

Sierra Nevada – Basin and Range transition near Reno, Nevada: Two-stage development at 12 and 3 Ma

Christopher D. Henry and Michael E. Perkins

DATA REPOSITORY 2001085: $^{40}\text{Ar}/^{39}\text{Ar}$ and tephrochronologic data for the Verdi-Boca basin, Nevada and California

TEPHROCHRONOLOGY

Four ash beds in the upper part of the Verdi-Boca basin correlate to dated ash beds. These include two ash beds in diatomite exposed west of downtown Reno in the Verdi part of the basin and two ash beds in diatomite along the western shore of Boca Reservoir. In the Reno area, the 4.45 ± 0.05 Ma Kilgore ash bed is present near the base of the diatomite unit, and the 3.06 ± 0.02 Ma upper Horse Hill ash bed is present near the top of the diatomite unit. At Boca Reservoir, the 3.4 ± 0.10 Ma Putah ash bed along with an unnamed, 3.26 ± 0.04 Ma ash are present in the middle part of the exposed diatomite. Identification of these ash beds is based on electron probe microanalysis of glass shards from the ash beds. These analyses were done following methods discussed in Perkins et al. (1995). The analyses of the Verdi-Boca ash beds were compared to those in the extensive University of Utah database of glass shard analyses of late Cenozoic ash beds in the western U.S. using methods discussed in Perkins et al. (1998). The glass shard analyses of the Verdi-Boca ash beds and correlative ash beds in the University of Utah database are listed in Table DR1. Some information on age estimates of these ash beds is given below.

Upper Horse Hill Ash Bed

The type locality for the Upper Horse Hill ash bed is in the Glenns Ferry Fm. of southern Idaho, and this ash bed is also present in northern Utah in the Burmester core (Williams, 1994). The Upper Horse Hill ash bed lies near the top of a short reversed interval in the Burmester core correlated by Williams (1994) with magnetochron C2An.1r (Kaena Event). Based on the revised

global magnetic polarity timescale of Cande and Kent (1995), we estimate the age of the Upper Horse Hill ash bed at 3.06 ± 0.02 Ma.

Unnamed Ash Bed

The unnamed ash bed was first sampled in two sections of the Glenns Ferry Fm. near Oreana, Idaho (Williams, pers. com., 1995). In both these sections the unnamed ash bed lies just a few meters above the Nomlaki ash bed, which was produced during the eruption of the Nomlaki Tuff in northern California (Sarna-Wojcicki, 1976). Williams (1994) reports the Nomlaki ash bed in the bottom of the Burmester core where it lies within a reversed interval correlated with magnetochron C2An.2r (Mammoth Event). Extrapolating downward from the top of Chron C2An.2r, we estimate the age of the Nomlaki ash bed at 3.27 ± 0.04 Ma using the Cande and Kent (1995) magnetic polarity timescale. This age is in agreement with less precise isotopic age estimates of 3.4 ± 0.3 Ma (FT zircon) and 3.4 ± 0.4 Ma (K/Ar) reported for the Nomlaki Tuff (Sarna-Wojcicki et al., 1991). Using sedimentation rates in the Glenns Ferry Fm. we estimate the age of the overlying unnamed ash bed at 3.26 ± 0.04 Ma.

Putah ash bed

The Putah ash bed is correlated with the Putah Tuff exposed at the base of the Tehema Formation in northern California (Sarna-Wojcicki, 1976). The Putah Tuff has a K/Ar date of 3.4 ± 0.10 Ma (new constants; reported as 3.3 ± 0.10 Ma in Sarna-Wojcicki, 1976) and lies just below the Nomlaki Tuff in the Sacramento Valley (Sarna-Wojcicki et al., 1991).

Kilgore ash bed

The Kilgore ash bed correlates with the basal ash-fall unit of the tuff of Kilgore of the Heise volcanic field in the eastern Snake River Plain (Morgan et al., 1984). The tuff of Kilgore includes this basal ash-fall as well as overlying welded ash-flow tuff. The tuff of Kilgore was first dated at ~4.5 Ma by K/Ar and fission track zircon methods (Morgan et al., 1984). More recently, a high-precision $^{40}\text{Ar}/^{39}\text{Ar}$ date of 4.45 ± 0.05 Ma is reported by Morgan et al. (1998), and we assign this date to the Kilgore ash bed.

TABLE DR1. ELECTRON PROBE MICROANALYSES OF GLASS SHARDS FROM ASH-FALL TUFFS IN THE VERDI FM. AND THEIR CORRELATIVES.

