DR2003057

APPENDIX DR- A
ANALYTICAL METHODS AND $^{40}Ar/^{39}Ar$ DATING RESULTS

A. Analytical Methods

Twenty volcanic samples from the Valle Central and Orotina debris fan were dated by the $^{40}Ar/^{39}Ar$ technique in the Geochronology Laboratory at Lehigh University. The samples were collected from recent quarry and roadcut exposures. Visibly altered material was rejected wherever possible; however, due to the high porosity of many of the sampled units and the intense tropical weathering pervasive in the field area, some of the samples show evidence of slight to moderate low-temperature alteration.

The alteration and low potassium content of these young andesitic and basaltic rocks dictated the choice of minerals available for dating. Plagioclase and biotite, occurring primarily as phenocrysts and microphenocrysts, were separated from some of the volcanic rocks using standard heavy-liquid and magnetic techniques. The groundmass of several fresh, well-crystallized volcanic rocks was also dated. Olivine and pyroxene phenocrysts were removed from these rocks prior to irradiation in order to reduce excess ^{40}Ar contamination. All of the samples were hand-picked to >99% purity prior to irradiation.

The purified separates were packaged in Sn foil and sealed in evacuated quartz vials. Packets containing monitor mineral GA1550 biotite (97.9 Ma; McDougall and Roksandic, 1974) were spaced evenly throughout the tubes to record the vertical variation in neutron flux within the irradiation container. CaF_2 and K_2SO_4 were also included in the irradiation packages to monitor neutron-induced interferences from Ca and K, respectively. The samples were irradiated in three separate batches in the L67 position of the Ford Reactor at the University of Michigan, each irradiation lasting 2 hours.

Argon was extracted from the samples by stepwise heating in a double-vacuum resistance furnace, and purified using a cold finger cooled to liquid nitrogen temperature and SAES St101 getters operated at room temperature and 400°C. The analyses were performed with a VG3600 noble gas mass spectrometer equipped with an electron multiplier operated in the analog mode. The mass spectrometer sensitivity was ~$6x10^{-17}$ moles/mV ^{40}Ar. Both the extraction line and mass spectrometer were operated under computer control using LabSpec, a custom LabVIEW program developed by Bruce Idleman at Lehigh University. Extraction line blanks were typically ~$3x10^{-15}$ moles ^{40}Ar at 1350°C and <$1x10^{-15}$ moles ^{40}Ar at temperatures below 1000°C, and were approximately atmospheric in composition. The isotopic data were corrected for extraction line blank, mass spectrometer background, mass discrimination, radioactive decay of ^{37}Ar and ^{39}Ar, neutron-induced interferences, and atmospheric contamination prior to calculation of the ages. The interference corrections varied slightly between the three irradiations. Their average values were: $(^{36}Ar/^{37}Ar)_{Ca} = 0.000227$, $(^{39}Ar/^{37}Ar)_{Ca} = 0.000790$, and $(^{40}Ar/^{39}Ar)_{K} = 0.0252$. Mass discrimination averaged 0.75%/AMU over

the course of the experiments (average measured atmospheric $^{40}Ar/^{36}Ar = 286.9 \pm 0.75\%$).

The results of the dating experiments are summarized in Table 1. A complete tabulation of the analytical data is presented in Appendix 1. The ages were calculated using the decay constants and isotopic abundances of Steiger and Jager (1977). Uncertainties associated with the ages reported in Table 1 and this appendix are quoted at the 1σ level and incorporate a 1% uncertainty in the J factor. The uncertainties reported for individual step ages in reported in the data tables in the appendix represent only the analytical component of the total uncertainty.

Plateau ages reported in Table 1 and in this appendix are the inverse-error weighted mean ages of contiguous steps that comprise 50% or more of the gas released from a sample and define individual ages statistically indistinguishable from the weighted mean at the 2σ analytical error level. For samples that do not define a statistically significant plateau but yielded several contiguous steps with nearly concordant ages, we report an inverse-error weighted mean age (i.e., an incremental or "near-plateau" age) for these steps. These ages are enclosed in parentheses where they are reported in the appendix. Isochron ages were determined by regressing blank-corrected data plotted on $^{36}Ar/^{40}Ar$ vs. $^{39}Ar/^{40}Ar$ isotope correlation diagrams using the method of York (1969). In general, we report the isochron age as the preferred age for samples that yielded acceptable isochrons (MSWD < 2.5); otherwise plateau or integrated ages are reported.

B. Summary of Dating Results

Sample Number	Field ID Number	Rock Type (Material Dated)	Location	Lat.	Long.	Plateau Age†	Isochron Age†	MSWD#
Formación Orotina (Qv2)								
1	CR94-32	welded tuff (plagioclase)	Cerro Túnel, Ceiba de Orotina	9° 53'	84° 38'	**326 ±18 ka**	(312 ± 44 ka)	3.56
2	CR93-13	welded tuff (plagioclase)	Quebrada Santa Rita, Costanera hwy., Orotina	9° 52'	84° 35'	384 ± 18 ka	**352 ± 40 ka**	0.89
3	CR95-26	welded tuff (plagioclase)	San Pedro, Turrubares	9° 52'	84° 28'	391 ± 13 ka	**373 ± 19 ka**	0.69
4	CR94-21	ash (biotite)	Jacó-Orotina junction, Costanera highway	9° 53'	84° 35'	----------	**(664 ± 109 ka)**	3.89
Formación Avalancha Ardiente (Qv2)								
5	CR96-2	welded tuff (biotite)	Quebrada Honda, Ciudad Colón	9° 54'	84° 15'	**320 ± 10 ka**	(313 ± 15 ka)	3.25
6	CR96-1	welded tuff (plagioclase)	Río Picagres, Picagres de Mora	9° 55'	84° 20'	(328 ± 15 ka)	**331 ± 23 ka**	2.08
7	DS-23	tuff	Tajo Pedregal, San Antonio de Belén	9° 58'	84° 11'	387 ± 17 ka	**390 ± 17 ka**	0.08
8	CR93-9	ash (biotite)	Quebrada Honda, Ciudad Colón	9° 54'	84° 15'	(527 ± 24 ka)	**(597 ± 54 ka)**	2.58
Formación Lavas Intracañon (Qv3)								
9	CR94-33	andesite lava	Tajo Pedregal,	9° 58'	84° 11'	341 ± 6 ka	**337 ± 7 ka**	1.00

