0.21
11	1400	12	0.122	7.526	0.522	6.301	86.279	73.1	3.4	16.72713119	8.756627	23.85	0.42
							Cumulative %39Ar rlsd =		100.0		Total gas age =	24.48	0.20
											No plateau		
											No isochron		

note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma

(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)



Little Creek Peak Amphibole
45
35
25
15
5
0
20
40
60
80
100
Age (Ma)
% 39Ar Released

Nevada Isotope Geochronology Laboratory - Description and Procedures

Samples analyzed by the $^{40}Ar/^{39}Ar$ method at the University of Nevada Las Vegas were wrapped in Al foil and stacked in 6 mm inside diameter sealed fused silica tubes. Individual packets averaged 2 mm thick and neutron fluence monitors (FC-2, Fish Canyon Tuff sanidine) were placed every 5–10 mm along the tube. Synthetic K-glass and optical grade CaF_2 were included in the irradiation packages to monitor neutron induced argon interferences from K and Ca. Loaded tubes were packed in an Al container for irradiation. Samples irradiated at the U.S. Geological Survey TRIGA Reactor, Denver, CO were in-core for 7 hours in the 1 MW TRIGA type reactor. Correction factors for interfering neutron reactions on K and Ca were determined by repeated analysis of K-glass and CaF_2 fragments. Measured $(^{40}Ar/^{39}Ar)_K$ values were 1.2 (± 32.77%) x 10^{-2}. Ca correction factors were $(^{36}Ar/^{37}Ar)_{Ca}$ = 2.66 (± 0.32%) x 10^{-4} and $(^{39}Ar/^{37}Ar)_{Ca}$ = 7.36 (± 0.36%) x 10^{-4}. J factors were determined by fusion of 6-10 individual crystals of neutron fluence monitors which gave reproducibility's of 0.09% to 0.11% at each standard position. Variation in neutron fluence along the 100 mm length of the irradiation tubes was <4%. Matlab curve fit was used to determine J and uncertainty in J at each standard position. No significant neutron fluence gradients were present within individual packets of crystals as indicated by the excellent reproducibility of the single crystal fluence monitor fusions.

Irradiated FC-2 sanidine standards together with CaF_2 and K-glass fragments were placed in a Cu sample tray in a high vacuum extraction line and were fused using a 20 W CO_2 laser. Sample viewing during laser fusion was by a video camera system and positioning was via a motorized sample stage. Samples analyzed by the furnace step heating method utilized a double vacuum resistance furnace similar to the Staudacher et al. (1978) design. Reactive gases were removed by three GP-50 SAES getters prior to being admitted to a MAP 215-50 mass spectrometer by expansion. The relative volumes of the extraction line and mass spectrometer allow 80% of the gas to be admitted to the mass spectrometer for laser fusion analyses and 76% for furnace heating analyses. Peak intensities were measured using a Balzers electron multiplier by peak hopping through 7 cycles; initial peak heights were determined by linear regression to the time of gas admission. Mass spectrometer discrimination and sensitivity was monitored by repeated analysis of atmospheric argon aliquots from an on-line pipette system. Measured $^{40}Ar/^{36}Ar$ ratios were 282.03 ± 0.08% during this work, thus a discrimination correction of 1.0478 (4 AMU) was applied to measured isotope ratios. The sensitivity of the mass spectrometer was ~6 x 10^{-17} mol mV^{-1} with the multiplier operated at a gain of 36 over the Faraday. Line blanks averaged 3.79 mV for mass 40 and 0.01 mV for mass 36 for laser fusion analyses and 10.48 mV for mass 40 and 0.03 mV for mass 36 for furnace heating analyses. Discrimination, sensitivity, and blanks were relatively constant over the period of data collection. Computer automated operation of the sample stage, laser, extraction line and mass spectrometer as well as final data reduction and age calculations were done using LabSPEC software written by B. Idleman (Lehigh University). An age of 28.02 Ma (Renne et al., 1998) was used for the Fish Canyon Tuff sanidine fluence monitor in calculating ages for samples.

