

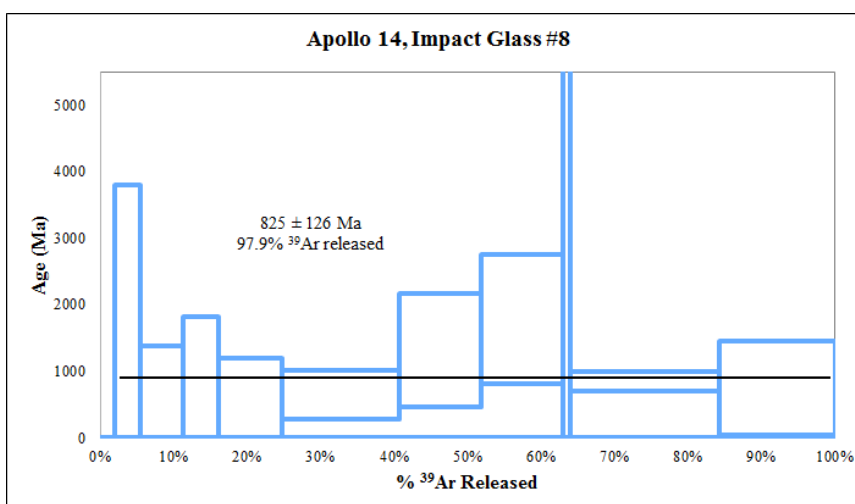
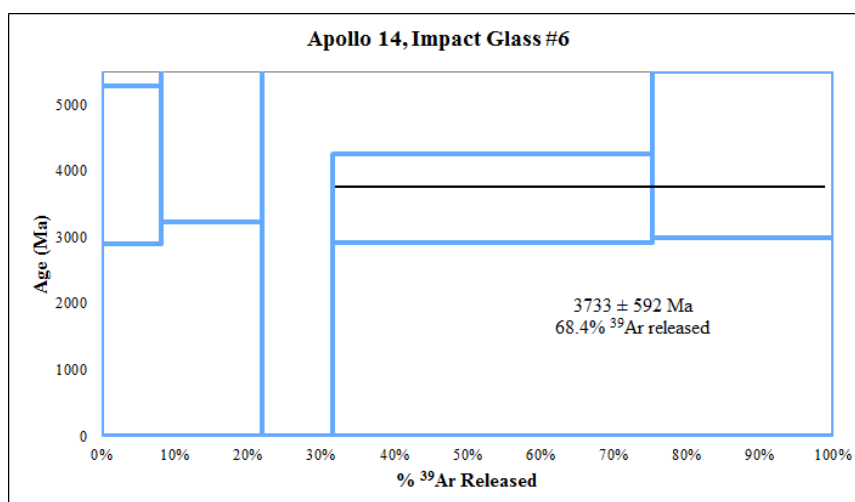
Using Size and Composition to Assess the Quality of Lunar Impact Glass Ages

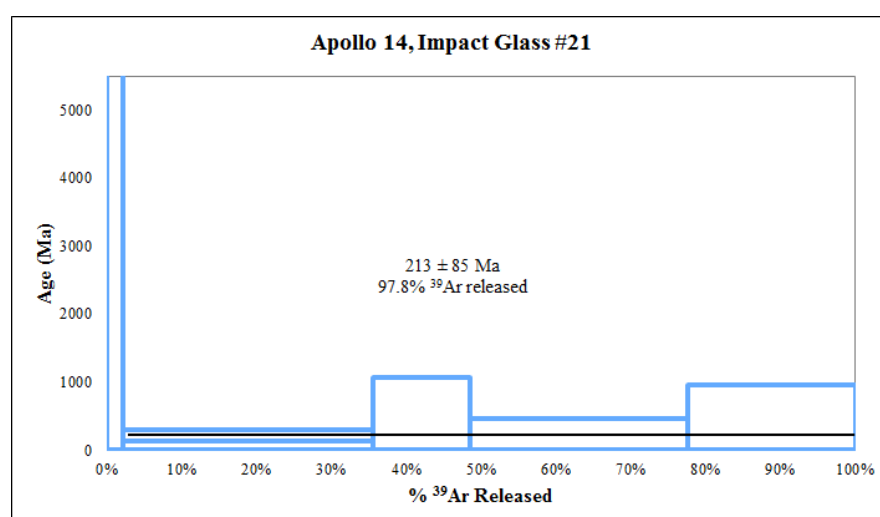
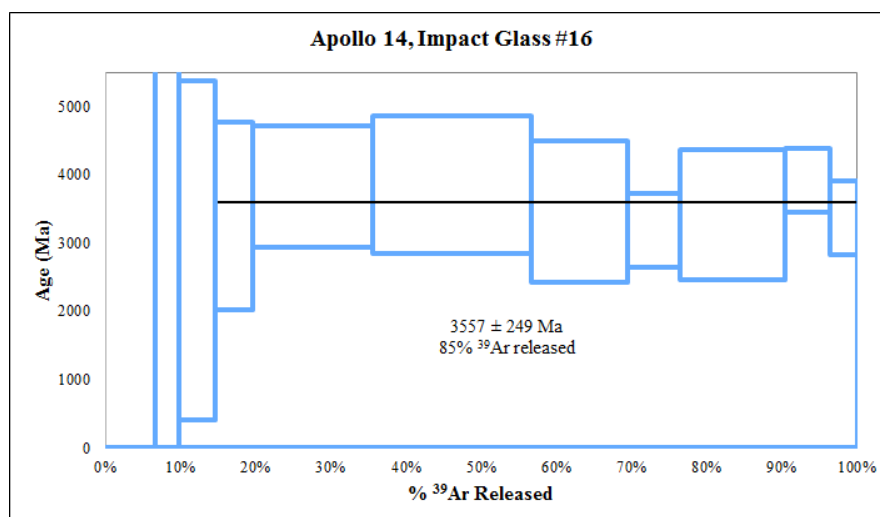
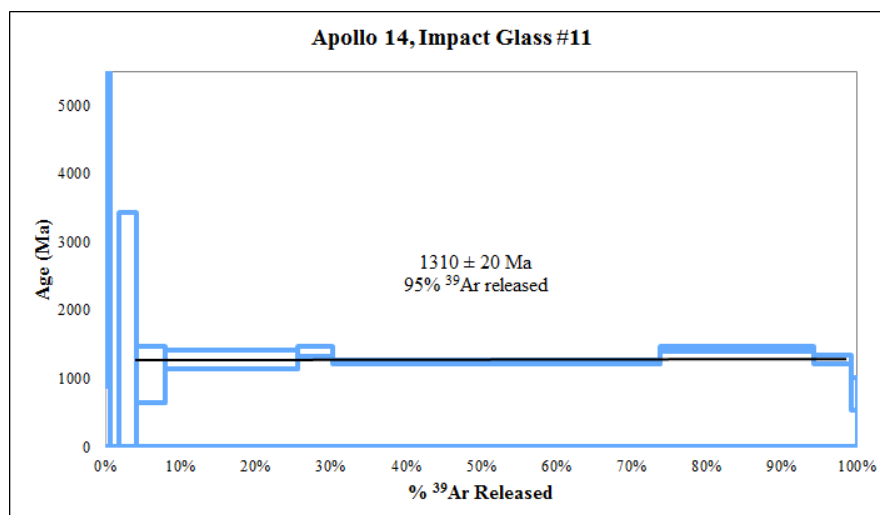
Pham Nguyen ¹ and Nicolle Zellner ^{2,*}