Sample	Ash Bed	n	SiO [0.8]	TiO [0.01]	Al O [0.1]	Fe O [0.03]	MnO [0.005]	MgO [0.01]	CaO [0.01]	BaO [0.01]	Na O [0.45]	K O [0.29]	Cl [.004]	F [0.03]	H O [1.0]	-O [0.02]	Total [1.0]
ore92-04	unnamed	16	71.0	0.26	13.3	2.20	.043	0.20	1.01	0.05	2.8	4.0	0.10	n.a.	5.4	0.02	100.3
boca99-1089	"	19	71.1	0.27	13.2	2.16	.037	0.19	0.95	0.06	3.7	4.0	0.09	0.11	6.5	0.07	102.3
sfc92-18	u. Horse Hill	22	71.0	0.29	13.8	2.69	.105	0.26	0.83	0.11	4.0	3.4	0.16	0.04	3.4	0.05	100.0
vr93-391	"	18	70.2	0.30	13.8	2.61	.980	0.25	0.81	0.10	5.0	3.4	0.16	0.15	3.5	0.10	100.3
pvr-1	Putah	21	71.4	0.13	12.5	1.76	.028	0.09	0.71	0.07	3.5	4.8	0.10	0.16	5.8	0.09	101.0
boca99-1084	"	21	73.2	0.14	13.0	1.84	.023	0.09	0.74	0.07	3.1	4.4	0.11	0.22	5.7	0.12	102.5
rir93-09	Kilgore	20	75.0	0.17	11.8	1.56	.035	0.07	0.47	0.07	3.2	5.3	0.09	0.06	2.2	0.05	100.0
vr99-1066	"	20	71.5	0.17	11.3	1.53	.033	0.07	0.48	0.04	2.8	5.5	0.09	0.28	6.8	0.14	100.4

Note: Sample preparation, analysis, and estimation of H₂O as discussed by Perkins et al. (1995; 1998). Listed analyses are the means of 16 to 22 shards. Number of shards analyzed is given in the column headed by "n". Values in brackets are the estimated analytical precisions for oxides and elements. Samples ore92-04, rir93-09, and sfc93-18 were collected by S. Williams (1994; pers. com., 1995). Sample pvr-1, from the type area of the Putah Tuff, was collected by A. Sarna-Wojcicki (pers. com., 2000). Analyses of ore92-04 and rir93-09 by S. Williams; all other analyses by M. Perkins.

⁴⁰Ar/³⁹Ar DATING

⁴⁰Ar/³⁹Ar analyses were done on hornblende or plagioclase phenocrysts or on whole-rock samples (Table DR2). Phenocrysts were concentrated to >99 percent purity using magnetic and density separation, leaching with dilute HF (feldspars only), and hand picking. Samples were irradiated at Texas A&M University and analyzed at the Nevada Isotope Geochronology Laboratory (methodology discussed in Justet and Spell, in review) or the New Mexico Geochronology Research Laboratory (methodology in McIntosh and Chamberlin, 1994). Fish Canyon sanidine was used as a neutron fluence monitor. New Mexico uses an age of 27.84 Ma, relative to an age of 520.4 Ma on hornblende MMhb-1 (Cebula and others, 1986; Samson and Alexander, 1987), whereas Nevada uses 27.90 Ma based on average K-Ar ages reported by Steven et al. (1967) and Cebula et al. (1986). For this report, all analyses were normalized to 27.84 Ma. Individual plagioclase grains were completely melted using a CO₂ laser operating at 5 watts. Hornblende and whole-rock samples were heated incrementally in a low-blank, resistance furnace.

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Table DR2. $^{40}\text{Ar}/^{39}\text{Ar}$ data for volcanic rocks, Verdi-Boca basin, Nevada and California.

data from Nevada Isotope Geochronology Laboratory

Henry - NBMG, H99-1 plagioclase, 14.93 mg, J = 0.0009441 +/- 0.5%

4 amu discrimination = 1.01982 +/- 0.35%. 40/39K = 0.01207 +/- 83.0%. 36/37Ca = 0.0002723 +/- 4.28%. 39/37Ca = 0.0006968 +/- 1.73%

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma

(Not corrected for dec)

Cummulative %39Ar rlsd =

step	blk corr beam errors												WtdAge39Ar			calc plateau age		
	39/40c	39/40err	36/40c	36/40err	R2	T (C)	36c	39c	40c	%36err	%39err	%40err	%36err	%40err	WtdAge39Ar	calc plateau age		
1	0.0077	0.3700	0.0031823	0.9244	0.3162	700	0.86	2.06	265.61	0.04	0.08	0.04	0.851	0.089	0.501746723	1	12.9797	16.1343
2	0.03972	0.3937	0.0025213	0.9301	0.1911	800	0.26	3.99	99.95	0.1	0.15	0.06	0.856	0.100	0.831712657	2	12.07915	12.79885
3	0.09435	0.3670	0.0014713	1.2022	0.0153	925	0.15	9.54	100.63	0.77	0.07	0.03	1.147	0.085	1.908719933	3	11.63939	12.22461
4	0.1041	0.3646	0.0013378	0.9605	0.2133	1000	0.14	10.43	99.68	0.26	0.02	0.06	0.889	0.100	2.030849019	4	11.43233	11.88367
5	0.10503	0.3608	0.0013312	0.9616	0.0410	1075	0.14	11.04	104.60	0.27	0.03	0.02	0.892	0.082	2.143592288	5	11.36045	11.80355
6	0.13942	0.3618	0.0004435	1.9084	0.0214	1130	0.03	8.67	61.90	1.67	0.02	0.04	1.874	0.089	1.786216345	6	11.88546	12.68454
7	0.11334	0.5000	0.0007755	1.2863	0.2036	1200	0.04	6.36	55.85	0.86	0.24	0.252	1.209	0.264	1.424480101	7	12.87202	13.84398
8	0.11586	0.4169	0.000896	1.2770	0.0262	1275	0.03	3.95	33.93	0.88	0.2	0.07	1.223	0.106	0.826354568	8	11.93308	13.02492
9	0.0802	0.3974	0.0013142	1.4744	0.0005	1400	0.06	3.61	44.77	1.15	0.17	0.01	1.430	0.081	0.885094116	9	13.83023	15.43577