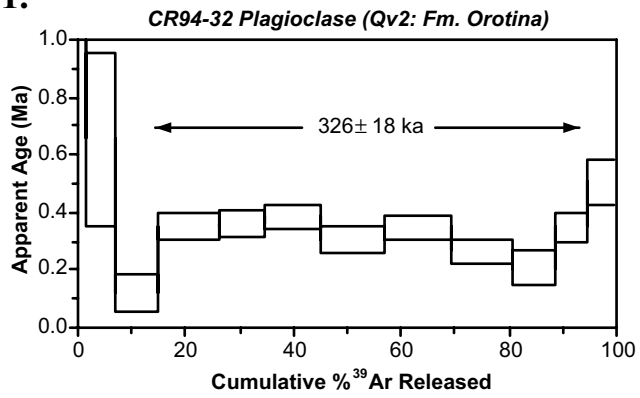
		(groundmass)	San Antonio de Belén					
10	CR94-34	andesite lava (groundmass)	Tajo Pedregal, San Antonio de Belén	9° 58'	84° 11'	375 ± 22 ka	**371 ± 49 ka**	1.97
11	CR95-6	andesite lava (groundmass)	Cebadilla, Turrucares	9° 56'	84° 21'	775 ± 10 ka	**758 ± 16 ka**	1.16
Formación Tivives (Qvl)								
12	CR94-7a	lahar (biotite)	Bajamar, Tivives	9° 50'	84° 41'	(908 ± 20 ka)	**(909 ± 53 ka)**	4.35
13	CR94-7b	lahar (plagioclase)	Bajamar, Tivives	9° 50'	84° 41'	1.14 ±0.07 Ma	**1.10 ±0.07 Ma**	1.01
14	CR94-18	Pumice sand (plagioclase)	Puente Agres, Orotina	9° 53'	84° 32'	(1.26 ± 0.13 Ma)	**1.12 ± 0.13 Ma**	2.36
15	CR93-12	lahar (biotite)	Alto de las Mesas, Tivives	9° 55'	84° 42'	----------	**1.42 ± 0.13 Ma**	2.15
16	CR94-9	lahar (plagioclase)	Río Jesús María Costanera highway	9° 55'	84° 40'	1.53 ± 0.04 Ma	**1.45 ±0.05 Ma**	0.17
17	CR94-38	welded tuff (biotite)	Cerro Tamarindo, Ceiba de Orotina	9° 53'	84° 38'	(1.91 ± 0.03 Ma)	**1.45 ± 0.07 Ma**	1.27
18	CR94-16	lahar (plagioclase)	Puente Agres, Orotina	9° 53'	84° 32'	(2.39 ± 0.03 Ma)	**1.66 ± 0.16 Ma**	0.92
Grupo Aguacate: Formación Grifo Alto (TQga)								
19	CR94-13	andesite lava (groundmass)	Cruz de Guatuso, Puriscal	9° 51'	84° 23'	**5.01 ± 0.11 Ma**	(5.02 ± 0.39 Ma)	7.76
20	CR93-24	trachyte lava (plagioclase)	Tajo La Aduana, La Garita	9° 59'	84° 21'	5.55 ± 0.05 Ma	**5.52 ± 0.08 Ma**	0.51

[†]Ages in bold are preferred values; ages in parentheses represent analyses that failed to meet plateau criteria or that defined isochrons with MSWD>2.5.

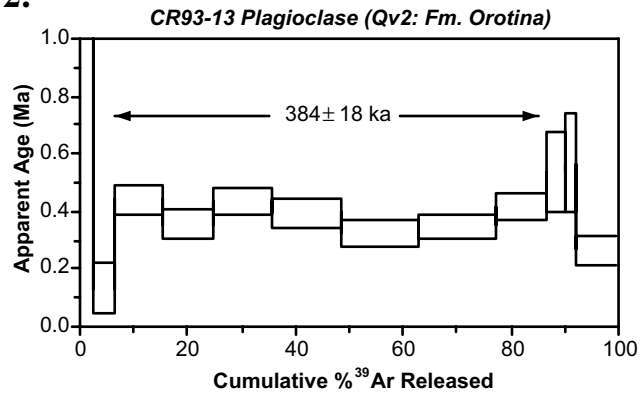
[#]Mean square of weighted deviates for isochron fit.

C. Age Spectra

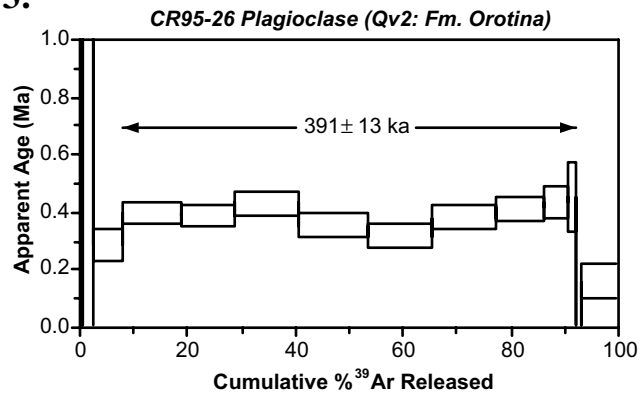
1.


CR94-32 Plagioclase (Qv2: Fm. Orotina)
326± 18 ka
Apparent Age (Ma)
Cumulative %39Ar Released

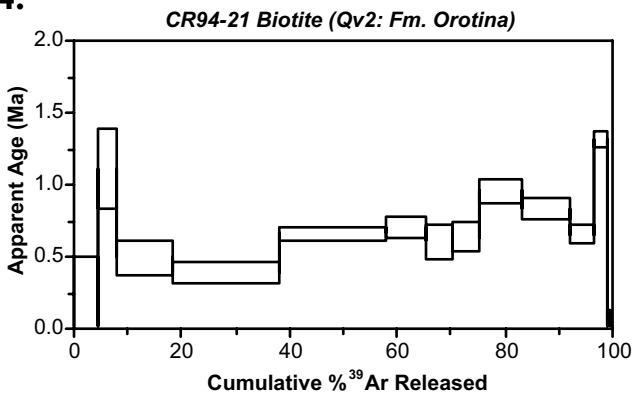
2.


CR93-13 Plagioclase (Qv2: Fm. Orotina)
384± 18 ka
Apparent Age (Ma)
Cumulative %39Ar Released

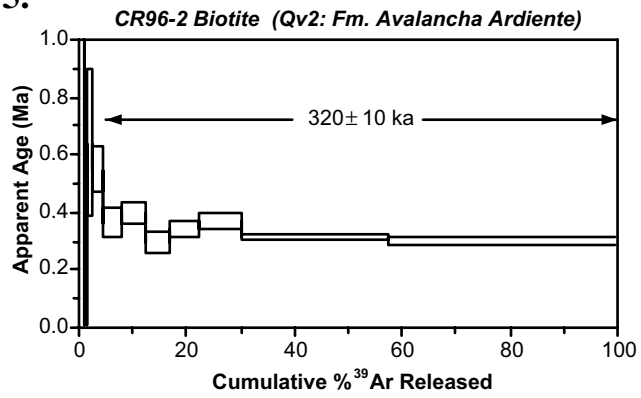
3.


CR95-26 Plagioclase (Qv2: Fm. Orotina)
391± 13 ka
Apparent Age (Ma)
Cumulative %39Ar Released

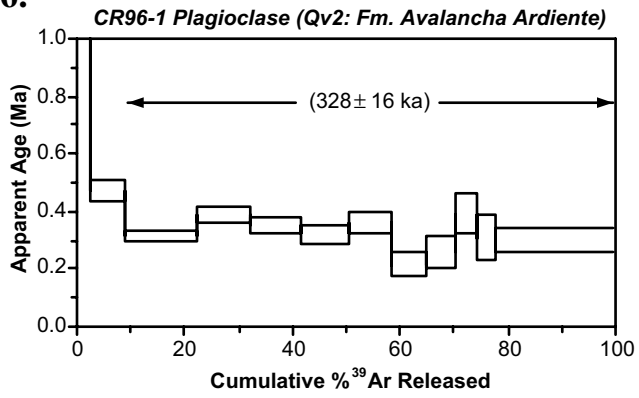
4.


CR94-21 Biotite (Qv2: Fm. Orotina)
Apparent Age (Ma)
Cumulative %39Ar Released

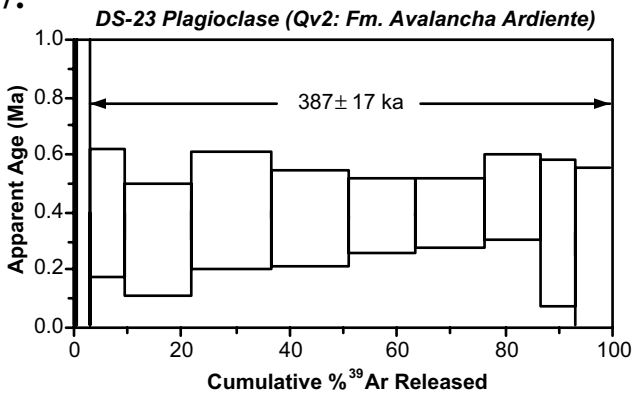
5.