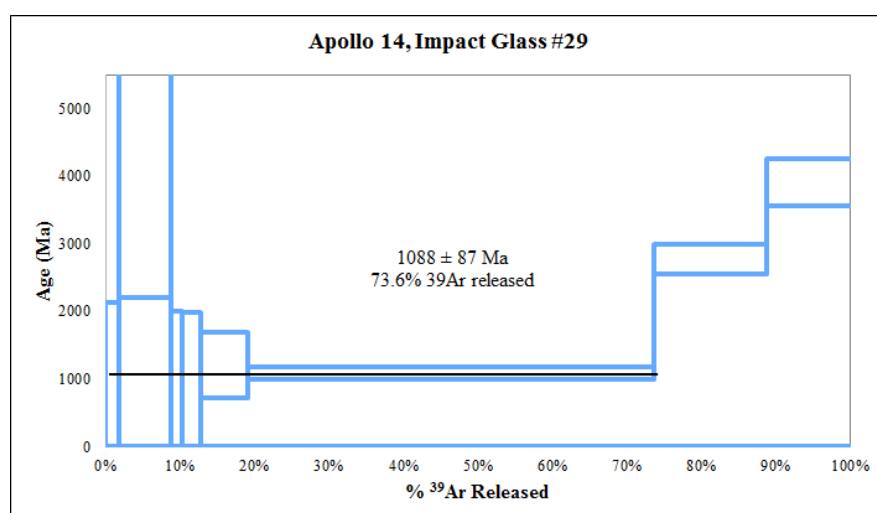
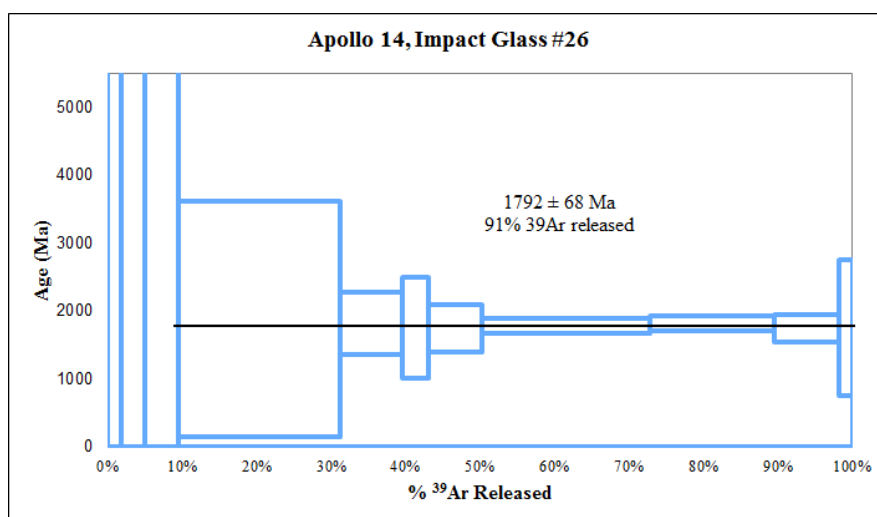
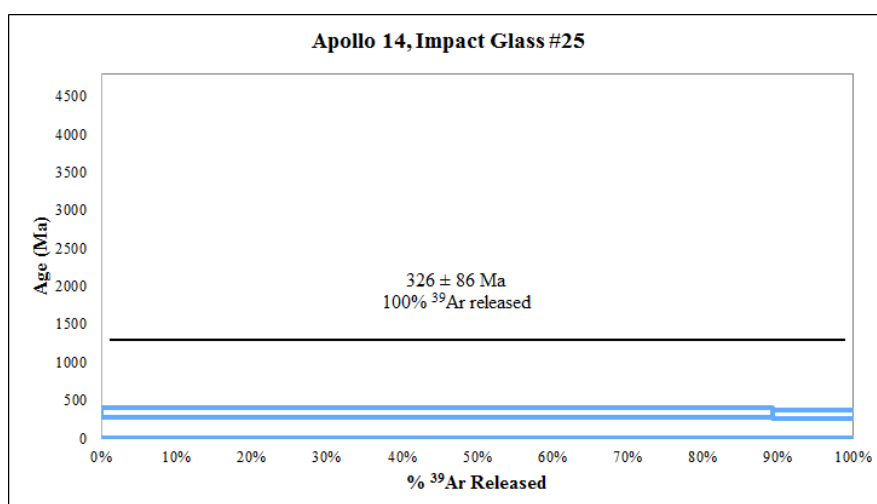
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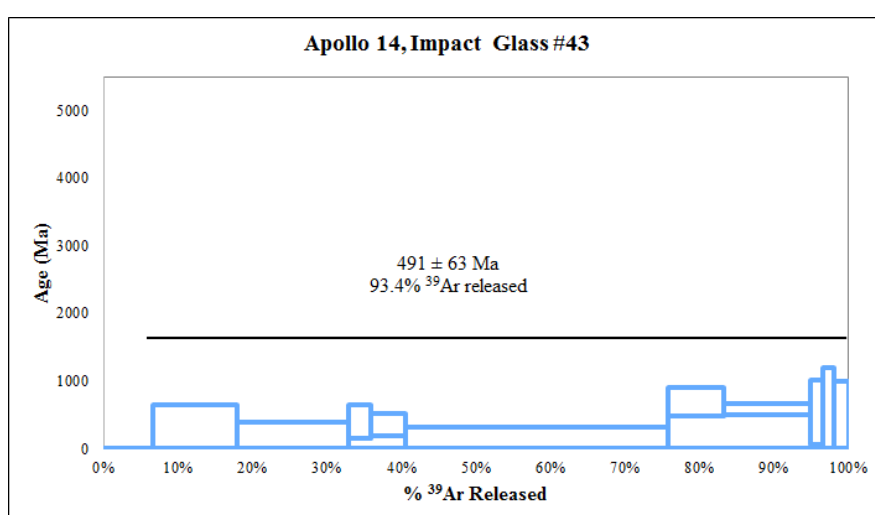
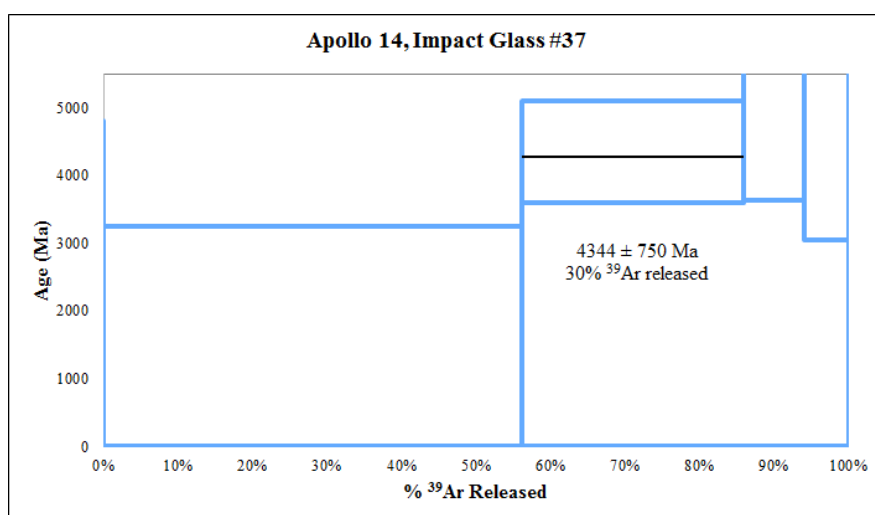
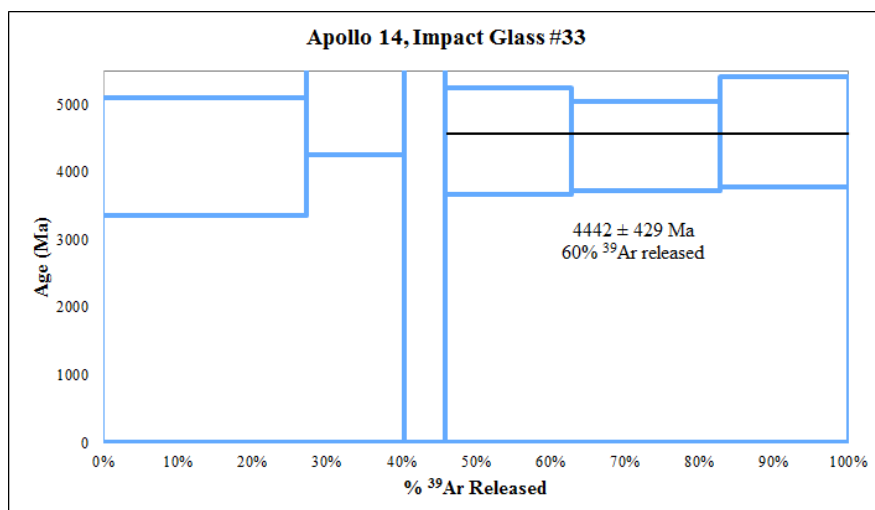
² Department of Physics, Albion College; Albion, MI 49224, United States