Henry - NBMG, H99-1 hornblende, 25.77 mg, J = 0.0009507 +/- 0.5%

4 amu discrimination = $1.01750 \pm 0.21\%$, $40/39K = 0.01207 \pm 83.0\%$, $36/37Ca = 0.0002723 \pm 4.28\%$, $39/37Ca = 0.0006968 \pm 1.73\%$

note: isotope beams in mV rlsd = released, error in age includes 0.5% J error, all errors 1 sigma

(Not corrected for dec)

Cummulative %³⁹Ar rlsd = 100.0

step	Cumulative %SSEA fnsd = 100.0										blk corr beam errors			
	39/40c	39/40err	36/40c	36/40err	R2	36c	39c	40c	%36err	%39err	%40err	%36err	%40err	WtdAge39Ar
1	0.0005	0.2573	0.0032921	1.0531	0.1257	6.48	0.98	1935.11	0.04	0.14	0.03	1.031	0.050	0.496709106
2	0.0019	0.3390	0.0033123	1.0557	0.0680	1.41	0.80	418.37	0.08	0.26	0.04	1.033	0.057	0.089240182
3	0.02935	0.2396	0.0027677	1.0537	0.5472	1.62	16.97	575.61	0.01	0.09	0.06	1.030	0.072	1.102041405
4	0.07138	0.2269	0.0018964	1.0890	0.0420	2.99	110.95	1547.51	0.28	0.07	0.03	1.067	0.050	7.1120183693
5	0.07213	0.3030	0.001867	1.1371	0.1079	0.90	34.17	471.66	0.42	0.19	0.10	1.112	0.108	2.201654139
6	0.06432	0.2412	0.0020124	1.1036	0.0670	0.39	12.24	189.49	0.33	0.1	0.05	1.082	0.064	0.806456911
7	0.03019	0.2149	0.002626	1.0641	0.0279	0.22	2.53	83.46	0.16	0.02	0.01	1.042	0.041	0.195179276
8	0.04478	0.2619	0.0024413	1.0658	0.0154	0.23	4.11	91.38	0.17	0.15	0.02	1.044	0.045	0.261672893
9	0.01583	0.2460	0.0029408	1.1120	0.0091	0.37	1.97	123.99	0.36	0.12	0.02	1.091	0.045	0.174125808
														9 14.90137 17.73463

Henry - NBMG, H9-9 plagioclase, 27.75 mg, J = 0.0009554 +/- 0.5%
 4 ramu discrimination = 0.01982 +/- 0.35%, 40/39K = 0.01207 +/- 83.0%, 36/37Ca = 0.0002723 +/- 4.28%, 39/37Ca = 0.00068688 +/- 1.73%
 note: isotopic beams in mV /std = released, error in age includes 0.5% J error, all errors 1 sigma
 (Not corrected for decay)

step	39Ar	39Arerr	36Ar	36Arerr	R2	36c	38c	40Ar	%40Ar*	%39Ar /std	Ca/K	40Ar/39ArK	Age (Ma)	1 s.d.	anal err	3739c	%39ArK	total39 mol 39Ar	Wmdata	Wms	wfactor	Wxx	
1	0.01068	0.3597	0.00301	0.9233	0.5587	29.50	103.12	9.60937	0.025	%39err	9.39121	17.01	0.57	0.56665332	0.744393	99.94865452	325.78	6.19E-15	17.01	0.45	0.6569565		
2	0.03747	0.604	0.026233	0.9247	0.0520	4.79	178.87	2.89	0.06	0.03	0.052	11.4107935	10.4	0.15	0.16586497	0.1671023	99.75094394	3.85E-15	10.45	0.10761	86.357	917.196	
3	0.08445	0.3652	0.020894	0.9468	0.0632	2.12	64.19	99.11	0.21	0.06	0.03	14.58847935	6.0815	0.12	0.10760975	0.315534	98.569596	4.03E-15	10.39	0.104319	91.891	932.3264	
4	0.08518	0.3635	0.021651	0.9230	0.2626	1.14	33.73	51.49	0.1	0.06	0.04	16.25025866	6.1796	0.10	0.1043123	0.21753388	98.5630823	1.21E-15	10.39	0.134312	55.433	575.6778	
5	0.0504	0.3637	0.024422	0.9306	0.3548	0.99	20.21	39.8	0.11	0.03	0.05	14.2755272	6.2035	0.09	0.12972109	6.180211	98.57239123	2.8E-16	9.91	0.24	0.217564	21.126	225.2501
6	0.03411	0.3615	0.020735	0.9514	0.0915	0.77	27.14	63.71	1.4	0.03	0.05	19.70848904	6.5064	0.08	0.35455899	8.857503	98.40790638	1.40E-16	14.60	0.36	0.90303	59.023	1.40E-16
7	0.0328	0.3635	0.0208012	0.9373	0.1715	0.40	4.66	141.42	0.16	0.04	0.04	18.90092732	6.526356	0.23	0.885	0.1471757542	7.9446558	9.16E-16	15.84	0.31	0.50352434	8	1.40E-16
8	0.02814	0.3637	0.026459	0.9619	0.0568	0.32	3.35	118.59	0.27	0.05	0.03	18.84979044	9.2031	0.15	0.885	0.507951203	9	1.5312	0.31	0.57951203	9	1.5312	
9	0.02433	0.3635	0.023733	0.9373	0.1715	1.36	11.93	487.73	0.16	0.04	0.04	18.84979044	14.0852	0.12	0.72	0.7128724	38.647632	9.73288933	4.7E-16	24.12	0.1040815	0.0586	0.128252
10	0.00972	0.3670	0.030375	0.9297	0.1036	2.50	7.87	806.07	0.11	0.07	0.03	10.41	0.13	steps 2-6									