CR96-2 Biotite (Qv2: Fm. Avalancha Ardiente)
320± 10 ka
Apparent Age (Ma)
Cumulative % 39Ar Released

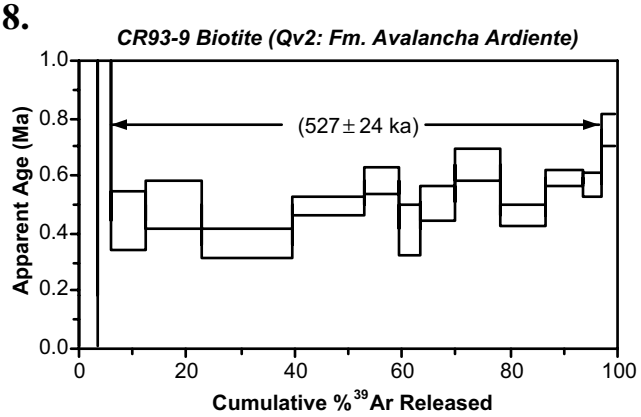
6.


CR96-1 Plagioclase (Qv2: Fm. Avalancha Ardiente)
(328± 16 ka)
Apparent Age (Ma)
Cumulative % 39Ar Released

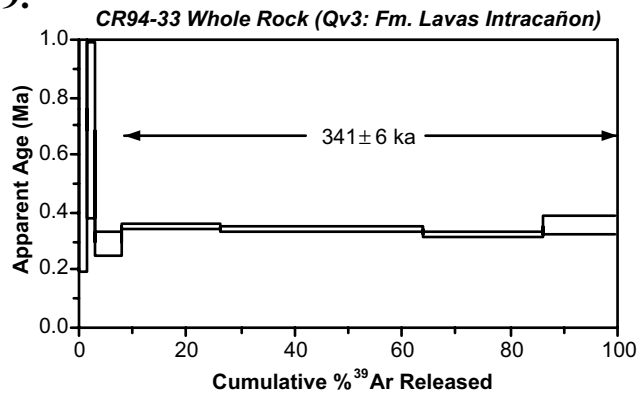
7.


DS-23 Plagioclase (Qv2: Fm. Avalancha Ardiente)
387± 17 ka
Apparent Age (Ma)
Cumulative % 39Ar Released

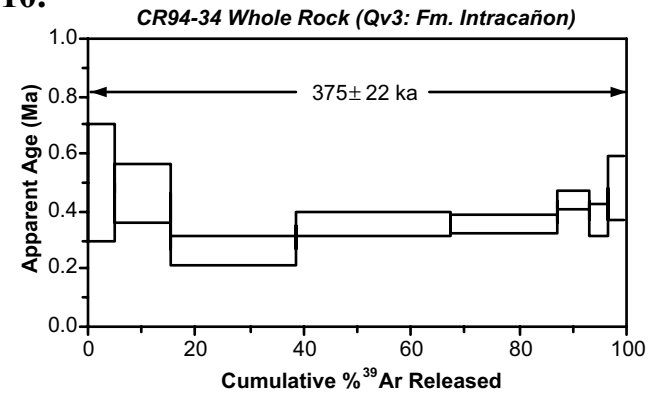
8.


CR93-9 Biotite (Qv2: Fm. Avalancha Ardiente)
(527± 24 ka)
Apparent Age (Ma)
Cumulative % 39Ar Released

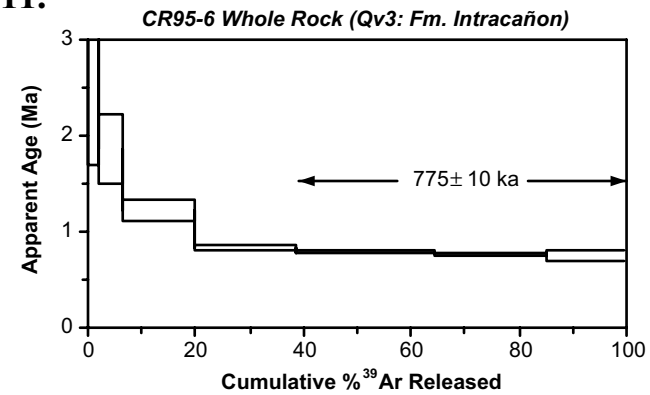
9.


CR94-33 Whole Rock (Qv3: Fm. Lavas Intracañon)
341± 6 ka
Apparent Age (Ma)
Cumulative % 39Ar Released

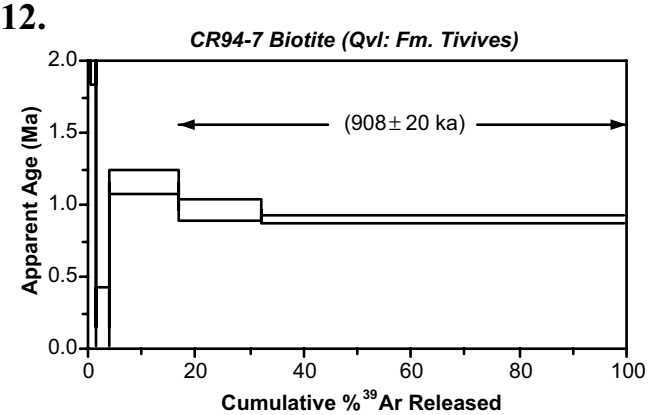
10.


CR94-34 Whole Rock (Qv3: Fm. Intracañon)
375± 22 ka
Apparent Age (Ma)
Cumulative % 39Ar Released

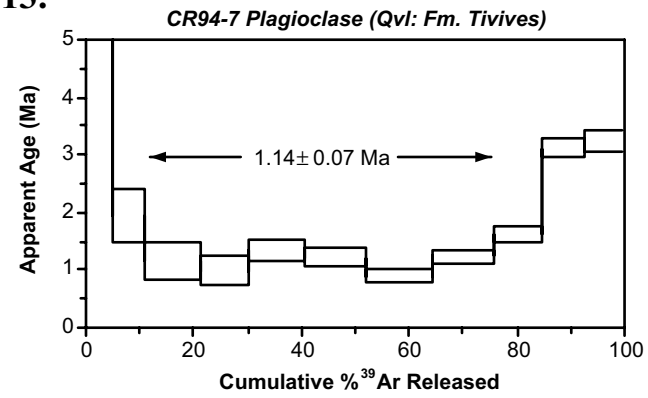
11.


CR95-6 Whole Rock (Qv3: Fm. Intracañon)
775± 10 ka
Apparent Age (Ma)
Cumulative % 39Ar Released

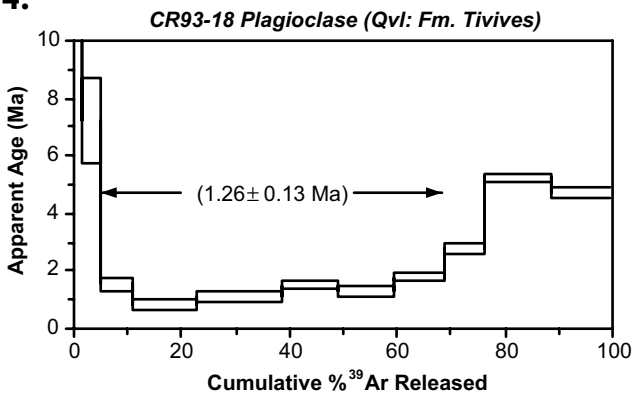
12.