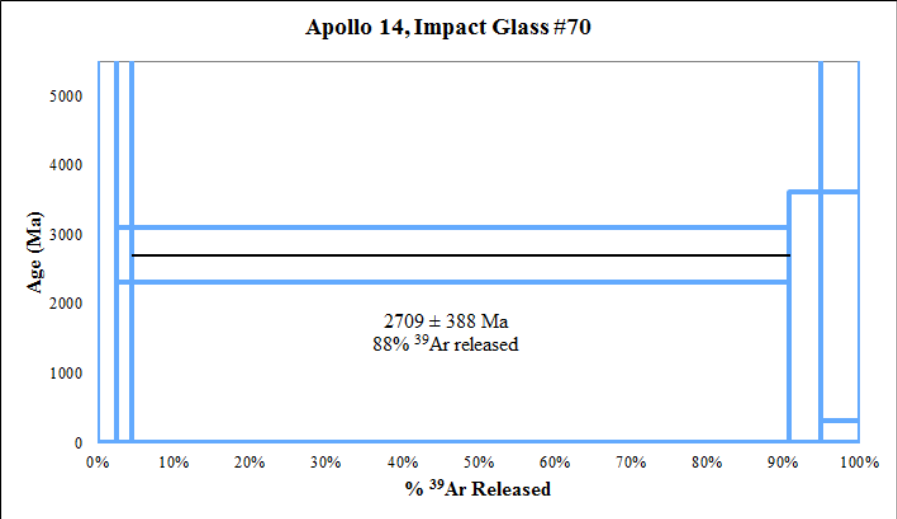
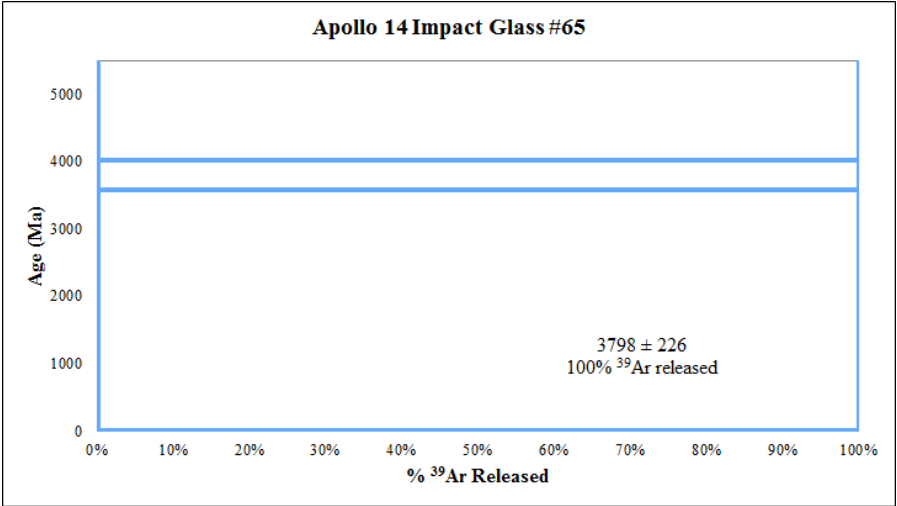
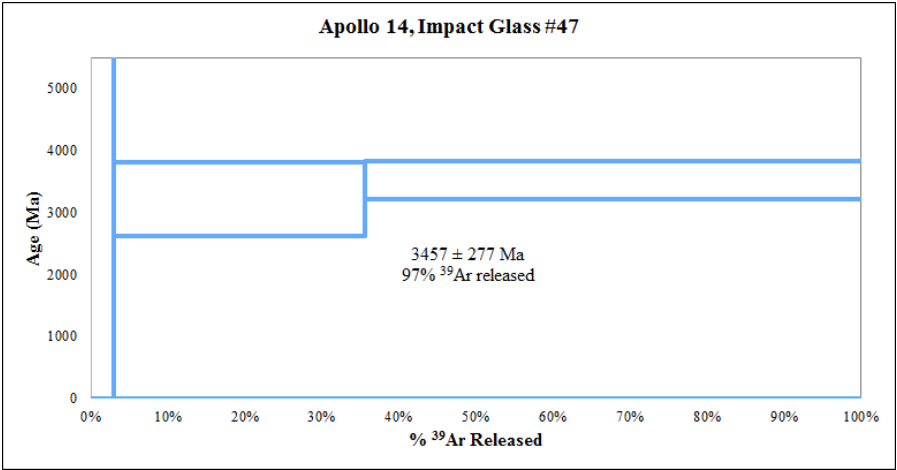
Supplementary Materials

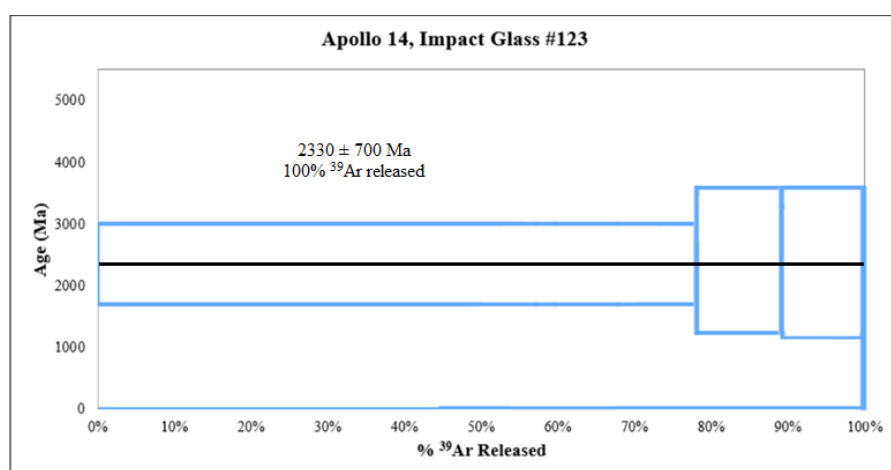
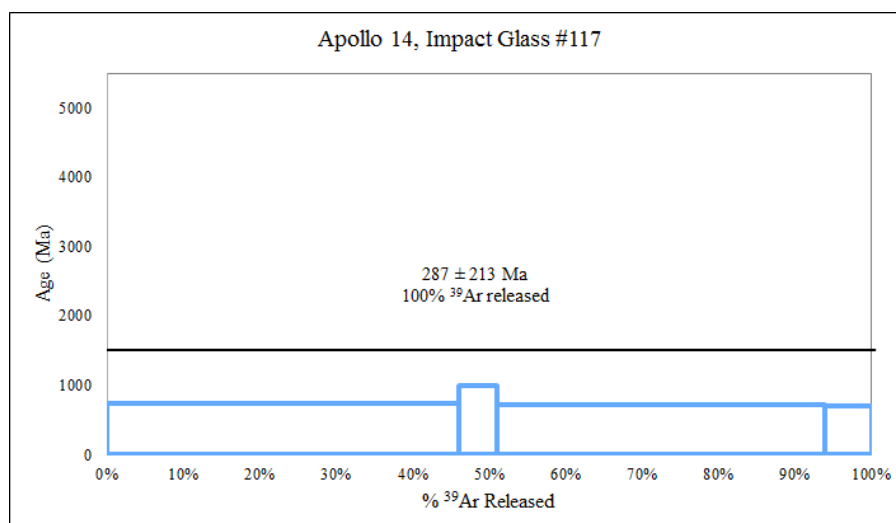
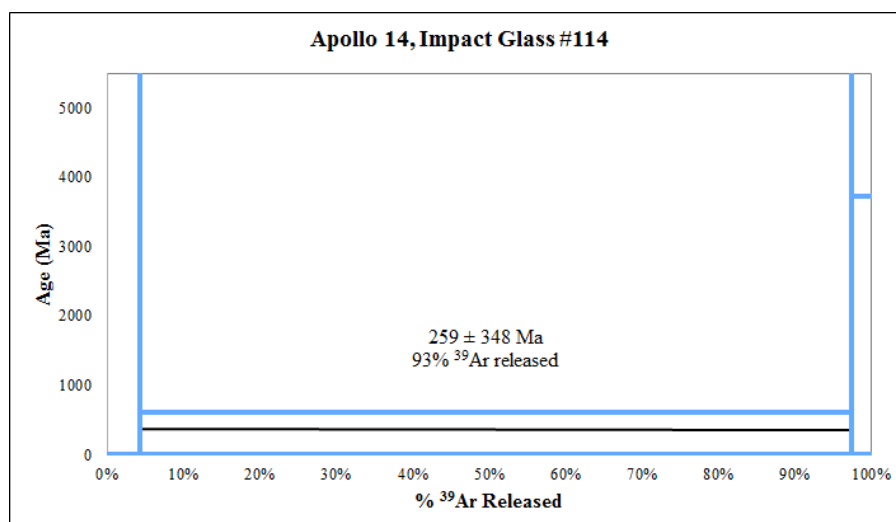