Cumulative %39Ar /std = 100.0
 plateau age = %39Ar
 Total gas age = %39Ar
 note: isotopic beams in mV /std = released, error in age includes 0.5% J error, all errors 1 sigma
 (Not corrected for decay)

step	39Ar	39Arerr	36Ar	36Arerr	R2	36c	38c	40Ar	%40Ar*	%39Ar /std	Ca/K	40Ar/39ArK	Age (Ma)	1 s.d.	anal err	3739c	%39ArK	total39 mol 39Ar	Wmdata	Wms	wfactor	Wxx	
1	0.01068	0.3597	0.00301	0.9233	0.5587	29.50	103.12	9.60937	0.025	%39err	9.39121	17.01	0.57	0.56665332	0.744393	99.94865452	325.78	6.19E-15	17.01	0.45	0.6569565		
2	0.03747	0.604	0.026233	0.9247	0.0520	4.79	178.87	2.89	0.06	0.03	0.052	11.4107935	10.4	0.15	0.16586497	0.1671023	99.75094394	4.03E-15	10.39	0.10761	86.357	917.196	
3	0.08445	0.3652	0.020894	0.9468	0.0632	2.12	64.19	99.11	0.21	0.06	0.04	14.58847935	6.0815	0.12	0.10760975	0.315534	98.569596	4.03E-15	10.39	0.1043123	55.433	575.6778	
4	0.08518	0.3635	0.021651	0.9230	0.2626	1.14	33.73	51.49	0.1	0.03	0.04	16.25025866	6.1796	0.10	0.12972109	6.180211	98.57239123	2.8E-16	9.91	0.24	0.217564	21.126	225.2501
5	0.0504	0.3637	0.024422	0.9306	0.3548	0.99	20.21	39.8	0.11	0.03	0.05	14.2755272	6.2035	0.09	0.35455899	8.857503	98.40790638	1.40E-16	14.60	0.36	0.90303	59.023	1.40E-16
6	0.03411	0.3615	0.020735	0.9514	0.0915	0.77	27.14	63.71	1.4	0.03	0.05	19.70848904	6.5064	0.15	0.885	0.1471757542	7.9446558	9.16E-16	15.84	0.31	0.50352434	8	1.40E-16
7	0.0328	0.3635	0.0208012	0.9373	0.1715	0.40	4.66	141.42	0.16	0.04	0.04	18.84979044	14.0852	0.12	0.72	0.7128724	38.647632	9.73288933	4.7E-16	24.12	0.1040815	0.0586	0.128252
8	0.02814	0.3637	0.026459	0.9619	0.0568	0.32	3.35	118.59	0.27	0.05	0.03	18.84979044	18.90092732	0.15	0.885	0.507951203	9	1.5312	0.31	0.57951203	9	1.5312	
9	0.02433	0.3635	0.023733	0.9373	0.1715	1.36	11.93	487.73	0.16	0.04	0.04	18.84979044	18.90092732	0.15	0.885	0.507951203	9	1.5312	0.31	0.57951203	9	1.5312	
10	0.00972	0.3670	0.030375	0.9297	0.1036	2.50	7.87	806.07	0.11	0.07	0.03	10.41	0.13	steps 2-9									