CR94-7 Biotite (Qvl: Fm. Tivives)
(908± 20 ka)
Apparent Age (Ma)
Cumulative % 39Ar Released

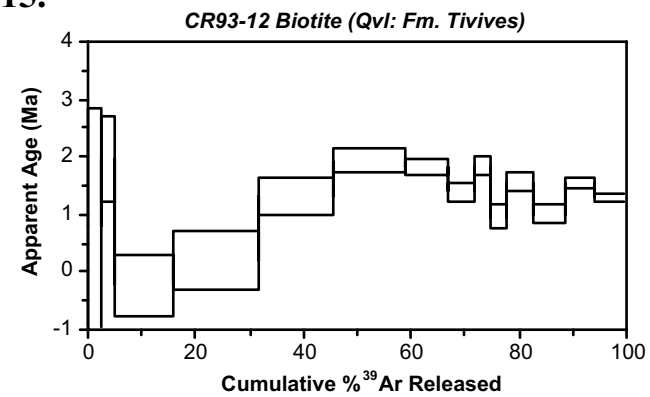
13.


CR94-7 Plagioclase (Qvl: Fm. Tivives)
Apparent Age (Ma)
1.14± 0.07 Ma
Cumulative % 39Ar Released

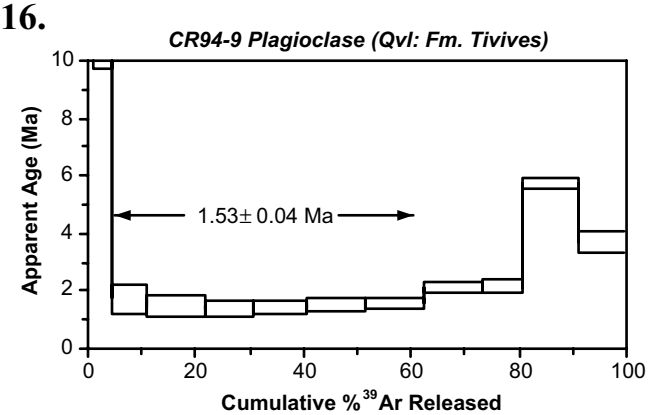
14.


CR93-18 Plagioclase (Qvl: Fm. Tivives)
Apparent Age (Ma)
(1.26± 0.13 Ma)
Cumulative % 39Ar Released

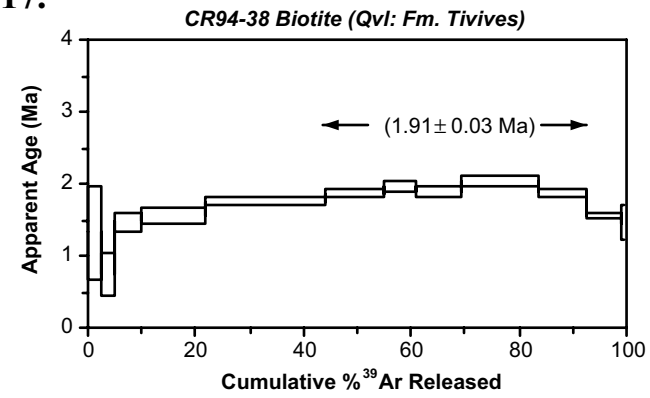
15.


CR93-12 Biotite (Qvl: Fm. Tivives)
Apparent Age (Ma)
Cumulative % 39Ar Released

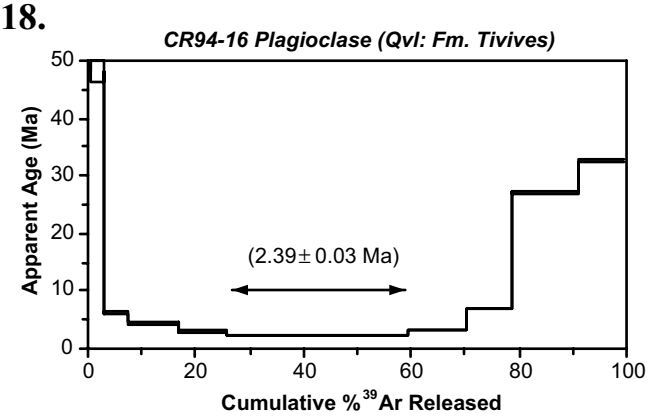
16.


CR94-9 Plagioclase (Qvl: Fm. Tivives)
Apparent Age (Ma)
1.53± 0.04 Ma
Cumulative % 39Ar Released

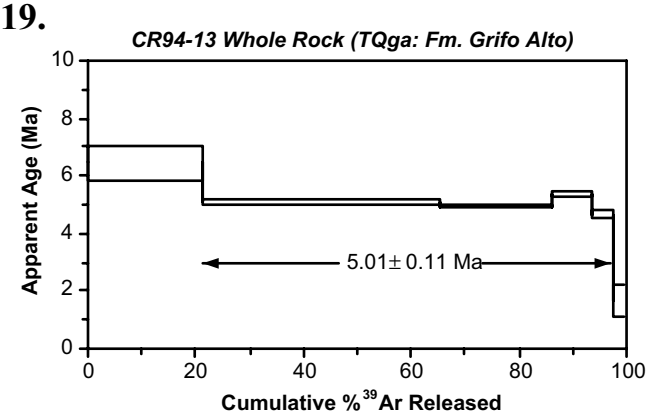
17.


CR94-38 Biotite (Qvl: Fm. Tivives)
Apparent Age (Ma)
(1.91± 0.03 Ma)
Cumulative % 39Ar Released

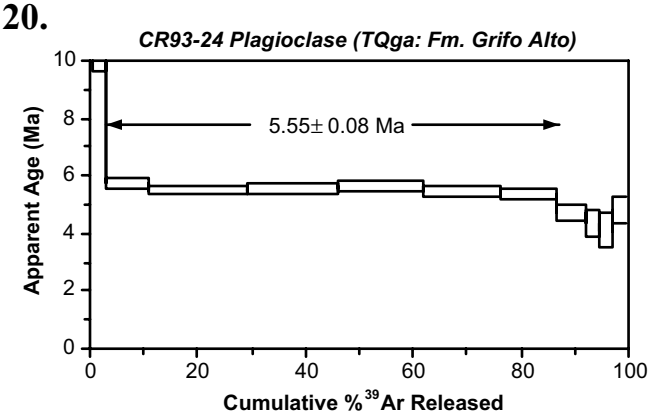
18.


CR94-16 Plagioclase (Qvl: Fm. Tivives)
Apparent Age (Ma)
(2.39± 0.03 Ma)
Cumulative % 39Ar Released

19.


CR94-13 Whole Rock (TQga: Fm. Grifo Alto)
Apparent Age (Ma)
5.01± 0.11 Ma
Cumulative % 39Ar Released

20.