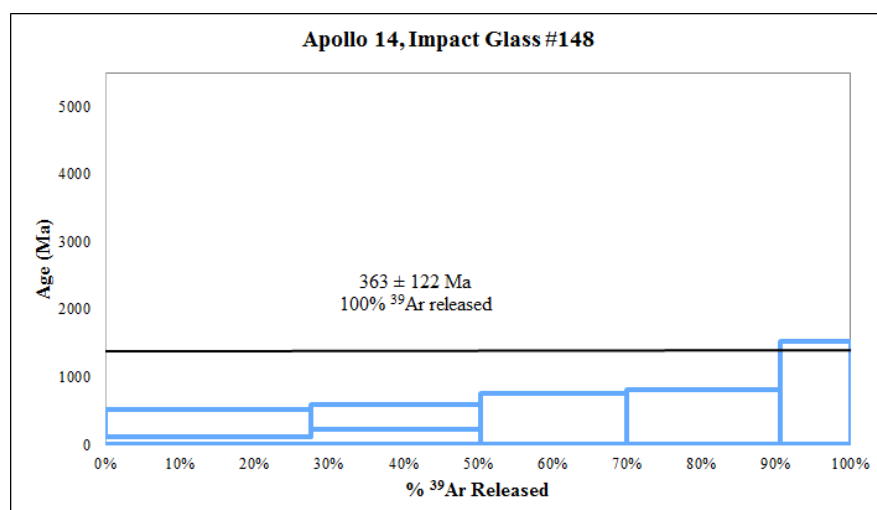
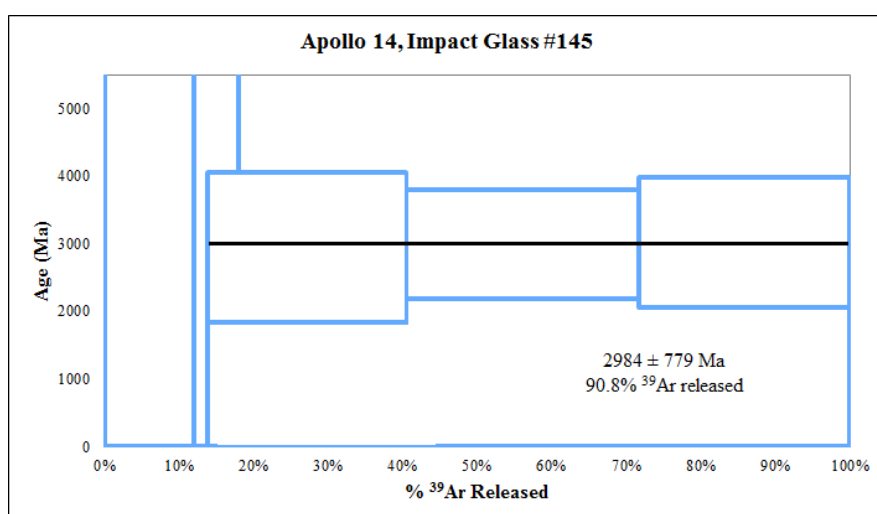
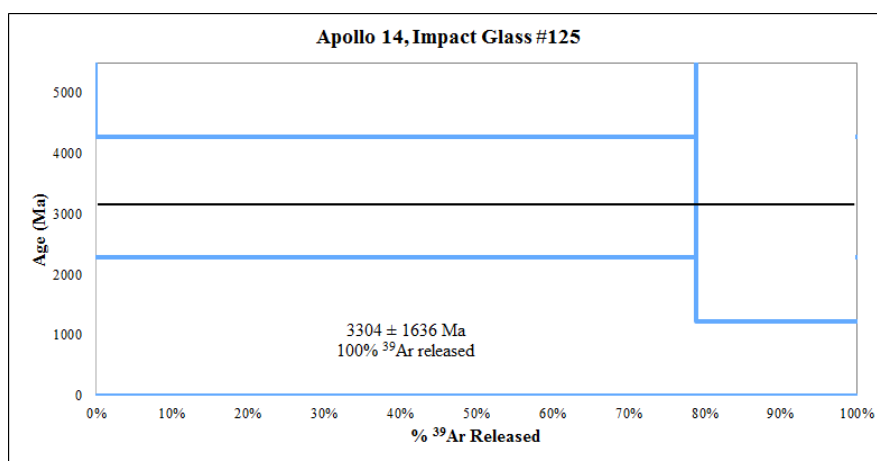


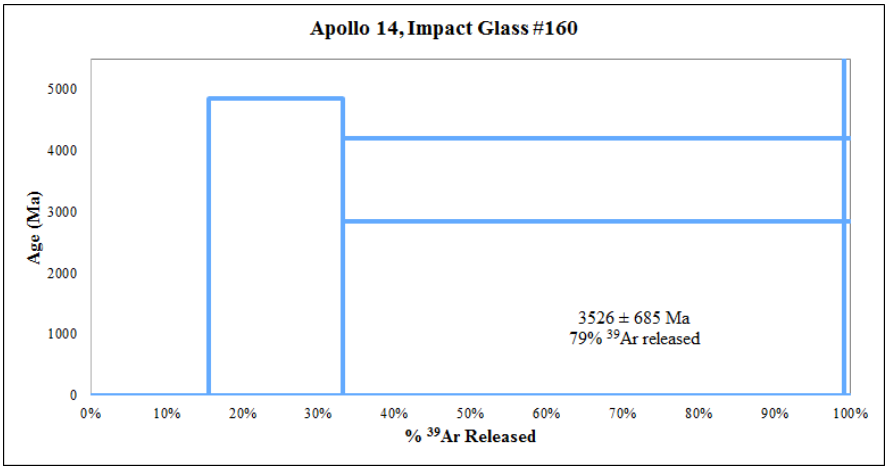
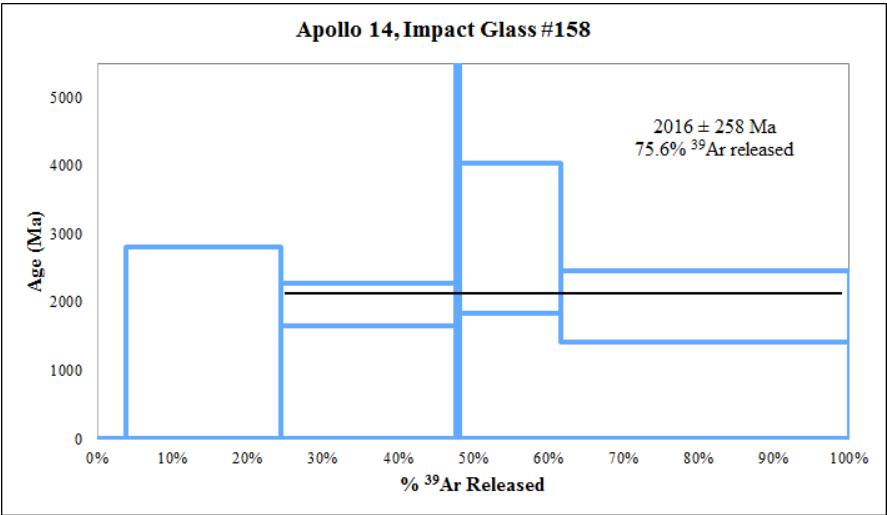
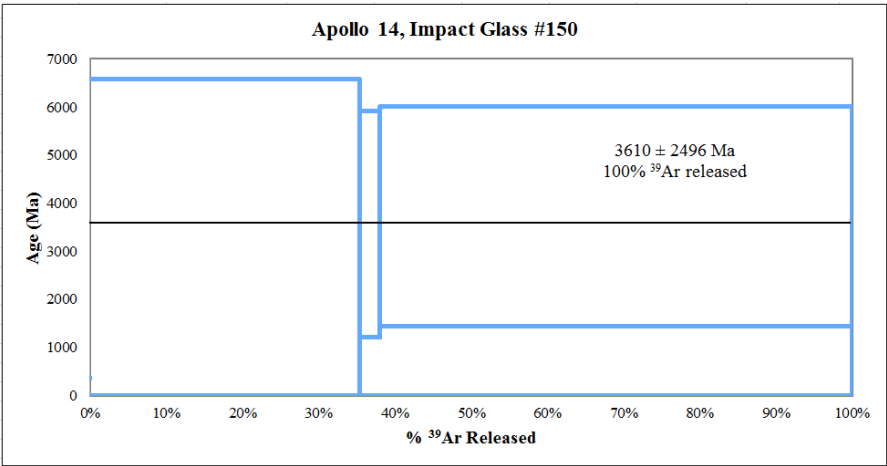