Cumulative %39Ar /std = 100.0
 plateau age = %39Ar
 Total gas age = %39Ar
 note: isotopic beams in mV /std = released, error in age includes 0.5% J error, all errors 1 sigma
 (Not corrected for decay)

step	39Ar	39Arerr	36Ar	36Arerr	R2	36c	38c	40Ar	%40Ar*	%39Ar /std	Ca/K	40Ar/39ArK	Age (Ma)	1 s.d.	anal err	3739c	%39ArK	total39 mol 39Ar	Wmdata	Wms	wfactor	Wxx	
1	0.01068	0.3597	0.00301	0.9233	0.5587	29.50	103.12	9.60937	0.025	%39err	9.39121	17.01	0.57	0.56665332	0.744393	99.94865452	325.78	6.19E-15	17.01	0.45	0.6569565		
2	0.03747	0.604	0.026233	0.9247	0.0520	4.79	178.87	2.89	0.06	0.03	0.052	11.4107935	10.4	0.15	0.16586497	0.1671023	99.75094394	4.03E-15	10.39	0.10761	86.357	917.196	
3	0.08445	0.3652	0.020894	0.9468	0.0632	2.12	64.19	99.11	0.21	0.06	0.04	14.58847935	6.0815	0.12	0.10760975	0.315534	98.569596	4.03E-15	10.39	0.1043123	55.433	575.6778	
4	0.08518	0.3635	0.021651	0.9230	0.2626	1.14	33.73	51.49	0.1	0.03	0.04	16.25025866	6.1796	0.10	0.12972109	6.180211	98.57239123	2.8E-16	9.91	0.24	0.217564	21.126	225.2501
5	0.0504	0.3637	0.024422	0.9306	0.3548	0.99	20.21	39.8	0.11	0.03	0.05	14.2755272	6.2035	0.09	0.35455899	8.857503	98.40790638	1.40E-16	14.60	0.36	0.90303	59.023	1.40E-16
6	0.03411	0.3615	0.020735	0.9514	0.0915	0.77	27.14	63.71	1.4	0.03	0.05	19.70848904	6.5064	0.15	0.885	0.1471757542	7.9446558	9.16E-16	15.84	0.31	0.50352434	8	1.40E-16
7	0.0328	0.3635	0.0208012	0.9373	0.1715	0.40	4.66	141.42	0.16	0.04	0.04	18.84979044	14.0852	0.12	0.72	0.7128724	38.647632	9.73288933	4.7E-16	24.12	0.1040815	0.0586	0.128252
8	0.02814	0.3637	0.026459	0.9619	0.0568	0.32	3.35	118.59	0.27	0.05	0.03	18.84979044	18.90092732	0.15	0.885	0.507951203	9	1.5312	0.31	0.57951203	9	1.5312	
9	0.02433	0.3635	0.023733	0.9373	0.1715	1.36	11.93	487.73	0.16	0.04	0.04	18.84979044	18.90092732	0.15	0.885	0.507951203	9	1.5312	0.31	0.57951203	9	1.5312	
10	0.00972	0.3670	0.030375	0.9297	0.1036	2.50	7.87	806.07	0.11	0.07	0.03	10.41	0.13	steps 2-9									

Cumulative %39Ar /std = 97.44
 plateau age = %39Ar
 Total gas age = %39Ar
 note: isotopic beams in mV /std = released, error in age includes 0.5% J error, all errors 1 sigma
 (Not corrected for decay)

step	39Ar	39Arerr	36Ar	36Arerr	R2	36c	38c	40Ar	%40Ar*	%39Ar /std	Ca/K	40Ar/39ArK	Age (Ma)	1 s.d.	anal err	3739c	%39ArK	total39 mol 39Ar	Wmdata	Wms	wfactor	Wxx
1	0.00415	0.2209	0.033212	1.0595	0.3568	3.10	3.83	9.1853	0.116	0.024	0.052	1.71286993	10.4	0.15	0.16586497	0.1671023	99.75094394	1.71E-04	11.2946	1	0.236315294	
2	0.0091	0.2250	0.0331901	1.1338	0.4023	2.43	6.64	10.18	0.028	0.022	0.034	1.043123	6.0815	0.12	0.16586497	0.1671023	99.75094394	1.71E-04	11.2946	1	0.236315294	
3	0.01537	0.2149	0.0330566	1.0528	0.6079	2.87	14.06	9.1118	0.128	0.022	0.034	1.043123	6.0815	0.12	0.16586497	0.1671023	9					

Henry - NBMB4 H9+10 plagioclase									
Henry - NBMB4 H9+10 plagioclase, 83-100 mg, J = 0.001207 +/- 0.5% 36/37Ca = 0.00069584 +/- 0.5%									
Henry - NBMB4 H9+10 plagioclase, 83-100 mg, J = 0.001207 +/- 0.5% 36/37Ca = 0.00069686 +/- 1.73%									
step	T (C)	t (min)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar	%39Ar flsd
1	700	12	0.86	0.025	0.184	2.116	264.483	6.4	2.8
2	800	12	0.25	11.387	4.197	97.926	36.0	5.6	22.241207006
3	925	12	0.23	32.826	0.18	11.582	130.336	70.9	15.6
4	1000	12	0.23	36.976	0.199	12.554	128.95	81.4	16.9
5	1075	12	0.23	37.738	13.254	144.986	74.5	17.8	23.320248266
6	1130	12	0.19	27.288	9.713	111.963	96.5	13.1	23.01671193
7	1200	12	0.19	22.009	0.127	7.966	100.634	95.2	10.7
8	1275	12	0.18	16.222	0.117	5.981	88.291	94.8	8.0
9	1400	12	0.29	17.577	0.145	7.051	121.219	74.1	9.5