CR93-24 Plagioclase (TQga: Fm. Grifo Alto)
Apparent Age (Ma)
5.55± 0.08 Ma
Cumulative % 39Ar Released

D. Analytical Data

1. CR94-32 Plagioclase ***J = 0.00031836***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	399.043	0.3461	0.2064	1.3189	9.99E-16	1.73	2.33	9.302	5.335	1.636
650	72.677	0.1538	0.8093	0.2422	3.05E-15	7.04	1.57	1.144	0.657	0.302
750	13.790	0.1202	1.7039	0.0463	4.63E-15	15.09	1.50	0.208	0.119	0.066
850	8.274	0.0727	3.4300	0.0266	6.37E-15	26.16	7.32	0.607	0.349	0.046
900	6.014	0.0279	4.5611	0.0192	5.03E-15	34.90	10.30	0.622	0.357	0.046
950	3.944	0.0178	4.7612	0.0121	5.83E-15	45.03	17.02	0.674	0.387	0.043
1000	3.271	0.0161	4.8185	0.0103	6.86E-15	56.94	16.26	0.534	0.307	0.044
1050	2.644	0.0163	4.7694	0.0079	7.21E-15	69.46	22.88	0.607	0.349	0.041
1100	2.955	0.0159	4.7229	0.0094	6.33E-15	80.45	15.74	0.467	0.268	0.041
1150	2.848	0.0153	4.6305	0.0094	4.60E-15	88.44	12.58	0.360	0.206	0.058
1250	5.836	0.0184	4.5231	0.0186	3.54E-15	94.60	10.34	0.605	0.348	0.055
1350	8.279	0.0253	4.1581	0.0259	3.11E-15	100.00	10.65	0.885	0.508	0.080
								Total Gas Age =	0.421	0.091

2. CR93-13 Plagioclase ***J = 0.00028907***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	4182.277	2.7429	1.9672	13.8152	1.12E-16	0.40	2.39	100.233	51.529	11.168
650	488.274	0.3323	3.2507	1.5964	5.47E-16	2.38	3.43	16.824	8.752	1.214
750	7.178	0.0197	4.5721	0.0246	1.18E-15	6.61	3.55	0.256	0.134	0.088
850	2.089	0.0161	5.3283	0.0056	2.47E-15	15.50	40.22	0.845	0.440	0.052
900	1.393	0.0156	5.2891	0.0038	2.51E-15	24.54	48.67	0.682	0.355	0.053
950	1.207	0.0142	5.1077	0.0026	3.05E-15	35.53	68.50	0.831	0.433	0.048
1000	1.167	0.0149	4.9571	0.0027	3.61E-15	48.55	64.54	0.757	0.395	0.050
1050	1.108	0.0158	4.8626	0.0029	4.00E-15	62.95	55.70	0.620	0.323	0.045
1100	1.130	0.0151	4.6932	0.0028	3.98E-15	77.29	58.95	0.669	0.349	0.043
1150	1.040	0.0138	4.4734	0.0020	2.61E-15	86.69	75.94	0.794	0.414	0.046
1200	9.924	0.0213	4.4200	0.0313	1.00E-15	90.30	10.29	1.026	0.535	0.138
1250	6.102	0.0210	4.5720	0.0181	4.94E-16	92.08	17.81	1.092	0.569	0.168
1350	2.048	0.0217	4.2794	0.0063	2.20E-15	100.00	24.85	0.511	0.267	0.053
								Total Gas Age =	0.747	0.125

3. CR95-26 Plagioclase ***J = 0.00029130***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	8799.362	5.7365	1.2168	29.9615	1.39E-16	0.45	-0.62	-54.266	-28.746	23.323
650	650.112	0.4430	2.0442	2.1910	6.37E-16	2.54	0.43	2.825	1.484	1.868
750	12.827	0.0223	2.6239	0.0422	1.58E-15	7.71	4.21	0.542	0.285	0.056
850	2.783	0.0159	3.3116	0.0077	3.44E-15	18.98	27.00	0.754	0.396	0.035
900	1.929	0.0158	3.9315	0.0050	3.03E-15	28.91	38.57	0.747	0.392	0.037
950	1.506	0.0146	4.2438	0.0034	3.49E-15	40.35	54.41	0.823	0.432	0.039
1000	1.382	0.0143	4.3810	0.0035	3.93E-15	53.22	48.72	0.676	0.355	0.040
1040	1.336	0.0153	4.3907	0.0036	3.75E-15	65.52	45.06	0.605	0.318	0.043
1080	1.302	0.0159	4.3530	0.0031	3.62E-15	77.41	55.89	0.731	0.384	0.040
1120	1.435	0.0156	4.2945	0.0033	2.74E-15	86.38	54.67	0.788	0.414	0.042

1160	4.423	0.0182	4.2997	0.0133	1.22E-15	90.37	18.51	0.822	0.432	0.056
1200	7.715	0.0214	4.2654	0.0243	4.97E-16	92.00	11.21	0.869	0.456	0.120
1250	6.532	0.0213	4.1146	0.0251	3.78E-16	93.24	-8.84	-0.580	-0.305	0.144
1350	4.032	0.0201	4.0573	0.0136	2.06E-15	100.00	7.57	0.306	0.161	0.060
								Total Gas Age =	0.248	0.187

4. CR94-21 Biotite ***J = 0.00029195***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	348.206	0.3158	0.0221	1.1811	2.52E-15	4.24	-0.24	-0.829	-0.437	0.932
600	106.731	0.1668	0.0169	0.3540	2.07E-15	7.73	1.98	2.114	1.113	0.275
700	48.246	0.1307	0.0123	0.1600	6.31E-15	18.34	1.96	0.948	0.499	0.122
800	28.248	0.1229	0.0103	0.0930	1.17E-14	38.04	2.59	0.731	0.385	0.078
900	18.280	0.1180	0.0126	0.0575	1.18E-14	57.82	6.89	1.260	0.664	0.044
940	28.177	0.1280	0.0101	0.0908	4.41E-15	65.24	4.71	1.328	0.699	0.076
980	40.172	0.1406	0.0097	0.1320	3.01E-15	70.31	2.85	1.146	0.603	0.117
1020	39.272	0.1384	0.0101	0.1287	2.96E-15	75.29	3.09	1.214	0.639	0.100
1060	34.511	0.1332	0.0078	0.1106	4.82E-15	83.39	5.27	1.819	0.958	0.088
1100	31.129	0.1285	0.0167	0.0999	5.25E-15	92.22	5.07	1.580	0.832	0.077
1150	26.005	0.1228	0.0837	0.0837	2.67E-15	96.72	4.80	1.249	0.658	0.068
1200	20.236	0.1191	0.0445	0.0600	1.33E-15	98.95	12.33	2.495	1.314	0.061
1250	19.177	0.1148	0.0250	0.0654	3.15E-16	99.48	-0.83	-0.159	-0.084	0.210
1350	15.175	0.0955	1.9237	0.0592	3.09E-16	100.00	-14.44	-2.196	-1.157	0.189
								Total Gas Age =	0.248	0.187

5. CR96-2 Biotite ***J = 0.00029200***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	4456.032	2.8848	0.1014	14.9760	1.42E-16	0.38	0.69	30.627	16.062	11.632
600	1008.088	0.6889	0.0650	3.3853	1.42E-16	0.77	0.77	7.714	4.059	2.889
700	94.219	0.1052	-0.0035	0.3306	2.54E-16	1.45	-3.72	-3.502	-1.846	0.663
800	33.076	0.0872	-0.0184	0.1077	2.98E-16	2.26	3.69	1.221	0.643	0.253
900	13.742	0.0960	-0.0159	0.0429	8.42E-16	4.53	7.58	1.042	0.549	0.077
950	6.066	0.0923	-0.0170	0.0181	1.23E-15	7.86	11.38	0.690	0.364	0.050
1000	3.138	0.0910	-0.0156	0.0080	1.61E-15	12.20	23.93	0.751	0.395	0.037
1040	2.485	0.0879	-0.0180	0.0064	1.66E-15	16.69	22.89	0.569	0.300	0.038
1080	2.709	0.0862	-0.0041	0.0069	2.08E-15	22.30	23.88	0.647	0.341	0.030
1120	3.019	0.0866	0.0180	0.0078	2.97E-15	30.30	23.27	0.703	0.370	0.024
1200	3.017	0.0953	0.1826	0.0082	9.96E-15	57.19	19.92	0.601	0.317	0.009
1350	2.258	0.0839	0.0411	0.0056	1.59E-14	100.00	25.36	0.573	0.302	0.012
								Total Gas Age =	0.388	0.081