For $^{40}Ar/^{39}Ar$ analyses a plateau segment consists of 3 or more contiguous gas fractions having analytically indistinguishable ages (i.e. all plateau steps overlap in age at $\pm 2\sigma$ analytical error) and comprising a significant portion of the total gas released (typically >50%). Total gas (integrated) ages are calculated by weighting by the amount of ^{39}Ar released, whereas plateau ages are weighted by the inverse of the variance. For each sample inverse isochron diagrams are examined to check for the effects of excess argon. Reliable isochrons are based on the MSWD criteria of Wendt and Carl (1991) and, as for plateaus, must comprise contiguous steps and a significant fraction of the total gas released. All analytical data are reported at the confidence level of 1σ (standard deviation).

Renne, P.R., Swisher, C.C, Deino, A.L., Karner, D.B., Owens, T.L., DePaolo, D.J., 1998, Intercalibration of standards, absolute ages and uncertainties in $^{40}Ar/^{39}Ar$ dating, *Chemical Geology*, v. 145, p. 117–152.

Staudacher, T.H., Jessberger, E.K., Dorflinger, D., and Kiko, J., A refined ultrahigh-vacuum furnace for rare gas analysis, *J. Phys. E: Sci. Instrum.*, 11, 781–784, 1978.

Wendt, I., and Carl, C., 1991, The statistical distribution of the mean squared weighted deviation, *Chemical Geology*, v. 86, p. 275–285.

Note: Check your samples data sheets for the discrimination, and fluence monitor values used for each sample.

Nevada Isotope Geochronology Laboratory - Sample Descriptions

General Comments:

Isochrons are the most desirable treatment of $^{40}Ar/^{39}Ar$ data. This is because the isochron actually defines the isotopic composition of the initial argon in the sample (non-radiogenic argon). Ages calculated for an age spectrum are referred to as "apparent ages" because they are calculated assuming the initial argon is atmospheric in composition - thus, if there is excess argon ($^{40}Ar/^{36}Ar > 295.5$) the age will be overestimated. Isochrons have their measure of reliability, known as the mean square of weighted deviates (MSWD) which is a statistical goodness of fit parameter. If it is greater than a certain value (which changes depending on the number of points, see Wendt and Carl, 1991, the statistical distribution of the mean squared weighted deviation, Chem. Geol., v. 86, p. 275–285) then there is more scatter than can be explained by analytical errors and it is not a statistically valid isochron. If we provide an isochron it means that the statistical test is valid, if not then no valid isochron was obtained. Also, there are issues of number of data points defining the isochron - the more the better. Four points should be considered a bare minimum for statistical reasons, three points is getting to be a real concern. This can be understood simply by considering two points - a perfectly fit straight line can be put through any two points, so completely accidental data can have a perfect line fit. It follows that with three points there is less of a chance of an accidental line fit, but it is still a very real possibility (especially if analytical errors are fairly large), this possibility gets exponentially smaller as the number of points defining the line (isochron) goes up, thus more points = a more reliable isochron.

If there is no isochron, then a plateau age is next in preference. This is because a sample that gives ages which are analytically indistinguishable from step to step is exhibiting what is known as "ideal" behavior, which suggests it has a simple geologic history, e.g., rapid cooling as a basalt lava, followed by no reheating or alteration, both of which may produce disturbed (discordant) age spectra. A reliable plateau is 3 or more consecutive steps which are indistinguishable in age at the 2 sigma level and comprise >50% of the total ^{39}Ar released. The lack of an isochron or a plateau does not mean the sample provides no useful information, but their presence gives greater confidence in the ages obtained and requires less subjective interpretation.

Of course, you must consider that we run samples such as this "blind" in that we do not know the geologic relations of the samples, either when we analyze them, or when we provide these general interpretations. The geologic constraints must always be considered when interpreting isotopic ages; if any discrepancies arise feel free to discuss them with us, as it can in some cases make a difference in how age data are interpreted. All analytical errors are 1σ.