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	Cumulative number of events =											
step	30/40c	30/40err	36/40c	36/40err	R2	36c	39c	40c	%36err	%39err	%40err	blink corr beam errors
1	0.00855	0.4986	0.0031679	1.01529	0.1009	0.77	2.12	238.28	0.56	0.05	0.07	1.9459864 15.47042
2	0.0584	0.4885	0.0022455	0.8462	0.0006	0.14	71.63	0.11	0.13	0.003	0.030	0.354610564 1.03551
3	0.11021	0.4845	0.0012813	0.58567	0.00498	0.16	11.58	104.74	0.16	0.05	0.03	0.637189894 1.16649
4	0.12177	0.4893	0.0009699	1.16109	0.0026	0.10	12.55	102.75	0.8	0.02	0.042	1.738012853 3.39167
5	0.11122	0.4893	0.0011715	0.8482	0.00000	0.14	13.25	118.77	0.11	0.09	0.00	1.989501869 1.18552
6	0.14878	0.4584	0.0051556	0.8703	0.0461	97.71	65.07	0.22	0.15	0.04	0.724	0.050 1.702979797 6.1107712 11.96888
7	0.14717	0.4864	0.0004937	1.8878	0.00333	0.03	7.97	1.69	0.07	0.02	0.825	0.036 1.4720398289 11.70982 11.96118
8	0.14216	0.5120	0.000544	1.1207	0.00070	0.02	5.95	41.72	0.74	0.03	0.042	8.1129145 1.927358465 11.89655
9	0.09844	0.4826	0.0011344	0.63030	0.00000	0.08	7.05	71.33	0.65	0.17	0.001	0.948 9.1273513 13.74087

Henry - NBMG, H99-10 hornblend, 24.18 mg, J = 0.0009591 +/- 0.5%

Henry - NBMG, H9-16 whole rock, 27.38 mg, J = 0.00095654 +/- 0.5%
 4 amu discrimination = 1.01982 +/- 0.35%, 40/39K = 0.01207 +/- 83.0%, 36/37Ca = 0.0002723 +/- 4.28%, 39/37Ca = 0.00069688 +/- 1.73%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	%39Ar lsid	Ca/K	40Ar/39Ar K	Age (Ma)	1 s.d.	anal err	37/39c	%39Ar K	total39	mol 39Ar	Wmdata	WMs	wfactor	Wxx
1	600	12	5.83	4.264	1.443	21.638	183.909	8.2	1.9	1.436755568	6.63951	11.87	0.51	0.51056435	0.624406	99.95679732 #####	1.35-15	11.87				
2	650	12	2.74	1.402	0.4038	13.0	4.130	7.0	1.70805552	2.6203	4.52	0.13	0.12497657	0.891936	99.94864251	2.64E-15	4.52					
3	700	12	1.58	23.85	1.408	84.727	589.476	25.5	7.6	2.052720385	1.7481	3.01	0.05	0.04767488	0.891936	99.93826862	5.08E-15	3.01				
4	775	12	1.06	57.171	2.947	156.179	636.132	55.7	19.4	1.937421391	1.5351	2.76	0.03	0.02253369	0.557761	99.96140852	8.92E-15	2.76				
5	800	12	0.48	26.157	1.989	148.596	358.721	67.2	13.4	1.283334589	1.5351	2.65	0.03	0.02353369	0.557761	99.96140852	8.92E-15	2.65	0.023534	1805.67	477.404	
6	875	12	0.62	39.159	2.737	282.797	595.974	74.0	25.5	1.008947642	1.5125	2.61	0.03	0.0236423	0.438767	99.9698424	4.789	1789	4685.821			
7	940	12	0.49	18.882	2.18	161.77	383.107	68.1	14.6	0.898566454	1.5284	2.63	0.03	0.02584211	0.3689843	99.97441507	9.71E-15	2.63	0.025842	1497.4	3941.215	
8	1015	12	0.49	8.937	1.045	74.801	252.041	48.5	6.7	0.969033454	1.4956	2.58	0.03	0.0282684	0.378120	99.97383789	4.49E-15	2.58	0.028268	1165.9	3036.812	
9	1110	12	0.61	9.904	0.935	51.658	204.414	36.6	1.01	1.510784449	1.5101	2.60	0.05	0.04411939	0.607492	99.95796765	3.1E-15	2.60	0.044119	513.75	1337.8	
10	1200	12	0.34	24.391	0.247	11.78	115.2	32.3	1.1	15.16456991	2.1261	3.67	0.13	0.12466032	0.6367366	7.07E-16	3.67	7.07E-16	3.67			
11	1400	12	0.71	22.619	0.315	12.787	226.814	14.6	1.2	12.94158219	0.2953	3.61	0.05	0.1479144	5.604954	99.94719324	7.67E-16	3.61	WtdMean	1sd	WJ	
																			2.61841	0.0122	0.027606	

note: isotope beams in mV / lsid = released error in age includes 0.5% J error, all errors 1 sigma
 (Not corrected for decay)