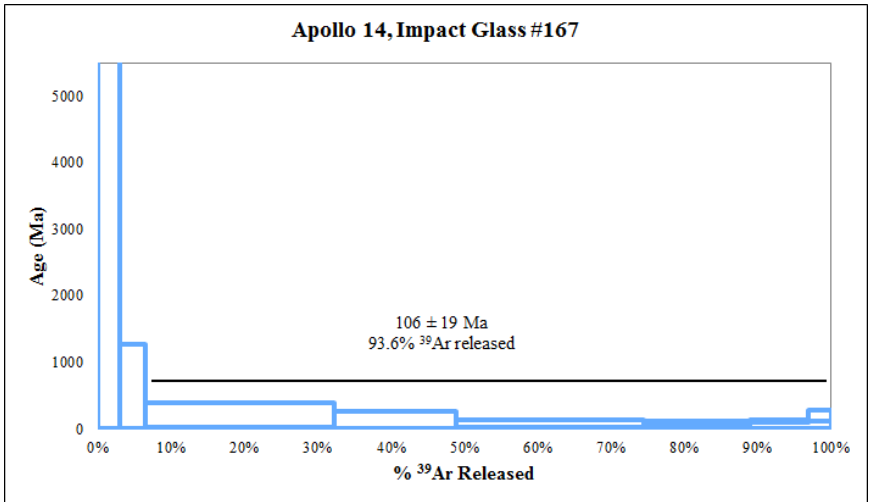
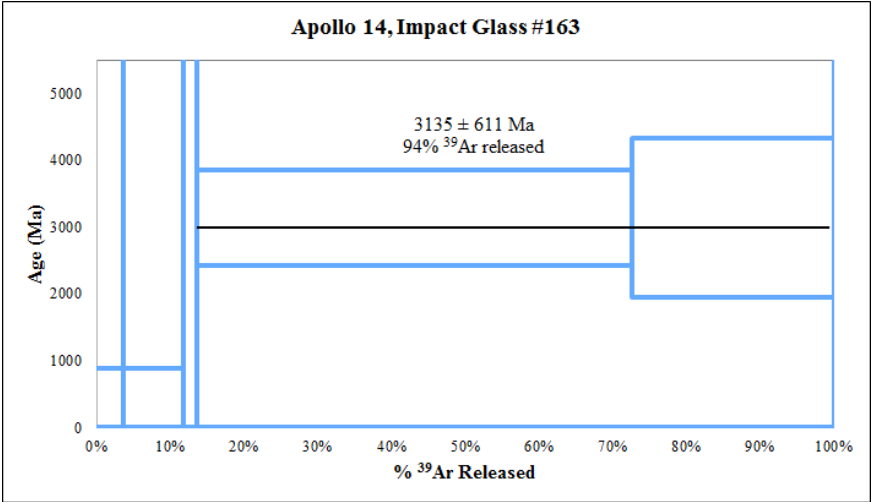
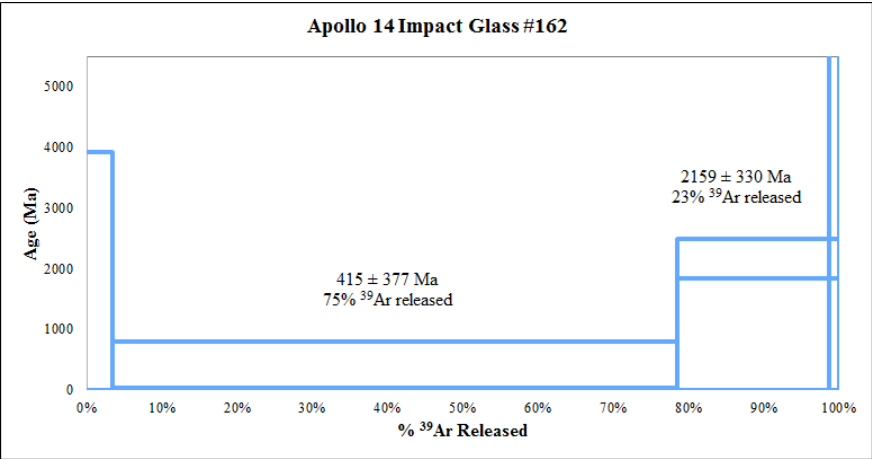


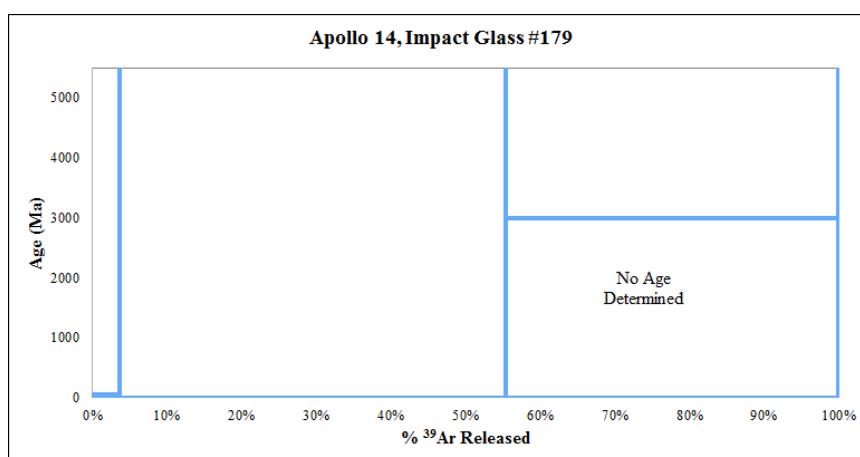
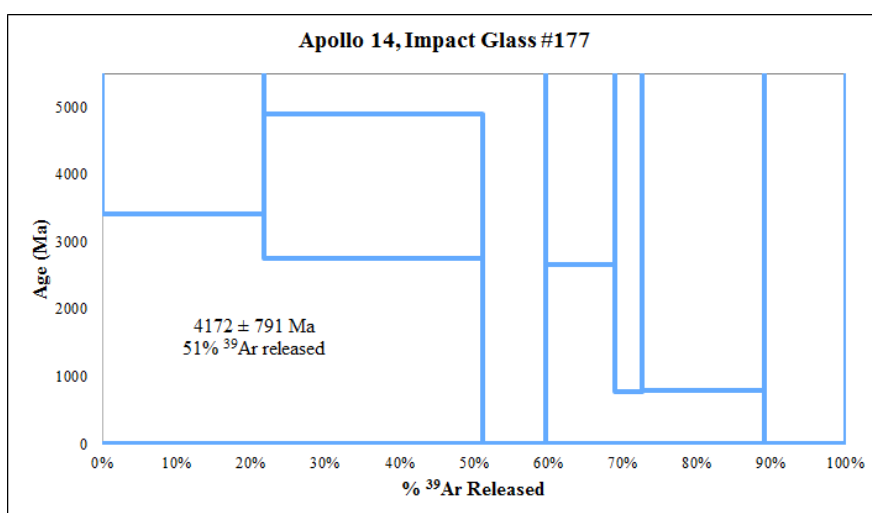
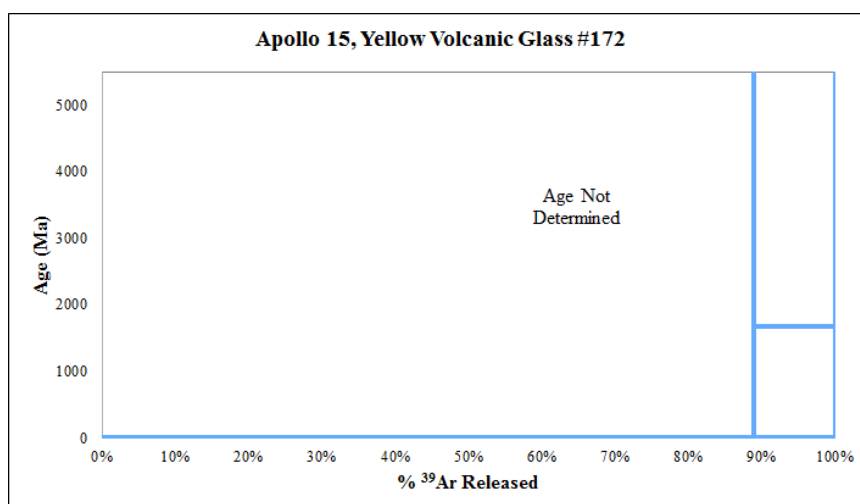