6. CR96-1 Plagioclase ***J = 0.00029201***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	4025.086	2.5574	0.8076	13.3209	1.22E-16	0.48	2.21	88.876	46.223	9.993
650	617.347	0.4046	1.6229	2.0508	5.57E-16	2.66	1.85	11.462	6.028	1.579
750	6.547	0.0172	1.6135	0.0195	1.59E-15	8.89	13.60	0.892	0.470	0.038
850	1.638	0.0147	1.5569	0.0039	3.44E-15	22.36	36.61	0.601	0.316	0.022
900	1.249	0.0155	1.7799	0.0021	2.49E-15	32.10	58.97	0.738	0.389	0.028
950	1.204	0.0179	2.1086	0.0023	2.42E-15	41.58	55.57	0.670	0.353	0.030
1000	1.222	0.0227	2.4059	0.0027	2.26E-15	50.42	49.78	0.610	0.321	0.033
1050	1.365	0.0315	2.5479	0.0029	2.00E-15	58.25	50.43	0.690	0.364	0.035

1100	1.456	0.0463	2.6546	0.0042	1.68E-15	64.82	28.02	0.409	0.216	0.041
1150	1.995	0.0493	2.6329	0.0057	1.46E-15	70.52	24.80	0.496	0.261	0.054
1200	7.696	0.0312	3.3699	0.0244	1.01E-15	74.46	9.67	0.747	0.393	0.070
1250	6.949	0.0223	4.0404	0.0226	8.79E-16	77.90	8.45	0.589	0.310	0.081
1350	1.939	0.0175	4.1584	0.0057	5.65E-15	100.00	29.39	0.572	0.301	0.038
								Total Gas Age =	0.677	0.120

7. DS-23 Plagioclase

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	3188.883	2.1528	12.3555	10.7949	1.80E-16	0.42	0.00	0.009	0.008	22.445
650	481.955	0.3222	12.1712	1.6343	1.04E-15	2.81	0.00	-0.004	-0.004	3.300
750	10.159	0.0180	12.1106	0.0362	2.86E-15	9.41	4.36	0.448	0.402	0.223
850	6.219	0.0157	11.8422	0.0232	5.30E-15	21.66	5.36	0.337	0.302	0.194
925	5.074	0.0157	12.7965	0.0192	6.54E-15	36.75	8.86	0.455	0.408	0.205
1000	4.386	0.0148	9.7387	0.0161	6.18E-15	51.01	9.62	0.425	0.381	0.166
1060	3.617	0.0156	6.3465	0.0125	5.43E-15	63.55	11.86	0.431	0.387	0.128
1120	2.874	0.0160	5.2953	0.0096	5.54E-15	76.34	15.47	0.447	0.400	0.121
1180	3.048	0.0169	5.3861	0.0100	4.50E-15	86.72	16.66	0.510	0.457	0.148
1250	3.056	0.0162	7.1614	0.0111	2.84E-15	93.27	11.94	0.367	0.329	0.252
1350	3.865	0.0172	8.0633	0.0143	2.92E-15	100.00	7.13	0.278	0.249	0.310
								Total Gas Age =	0.365	0.349

8. CR93-9 Biotite ***J = 0.00029177***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	350.430	0.2939	0.0193	1.1846	2.20E-15	3.30	0.10	0.356	0.187	0.943
600	113.253	0.1410	0.0133	0.3733	1.67E-15	5.87	2.57	2.913	1.532	0.327
700	38.290	0.1066	0.0117	0.1266	4.15E-15	12.17	2.21	0.846	0.445	0.100
800	30.662	0.1043	0.0087	0.1005	6.96E-15	22.73	3.10	0.950	0.500	0.082
900	20.172	0.1000	0.0088	0.0658	1.13E-14	39.84	3.44	0.695	0.366	0.050
950	12.803	0.0947	0.0077	0.0401	8.58E-15	52.87	7.38	0.945	0.497	0.032
1000	17.619	0.0985	0.0101	0.0558	4.46E-15	59.63	6.29	1.108	0.583	0.049
1040	21.133	0.1002	0.0116	0.0688	2.38E-15	63.24	3.71	0.785	0.413	0.086
1080	20.555	0.0982	0.0100	0.0662	4.28E-15	69.72	4.67	0.961	0.506	0.056
1120	19.994	0.0969	0.0128	0.0635	5.48E-15	78.03	6.07	1.213	0.638	0.054
1160	15.275	0.0946	0.0248	0.0486	5.57E-15	86.48	5.76	0.880	0.463	0.041
1200	10.029	0.0895	0.0254	0.0300	4.81E-15	93.77	11.27	1.130	0.595	0.029
1250	6.694	0.0897	0.0891	0.0189	2.28E-15	97.23	16.22	1.086	0.572	0.043
1350	6.852	0.0783	0.7050	0.0184	1.83E-15	100.00	20.96	1.437	0.756	0.056
								Total Gas Age =	0.517	0.091

9. CR94-33 Whole-rock ***J = 0.00030801***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	138.393	0.1235	0.3551	0.4637	2.44E-15	1.34	0.99	1.372	0.762	0.568
600	69.894	0.0780	0.5060	0.2324	2.92E-15	2.95	1.77	1.237	0.687	0.306
700	8.392	0.0273	0.4468	0.0266	8.97E-15	7.89	6.33	0.532	0.295	0.041
800	2.269	0.0189	0.3326	0.0055	3.32E-14	26.17	27.87	0.633	0.351	0.011
900	1.392	0.0201	0.2958	0.0026	6.87E-14	63.96	44.15	0.615	0.342	0.007
1000	1.385	0.0400	0.4348	0.0027	4.06E-14	86.30	42.47	0.589	0.327	0.010
1350	5.351	0.1628	1.4500	0.0162	2.49E-14	100.00	11.91	0.638	0.354	0.034
								Total Gas Age =	0.351	0.026

10. CR94-34 Whole-rock ***J = 0.00031055***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	50.748	0.2832	0.1859	0.1687	8.81E-15	4.73	1.76	0.895	0.501	0.205
600	25.286	0.2616	0.1754	0.0827	2.01E-14	15.52	3.27	0.828	0.464	0.101
700	12.925	0.2452	0.2253	0.0421	4.35E-14	38.85	3.67	0.474	0.266	0.051
800	10.402	0.2132	0.4169	0.0331	5.29E-14	67.22	6.07	0.631	0.354	0.040
900	7.599	0.1636	0.7928	0.0237	3.67E-14	86.94	8.38	0.637	0.357	0.031
1000	7.145	0.1697	1.4109	0.0218	1.14E-14	93.04	10.96	0.784	0.439	0.034
1100	6.464	0.1710	2.0333	0.0200	6.04E-15	96.29	10.19	0.659	0.369	0.054
1350	7.795	0.1859	3.5165	0.0242	6.92E-15	100.00	10.98	0.858	0.481	0.109
								Total Gas Age =	0.363	0.058

11. CR95-6 Whole-rock ***J = 0.00031429***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	466.928	0.5829	0.3466	1.5586	2.32E-15	2.00	1.36	6.353	3.599	1.911
600	90.816	0.3505	0.3028	0.2962	5.17E-15	6.47	3.62	3.291	1.865	0.366
700	28.877	0.2914	0.4492	0.0904	1.52E-14	19.63	7.51	2.169	1.229	0.113
800	5.932	0.1607	0.8896	0.0152	2.19E-14	38.54	24.76	1.470	0.833	0.024
900	3.368	0.0413	1.1884	0.0069	3.01E-14	64.54	41.01	1.382	0.784	0.016
1000	2.880	0.0365	1.4155	0.0054	2.39E-14	85.22	46.90	1.352	0.766	0.018
1350	6.259	0.0833	4.8916	0.0177	1.71E-14	100.00	21.24	1.335	0.757	0.056
								Total Gas Age =	0.949	0.090