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	%39Ar lsid	Ca/K	40Ar/39Ar K	Age (Ma)	1 s.d.	anal err	37/39c	%39Ar K	total39	mol 39Ar	Wmdata	WMs	wfactor	Wxx
1	600	12	5.83	4.264	1.443	21.638	183.909	8.2	1.9	1.436755568	6.63951	11.87	0.51	0.51056435	0.624406	99.95679732 #####	1.35-15	11.87				
2	650	12	2.74	1.402	0.4038	13.0	4.130	7.0	1.70805552	2.6203	4.52	0.13	0.12497657	0.891936	99.94864251	2.64E-15	4.52					
3	700	12	1.58	23.85	1.408	84.727	589.476	25.5	7.6	2.052720385	1.7481	3.01	0.05	0.04767488	0.891936	99.93826862	5.08E-15	3.01				
4	775	12	1.06	57.171	2.947	156.179	636.132	55.7	19.4	1.937421391	1.5351	2.76	0.03	0.02253369	0.557761	99.96140852	8.92E-15	2.76	0.022534	1805.67	477.404	
5	800	12	0.48	26.157	1.989	148.596	358.721	67.2	13.4	1.283334589	1.5351	2.65	0.03	0.02353369	0.557761	99.96140852	8.92E-15	2.65	0.023534	1805.67	477.404	
6	875	12	0.62	39.159	2.737	282.797	595.974	74.0	25.5	1.008947642	1.5125	2.61	0.03	0.0236423	0.438767	99.97441507	9.71E-15	2.61	0.023642	1497.4	3941.215	
7	940	12	0.49	18.882	2.18	161.77	383.107	68.1	14.6	0.898566454	1.5284	2.63	0.03	0.02584211	0.368983	99.97383789	4.49E-15	2.63	0.025842	1165.9	3036.812	
8	1015	12	0.49	8.937	1.045	74.801	252.041	48.5	6.7	0.969033454	1.4956	2.58	0.03	0.0282684	0.378120	99.95796765	3.1E-15	2.58	0.028268	513.75	1337.8	
9	1110	12	0.61	9.904	0.935	51.658	204.414	36.6	1.01	1.510784449	1.5101	2.60	0.05	0.04411939	0.607492	99.95796765	3.1E-15	2.60	0.044119	513.75	1337.8	
10	1200	12	0.34	24.391	0.247	11.78	115.2	32.3	1.1	15.16456991	2.1261	3.67	0.13	0.12466032	0.6367366	7.07E-16	3.67	7.07E-16	3.67			
11	1400	12	0.71	22.619	0.315	12.787	226.814	14.6	1.2	12.94158219	0.2953	3.61	0.05	0.1479144	5.604954	99.94719324	7.67E-16	3.61	WtdMean	1sd	WJ	
																			0.041614838	0.0122	0.027606	

(Not corrected for decay)

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	%39Ar lsid	Ca/K	40Ar/39Ar K	Age (Ma)	1 s.d.	anal err	37/39c	%39Ar K	total39	mol 39Ar	Wmdata	WMs	wfactor	Wxx
1	600	12	5.83	4.264	1.443	21.638	183.909	8.2	1.9	1.436755568	6.63951	11.87	0.51	0.51056435	0.624406	99.95679732 #####	1.35-15	11.87				
2	650	12	2.74	1.402	0.4038	13.0	4.130	7.0	1.70805552	2.6203	4.52	0.13	0.12497657	0.891936	99.94864251	2.64E-15	4.52					
3	700	12	1.58	23.85	1.408	84.727	589.476	25.5	7.6	2.052720385	1.7481	3.01	0.05	0.04767488	0.891936	99.93826862	5.08E-15	3.01				
4	775	12	1.06	57.171	2.947	156.179	636.132	55.7	19.4	1.937421391	1.5351	2.76	0.03	0.02253369	0.557761	99.96140852	8.92E-15	2.76				
5	800	12	0.48	26.157	1.989	148.596	358.721	67.2	13.4	1.283334589	1.5351	2.65	0.03	0.02353369	0.557761	99.96140852	8.92E-15	2.65	0.023534	1805.67	477.404	
6	875	12	0.62	39.159	2.737	282.797	595.974	74.0	25.5	1.008947642	1.5125	2.61	0.03	0.0236423	0.438767	99.97441507	9.71E-15	2.61	0.023642	1497.4	3941.215	
7	940	12	0.49	18.882	2.18	161.77	383.107	68.1	14.6	0.898566454	1.5284	2.63	0.03	0.02584211	0.368983	99.97383789	4.49E-15	2.63	0.025842	1165.9	3036.812	
8	1015	12	0.49	8.937	1.045	74.801	252.041	48.5	6.7	0.969033454	1.4956	2.58	0.03	0.0282684	0.378120	99.95796765	3.1E-15	2.58	0.028268	513.75	1337.8	
9	1110	12	0.61	9.904	0.935	51.658	204.414	36.6	1.01	1.510784449	1.5101	2.60	0.05	0.04411939	0.607492	99.95796765	3.1E-15	2.60	0.044119	513.75	1337.8	
10	1200	12	0.34	24.391	0.247	11.78	115.2	32.3	1.1	15.16456991	2.1261	3.67	0.13	0.12466032	0.6367366	7.07E-16	3.67	7.07E-16	3.67			
11	1400	12	0.71	22.619	0.315	12.787	226.814	14.6	1.2	12.94158219	0.2953	3.61	0.05	0.1479144	5.604954	99.94719324	7.67E-16	3.61	WtdMean	1sd	WJ	
																			0.041614838	0.0122	0.027606	