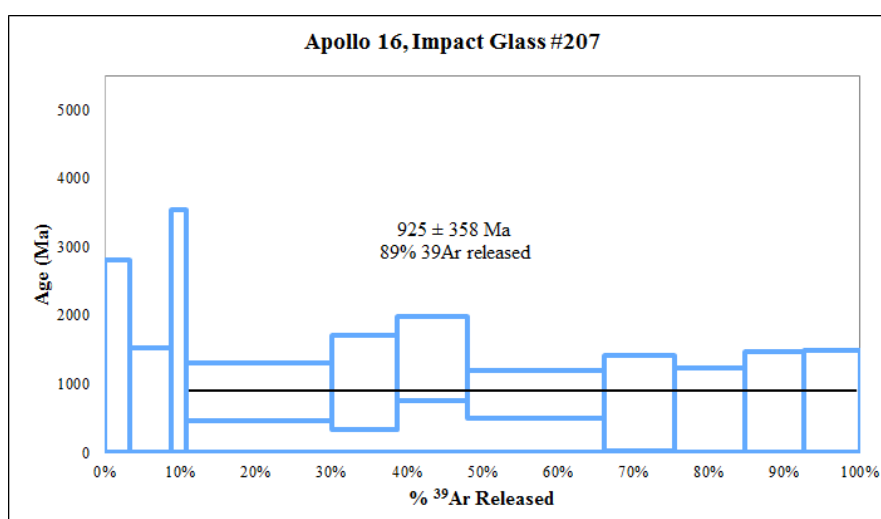
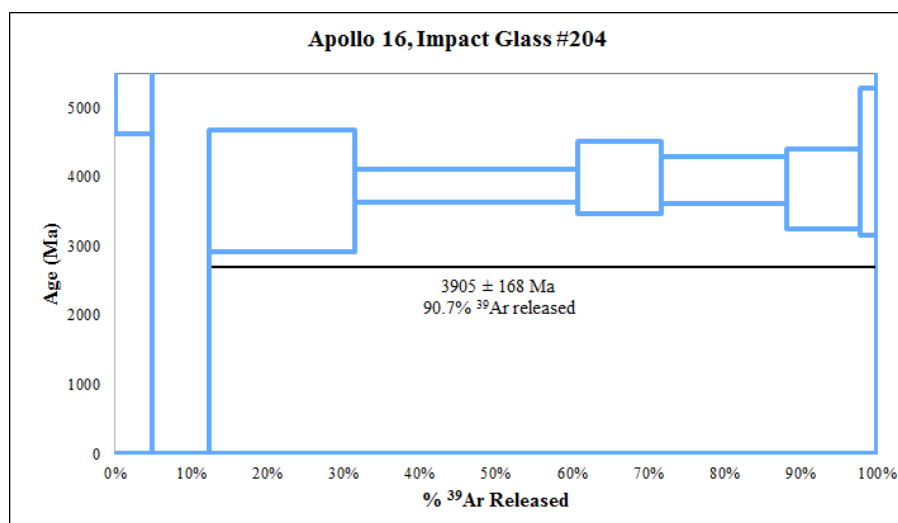
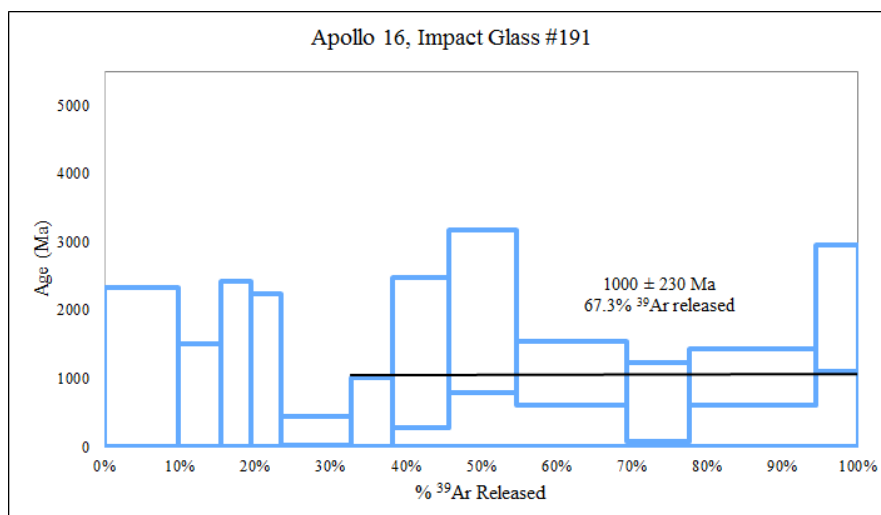


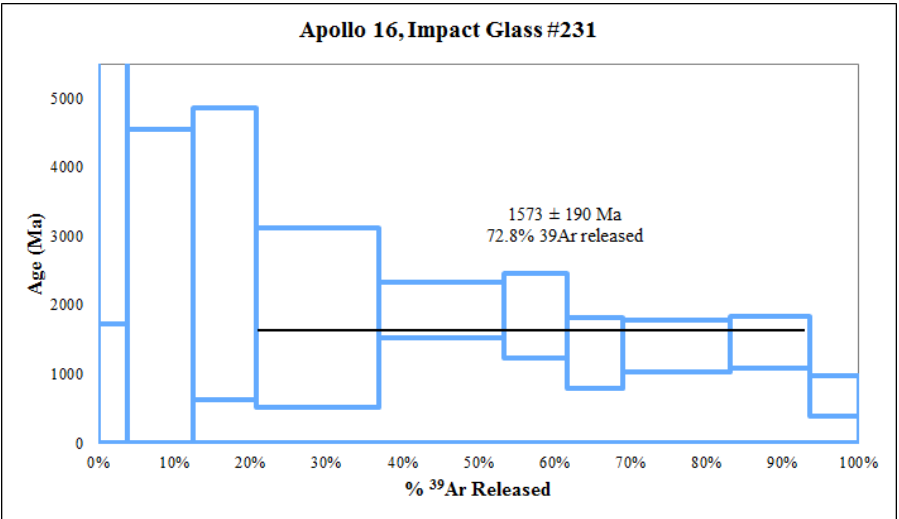
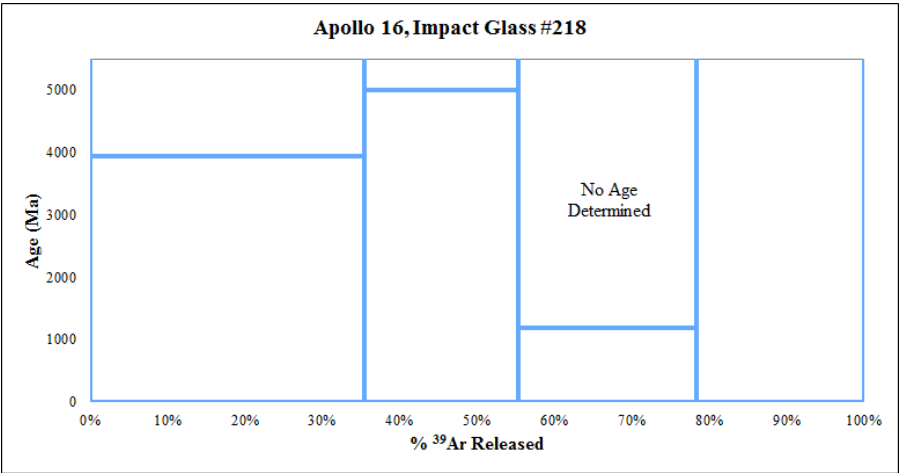
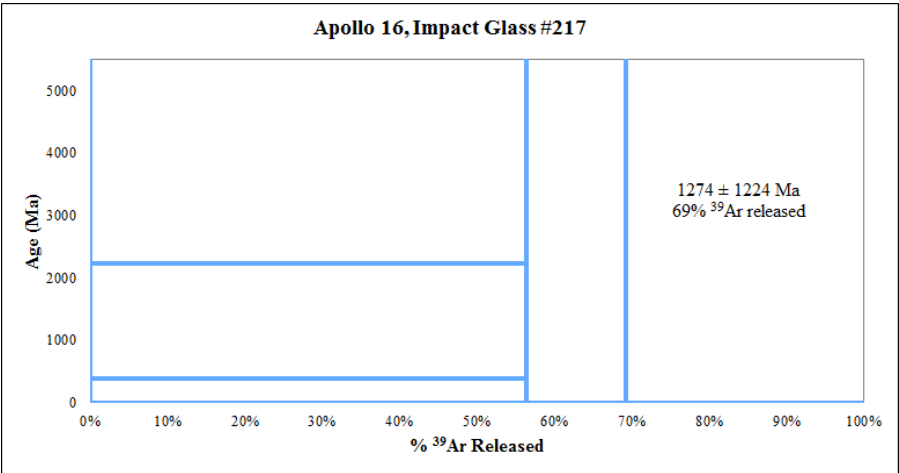