12. CR94-7 Biotite ***J = 0.00030682***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	3665.407	2.4766	0.0716	12.2539	1.11E-16	0.48	1.21	44.348	24.382	14.625
650	484.649	0.4212	0.1221	1.6157	2.18E-16	1.41	1.49	7.201	3.982	2.144
800	36.500	0.1022	0.1027	0.1225	6.32E-16	4.13	0.75	0.275	0.152	0.283
950	11.561	0.0569	0.0183	0.0320	2.95E-15	16.77	18.03	2.085	1.154	0.079
1100	8.156	0.0592	0.1454	0.0217	3.61E-15	32.27	21.24	1.732	0.959	0.077
1350	3.418	0.0521	0.2188	0.0060	1.58E-14	100.00	47.69	1.631	0.902	0.027
								Total Gas Age =	1.064	0.138

13. CR94-7 Plagioclase ***J = 0.00032616***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	2524.245	1.8023	18.9966	8.3379	1.53E-16	1.13	2.44	62.579	36.452	10.515
650	353.419	0.3303	29.7833	1.1644	5.08E-16	4.86	3.20	11.588	6.806	1.535
750	36.517	0.0967	49.4146	0.1240	8.17E-16	10.87	8.69	3.303	1.943	0.460
850	11.675	0.0475	39.6530	0.0419	1.43E-15	21.40	16.37	1.973	1.161	0.334
900	7.456	0.0249	27.7176	0.0258	1.22E-15	30.41	22.16	1.689	0.994	0.242
950	4.673	0.0162	21.4436	0.0129	1.39E-15	40.60	48.63	2.312	1.360	0.184
1000	4.640	0.0156	16.2361	0.0123	1.55E-15	51.98	44.42	2.088	1.228	0.145
1050	4.033	0.0150	12.3271	0.0112	1.68E-15	64.31	37.65	1.533	0.902	0.121
1100	5.561	0.0169	10.5929	0.0141	1.59E-15	75.98	37.33	2.093	1.231	0.107
1150	5.724	0.0203	10.5393	0.0124	1.18E-15	84.67	47.89	2.764	1.626	0.123
1250	15.465	0.0270	12.0519	0.0372	1.08E-15	92.58	34.03	5.313	3.124	0.153
1350	25.407	0.0379	12.0155	0.0701	1.01E-15	100.00	21.52	5.521	3.246	0.189
								Total Gas Age =	2.161	0.361

14. CR94-18 Plagioclase ***J = 0.00031541***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}{}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]

500	3627.719	2.4505	6.9208	12.0022	1.48E-16	1.31	2.25	81.947	46.038	14.523
650	366.582	0.3300	14.4814	1.2010	3.87E-16	4.72	3.44	12.765	7.249	1.503
750	18.877	0.0778	20.1835	0.0594	6.89E-16	10.80	14.09	2.703	1.538	0.204
850	11.276	0.0552	19.0114	0.0375	1.35E-15	22.70	12.76	1.461	0.831	0.168
950	9.347	0.0308	17.0404	0.0288	1.80E-15	38.54	20.94	1.984	1.129	0.184
1000	8.306	0.0201	15.5207	0.0227	1.21E-15	49.18	31.55	2.653	1.509	0.151
1050	11.477	0.0245	13.5664	0.0343	1.13E-15	59.19	19.38	2.249	1.279	0.161
1100	8.602	0.0199	12.0921	0.0212	1.07E-15	68.61	36.22	3.146	1.789	0.147
1150	11.218	0.0225	11.2158	0.0241	8.70E-16	76.28	42.96	4.862	2.764	0.175
1250	18.560	0.0286	8.5125	0.0335	1.41E-15	88.74	49.55	9.259	5.261	0.136
1350	16.712	0.0295	10.7660	0.0312	1.28E-15	100.00	48.99	8.257	4.692	0.183
								Total Gas Age =	3.088	0.406

15. CR93-12 Biotite ***J = 0.00029178***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	797.135	0.5723	0.0460	2.6925	1.17E-15	2.66	0.19	1.496	0.787	3.076
600	291.532	0.2414	0.0371	0.9739	9.82E-16	4.88	1.28	3.726	1.960	1.107
700	198.333	0.1946	0.0330	0.6726	4.81E-15	15.76	-0.22	-0.427	-0.225	0.776
800	173.611	0.1726	0.0276	0.5862	7.13E-15	31.90	0.22	0.377	0.198	0.720
850	124.283	0.1323	0.0204	0.4120	6.12E-15	45.75	2.02	2.507	1.319	0.472
900	86.719	0.1048	0.0184	0.2809	5.76E-15	58.79	4.25	3.688	1.940	0.324
940	57.052	0.0852	0.0188	0.1813	3.53E-15	66.78	6.08	3.470	1.826	0.206
980	57.433	0.0900	0.0295	0.1853	2.20E-15	71.77	4.62	2.652	1.396	0.234
1020	66.744	0.0997	0.0311	0.2139	1.32E-15	74.74	5.26	3.509	1.846	0.246
1060	69.385	0.1098	0.0597	0.2285	1.25E-15	77.59	2.65	1.836	0.966	0.297
1100	69.131	0.1026	0.0690	0.2238	2.18E-15	82.51	4.29	2.969	1.562	0.256
1150	61.063	0.1151	0.3690	0.2002	2.67E-15	88.57	3.15	1.925	1.013	0.228
1200	36.123	0.1113	0.3544	0.1123	2.37E-15	93.92	8.13	2.940	1.547	0.133
1350	23.429	0.0732	0.2967	0.0709	2.68E-15	100.00	10.55	2.474	1.302	0.083
								Total Gas Age =	1.106	0.343

16. CR94-9 Plagioclase ***J = 0.00032447***

Temp (°C)	$^{40}Ar/^{39}Ar^{1}$	$^{38}Ar/^{39}Ar^{1}$	$^{37}Ar/^{39}Ar^{1}$	$^{36}Ar/^{39}Ar^{1}$	^{39}Ar(moles)	% ^{39}Ar	%^{40}Ar*	$^{40}Ar^{*}/^{39}Ar_{K}^{2}$	Age (Ma)[3]	±1σ (Ma)[4]
500	3280.021	2.3411	20.1268	10.7537	1.35E-16	1.19	3.16	105.297	60.608	13.496
650	476.169	0.5336	38.9773	1.5540	3.75E-16	4.50	4.11	20.180	11.775	2.051
750	19.756	0.0656	57.8230	0.0703	7.03E-16	10.71	14.31	2.963	1.734	0.502
850	10.353	0.0385	47.5340	0.0374	1.25E-15	21.75	23.72	2.551	1.493	0.400
900	6.505	0.0253	34.7829	0.0221	9.98E-16	30.57	35.24	2.357	1.379	0.302
950	5.631	0.0199	27.3647	0.0171	1.13E-15	40.53	42.45	2.443	1.430	0.242
1000	5.594	0.0181	21.8672	0.0151	1.21E-15	51.25	46.20	2.630	1.539	0.202
1050	5.990	0.0196	16.5657	0.0148	1.28E-15	62.56	45.20	2.743	1.605	0.172
1100	5.783	0.0205	12.9427	0.0101	1.20E-15	73.12	62.83	3.671	2.148	0.160
1150	7.184	0.0221	12.4176	0.0146	8.84E-16	80.92	51.14	3.710	2.171	0.206
1250	15.833	0.0289	10.1734	0.0229	1.15E-15	91.10	61.42	9.804	5.730	0.202
1350	13.781	0.0374	11.5363	0.0277	1.01E-15	100.00	46.00	6.397	3.741	0.358
								Total Gas Age =	3.328	0.486