(Not corrected for decay)

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	%39Ar lsid	Ca/K	40Ar/39Ar K	Age (Ma)	1 s.d.	anal err	37/39c	%39Ar K	total39	mol 39Ar	Wmdata	WMs	wfactor	Wxx
1	600	12	5.83	4.264	1.443	21.638	183.909	8.2	1.9	1.436755568	6.63951	11.87	0.51	0.51056435	0.624406	99.95679732 #####	1.35-15	11.87				
2	650	12	2.74	1.402	0.4038	13.0	4.130	7.0	1.70805552	2.6203	4.52	0.13	0.12497657	0.891936	99.94864251	2.64E-15	4.52					
3	700	12	1.58	23.85	1.408	84.727	589.476	25.5	7.6	2.052720385	1.7481	3.01	0.05	0.04767488	0.891936	99.93826862	5.08E-15	3.01</td				

Henry-NBGMG, 4054, feldspar, J = 0.0009590 +/- 0.5%
 4 amu discrimination = 1.01650 +/- 0.21%, 40/39K = 0.01207 +/- 83.0%, 36/37Ca = 0.0002723 +/- 4.28%, 39/37Ca = 0.0006968 +/- 1.73%.

Henry-NBMG, 4071, feldspar, J = 0.0009600 +/- 0.5%

data from New Mexico Geochronology Research Laboratory

ID	Temp (°C)	$^{40}\text{Ar}/^{39}\text{Ar}$	$^{37}\text{Ar}/^{39}\text{Ar}$	$^{36}\text{Ar}/^{39}\text{Ar}$	$^{39}\text{Ar}/\text{Ca}$	$^{40}\text{Ar}/\text{Ca}$	^{39}Ar (%)	Age (Ma)	$\pm 2\sigma$ (Ma)
98JP141 D5.86, 29.46 mg groundmass, J=0.000794142±0.10%, D=1.00754±0.00124, NM:86, Lab#:8951-01									
A	625	6834.6	0.7311	23019.8	0.605 0.7	0.5	2.8	45.8	287.7
B	700	706.5	1.410	2377.2	1.07 0.26	0.6	7.6	6.0	18.9
C	750	253.6	2.063	842.3	0.906 0.25	1.9	11.8	7.0	7.2
D	800	2.772	565.1	1.11 0.18	3.1	16.8	7.6	5.4	
E	875	236.6	2.573	777.3	3.78 0.2	3.0	34.1	10.1	3.4
F	975	184.1	4.472	598.2	4.06 0.11	4.2	52.7	11.0	
G	1075	125.2	3.894	399.5	2.94 0.13	5.9	66.1	10.7	2.5
H	1250	78.14	9.847	243.7	6.83 0.052	8.8	97.3	9.9	1.4
I	1650	124.5	33.79	400.3	0.582 0.015	7.1	100.0	12.9	8.8
total gas age plateau									
		n=9	n=9	n=9	21.9 0.15	100	10.9	11.6	
						10.1		1.2	
98JP151 , D6.86, 26.23 mg groundmass, J=0.000797284±0.10%, D=1.00754±0.00124, NM:86, Lab#:8952-01									
A	625	5307.6	0.9852	17586.5	0.50 0.52	2.1	1.9	152.9	226.0
B	700	934.5	1.444	3119.0	1.41 0.25	1.4	6.8	18.5	18.1
C	750	841.9	2.201	2791.6	1.13 0.23	2.0	10.7	24.5	16.5
D	800	309.7	2.939	1011.7	2.45 0.17	3.5		15.8	5.3
E	875	181.8	2.992	587.5	4.09 0.17	4.6	33.4	12.1	2.7
F	975	69.71	2.970	213.0	5.07 0.17	10.0	51.0	10.1	1.4
G	1075	34.79	2.134	98.25	2.57 0.24	17.0	59.9	8.5	
H	1250	57.01	5.018	170.1	10.9 0.10	12.5	97.7	10.3	0.9
I	1650	43.86	15.99	133.1	0.674 0.032	13.1	100.0	8.4	
total gas age plateau									
		n=9	n=9	n=9	28.8 0.17	100.0	10.3	1.1	

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

Individual analyses show analytical error only, mean ages also include error in J and irradiation parameters.

Analyses in italics are excluded from mean age calculations.

Correction factors:

$$(36\text{Ar}/37\text{Ar})_{\text{Ca}} = 0.00070±0.00005$$

$$(38\text{Ar}/39\text{Ar})_{\text{K}} = 0.0119$$

$$(40\text{Ar}/39\text{Ar})_{\text{K}} = 0.002±0.0003$$