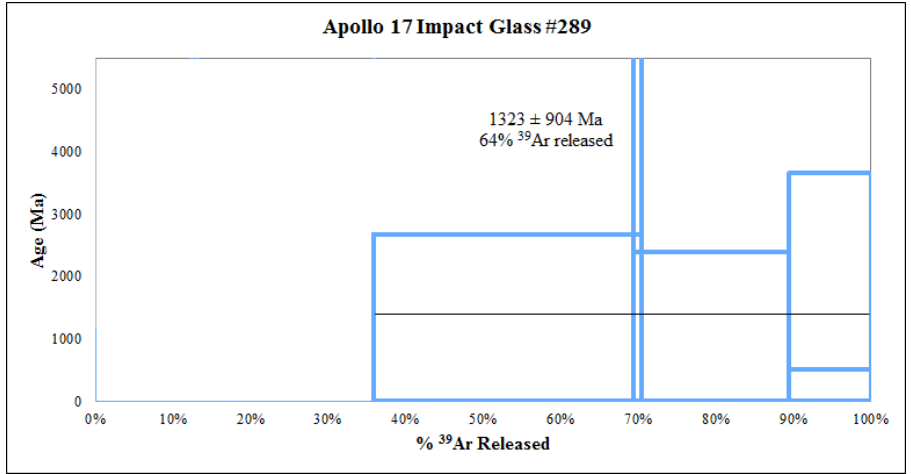
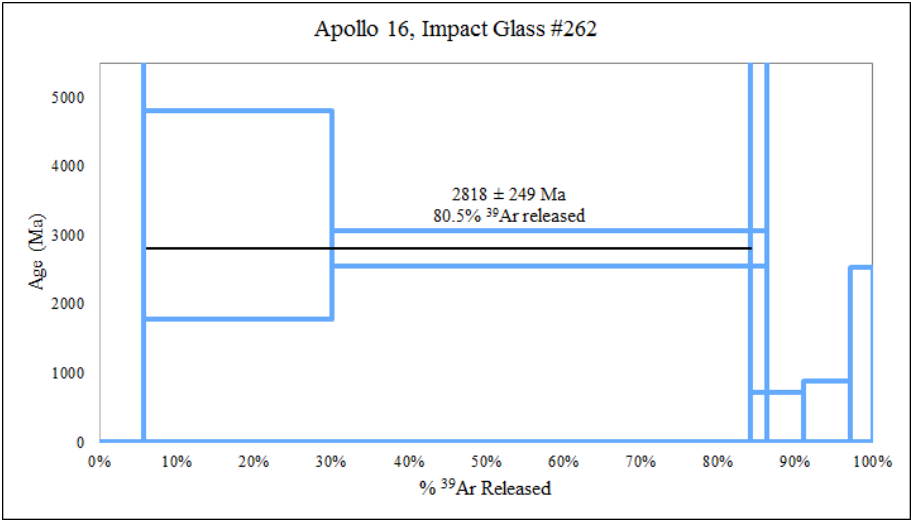
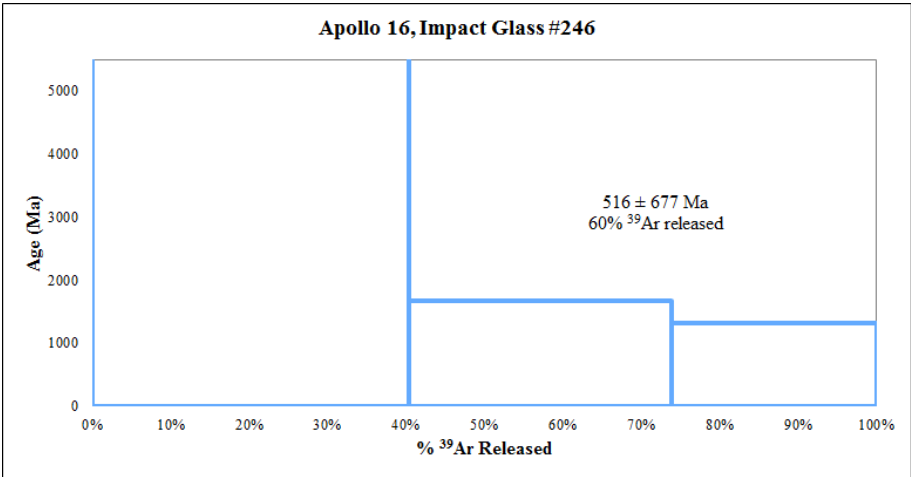


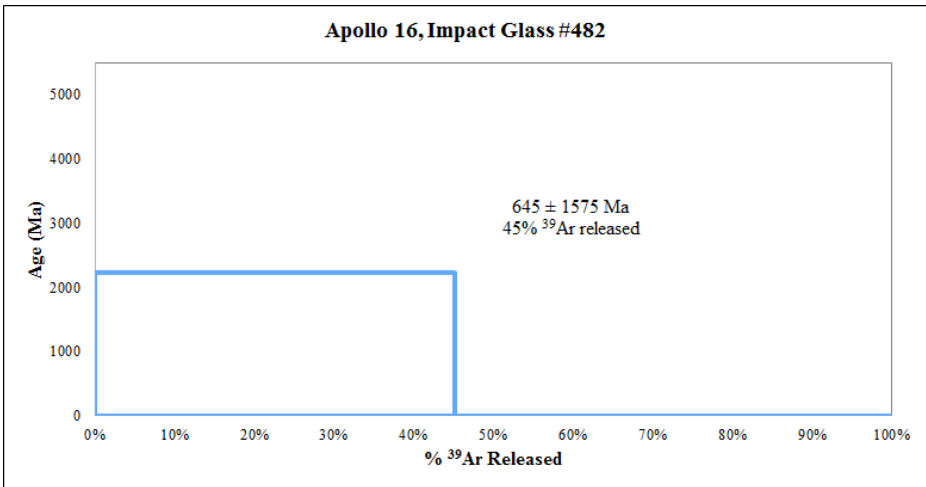
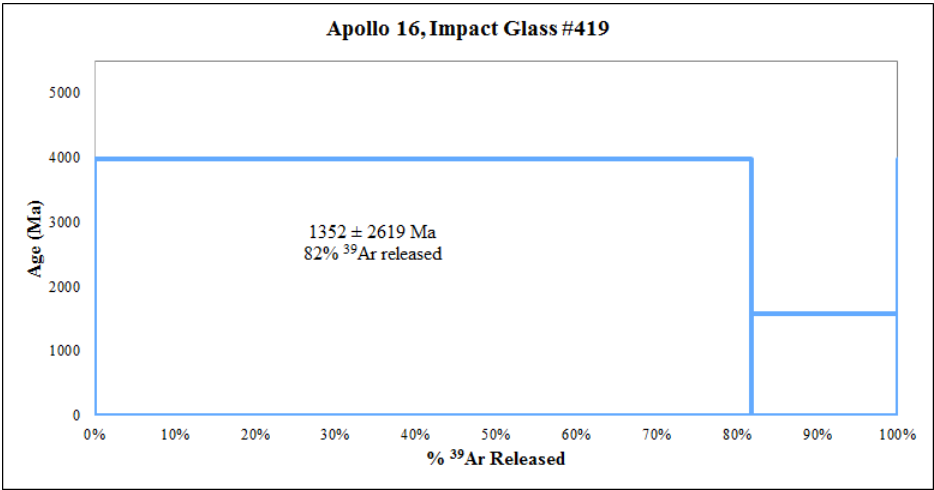
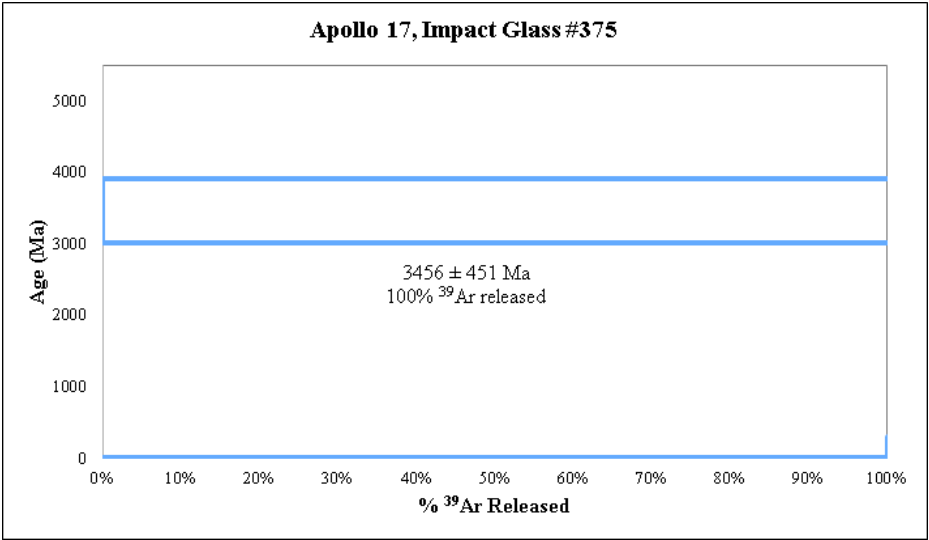