17. CR94-38 Biotite ***J = 0.00030937***

Temp (°C)	$^{40}Ar/^{39}Ar^1$	$^{38}Ar/^{39}Ar^1$	$^{37}Ar/^{39}Ar^1$	$^{36}Ar/^{39}Ar^1$	^{39}Ar(moles)	% ^{39}Ar	$\%^{40}Ar^*$	$^{40}Ar^*/^{39}Ar_K^2$	Age (Ma)[3]	±1σ (Ma)[4]
500	158.902	0.2703	0.0120	0.5296	2.46E-15	2.23	1.50	2.379	1.327	0.646
600	70.060	0.2129	0.0102	0.2325	3.18E-15	5.12	1.89	1.326	0.740	0.294
700	33.080	0.2000	0.0117	0.1029	5.30E-15	9.93	7.99	2.643	1.474	0.127
800	26.789	0.2082	0.0108	0.0811	1.32E-14	21.89	10.48	2.806	1.566	0.106
900	16.522	0.2048	0.0078	0.0452	2.43E-14	43.91	19.09	3.154	1.760	0.055
940	17.274	0.2079	0.0078	0.0470	1.21E-14	54.85	19.41	3.352	1.870	0.060
980	20.660	0.2099	0.0096	0.0580	6.84E-15	61.06	16.94	3.499	1.952	0.078
1020	22.658	0.2127	0.0094	0.0652	9.17E-15	69.37	14.91	3.379	1.885	0.083
1080	22.337	0.2089	0.0134	0.0632	1.56E-14	83.50	16.29	3.638	2.029	0.078
1140	15.145	0.2234	0.1603	0.0398	1.01E-14	92.63	22.33	3.383	1.887	0.053
1200	7.471	0.1912	0.0328	0.0157	6.86E-15	98.86	37.53	2.804	1.564	0.041
1350	8.198	0.1907	0.0912	0.0188	1.26E-15	100.00	31.99	2.623	1.463	0.232
								Total Gas Age =	1.752	0.093

18. CR94-16 Plagioclase ***J = 0.00032260***

Temp (°C)	$^{40}Ar/^{39}Ar^1$	$^{38}Ar/^{39}Ar^1$	$^{37}Ar/^{39}Ar^1$	$^{36}Ar/^{39}Ar^1$	^{39}Ar(moles)	% ^{39}Ar	$\%^{40}Ar^*$	$^{40}Ar^*/^{39}Ar_K^2$	Age (Ma)[3]	±1σ (Ma)[4]
500	3825.032	2.6232	11.2458	12.5134	1.26E-16	0.59	3.35	129.185	73.661	15.418
650	497.550	0.3934	17.8465	1.4078	4.78E-16	2.82	16.63	83.902	48.181	1.768
750	27.990	0.0524	23.3996	0.0641	9.59E-16	7.31	37.83	10.789	6.268	0.221
850	12.951	0.0248	19.6491	0.0221	2.05E-15	16.88	59.47	7.824	4.548	0.166
900	7.762	0.0178	14.1576	0.0125	1.93E-15	25.90	64.12	5.033	2.927	0.123
950	5.902	0.0142	11.6697	0.0087	2.23E-15	36.31	69.35	4.131	2.402	0.103
1000	5.297	0.0144	9.9544	0.0066	2.46E-15	47.81	75.31	4.021	2.338	0.093
1050	5.350	0.0157	8.5233	0.0060	2.52E-15	59.58	77.22	4.159	2.419	0.078
1100	6.900	0.0166	7.2592	0.0064	2.27E-15	70.21	79.09	5.488	3.191	0.075
1150	16.354	0.0200	6.6342	0.0163	1.84E-15	78.82	73.07	12.012	6.977	0.082
1250	56.654	0.0312	4.8175	0.0345	2.61E-15	91.03	82.51	46.923	27.104	0.094
1350	75.285	0.0512	5.8756	0.0656	1.92E-15	100.00	74.72	56.518	32.597	0.141
								Total Gas Age =	10.531	0.236

19. CR94-13 Whole-rock ***J = 0.00029075***

Temp (°C)	$^{40}Ar/^{39}Ar^1$	$^{38}Ar/^{39}Ar^1$	$^{37}Ar/^{39}Ar^1$	$^{36}Ar/^{39}Ar^1$	^{39}Ar(moles)	% ^{39}Ar	$\%^{40}Ar^*$	$^{40}Ar^*/^{39}Ar_K^2$	Age (Ma)[3]	±1σ (Ma)[4]
500	238.066	0.3603	0.2887	0.7640	6.50E-15	21.46	5.17	12.303	6.442	0.578
650	42.795	0.2193	0.4882	0.1122	1.32E-14	65.12	22.58	9.666	5.063	0.086
750	25.982	0.1831	1.6074	0.0564	6.43E-15	86.38	36.23	9.428	4.939	0.048
850	24.403	0.1050	6.2678	0.0500	2.17E-15	93.55	41.48	10.187	5.336	0.089
1000	30.091	0.2206	9.7752	0.0747	1.25E-15	97.68	29.17	8.865	4.644	0.136
1350	68.718	0.5654	33.9760	0.2314	7.02E-16	100.00	4.46	3.175	1.665	0.596
								Total Gas Age =	5.250	0.200

20. CR93-24 Plagioclase ***J = 0.00032090***

Temp (°C)	$^{40}Ar/^{39}Ar^1$	$^{38}Ar/^{39}Ar^1$	$^{37}Ar/^{39}Ar^1$	$^{36}Ar/^{39}Ar^1$	^{39}Ar(moles)	% ^{39}Ar	$\%^{40}Ar^*$	$^{40}Ar^*/^{39}Ar_K^2$	Age (Ma)[3]	±1σ (Ma)[4]
500	5548.161	3.6024	7.1169	18.5039	5.40E-17	0.46	1.45	81.164	46.387	22.859
650	474.393	0.3201	13.8133	1.5410	3.13E-16	3.14	4.20	20.143	11.624	1.961
750	15.466	0.0175	16.4252	0.0229	9.24E-16	11.04	63.16	9.896	5.720	0.181
850	12.080	0.0148	18.3442	0.0132	2.15E-15	29.42	77.59	9.510	5.497	0.169
900	11.047	0.0138	19.3145	0.0096	1.92E-15	45.82	85.94	9.640	5.572	0.167
950	11.094	0.0141	20.3929	0.0095	1.88E-15	61.87	86.87	9.795	5.662	0.175

1000	10.945	0.0144	20.2603	0.0102	1.69E-15	76.29	84.76	9.428	5.450	0.179
1050	11.798	0.0152	19.4687	0.0132	1.22E-15	86.75	77.70	9.310	5.382	0.190
1100	11.729	0.0228	15.7184	0.0159	6.29E-16	92.12	68.63	8.150	4.712	0.252
1150	14.247	0.0328	8.4951	0.0248	2.95E-16	94.64	52.41	7.517	4.347	0.489
1250	14.129	0.0341	7.9182	0.0256	2.79E-16	97.03	49.96	7.104	4.108	0.575
1350	23.876	0.0342	12.4075	0.0556	3.48E-16	100.00	34.50	8.319	4.810	0.497
								Total Gas Age =	5.767	0.362

[1] Corrected for mass spectrometer background, extraction line blank, mass discrimination, and radioactive decay of ^{37}Ar and ^{39}Ar.

[2] Corrected for (1) above plus atmospheric argon and neutron-induced interferences.

[3] Ages calculated using the decay constants of Steiger and Jager (1977).

[4] Analytical uncertainties quoted at the 1σ level. Uncertainties for total-gas ages include a 1% J-factor contribution.