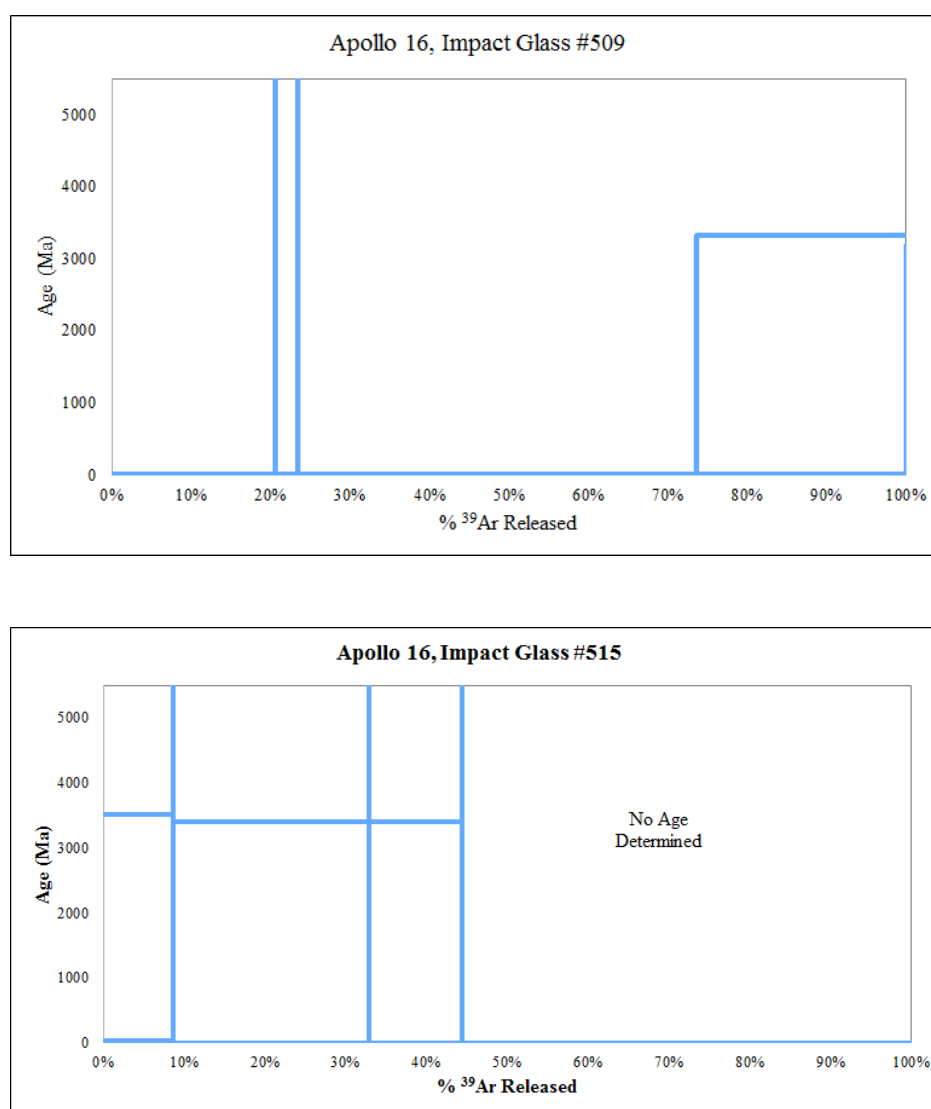


Figure S1. $^{40}\text{Ar}/^{39}\text{Ar}$ data for 43 newly analyzed Apollo 14, 16, and 17 lunar impact glasses. Data were acquired by the VG5400 mass spectrometer at the University of Arizona – Tucson. Data were reduced using Isotopic Analysis with Correlated Errors (ISAC; Hudson, 1981) and Deino software (Weirich, 2011; Deino, 2001); the decay constant of Steiger and Jäger (1977) and Renne et al. (2010) were used to determine the age of each sample (Table 1).

Table S1. Major-element compositions for Apollo 14, 16, and 17 lunar impact glasses.

Apollo 14 14259,624	Glass Sample	Estimated Size (m)	Shape	wt% SiO ₂	TiO ₂	Al ₂ O ₃	Cr ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O	Total
	A6 /6	150	dumbbell	46.50	1.80	17.84	0.15	10.72	0.14	9.79	11.48	0.21	0.15	98.78
	B1/8	174	shard	45.38	1.15	17.80	0.27	15.01	0.25	6.90	10.86	0.39	0.26	98.26
	B4/11	300	shard	48.18	1.90	15.48	0.19	10.82	0.15	10.37	10.27	0.85	0.58	98.77
	C2/16	300	shard	46.72	2.79	14.38	0.22	12.67	0.18	9.60	9.91	0.44	0.21	97.11
	C7/21	250.5	oblong	46.66	1.70	17.75	0.15	10.30	0.16	11.81	10.81	0.24	0.16	99.73
	D4/25	199.5	dumbbell	48.59	2.00	17.19	0.18	10.68	0.16	9.30	10.73	0.36	0.29	99.45
	D5/26	300	shard	47.89	2.28	14.94	0.27	12.46	0.18	9.97	10.30	0.64	0.50	99.44
	E1/29	250.5	sphere	48.35	1.75	16.17	0.18	10.20	0.15	11.17	9.98	0.54	0.43	98.90
	E5/33	174	sphere	44.17	2.17	17.44	0.25	11.23	0.14	9.27	12.11	0.35	0.30	97.44
	F2/37	199.5	shard	50.49	2.23	16.85	0.08	10.09	0.16	7.29	10.45	0.84	0.58	99.05
	G1/43	250.5	shard	46.38	2.80	10.45	0.43	19.78	0.26	8.81	9.87	0.46	0.28	99.53
	G5/47	150	sphere	47.25	1.87	15.97	0.19	11.10	0.15	9.98	10.14	1.17	0.88	98.70
	J2/65	199.5	shard	48.94	2.13	14.08	0.23	12.75	0.15	10.74	9.30	0.81	0.58	99.70
	J7/70	199.5	sphere	47.23	2.00	16.05	0.22	11.72	0.15	10.55	10.29	0.72	0.36	99.29
	Q2/114	300	shard	47.63	1.21	21.94	0.14	6.85	0.10	8.99	12.59	0.53	0.28	100.25
	Q5/117	199.5	sphere	46.40	1.82	17.25	0.20	10.21	0.12	9.88	10.74	0.47	0.30	97.39
	R4/123	199.5	sphere	46.63	2.22	17.53	0.18	10.50	0.16	9.92	10.90	0.18	0.14	98.35
	R6/125	199.5	shard	47.90	1.75	17.00	0.20	9.86	0.13	9.83	10.77	0.75	0.61	98.80
	U5/145	150	sphere	48.06	1.86	17.16	0.21	10.41	0.17	8.77	10.96	0.50	0.40	98.49
	V1/148	250.5	sphere	47.76	1.93	17.27	0.15	10.94	0.14	10.20	11.19	0.25	0.16	100.00
	V3/150	150	dumbbell	49.38	1.06	12.19	0.30	16.21	0.23	8.67	11.49	0.34	0.15	100.01
	W4/158	199.5	shard	52.02	1.54	17.64	0.16	9.95	0.13	4.87	11.12	0.62	0.72	98.77
	W6/160	199.5	shard	44.66	4.47	11.88	0.28	19.18	0.24	8.01	9.55	0.50	0.35	99.12
	X1/162	250.5	1/2 sphere	52.06	1.50	18.58	0.14	8.97	0.12	4.85	11.22	0.91	0.60	98.95
	X2/163	199.5	shard	46.52	1.82	16.71	0.21	10.26	0.14	9.73	10.97	0.66	0.45	97.48
	X6/167	300	shard	47.99	1.81	17.29	0.18	10.02	0.13	9.54	10.53	0.62	0.47	98.58
	Y5/172	276	shard	47.14	1.89	15.82	0.18	10.28	0.15	9.96	10.47	0.84	0.60	97.33
	Z3/177	276	shard	42.83	3.75	8.43	0.36	21.50	0.27	12.39	8.60	0.50	0.14	98.76
	Z5/179	300	sphere	45.76	1.38	22.12	0.13	6.57	0.12	8.04	13.53	2.31	0.35	100.30

Apollo 16 64501,225	Glass Sample	Estimated Size (m)	Shape	wt% SiO₂	TiO₂	Al₂O₃	Cr₂O₃	FeO	MnO	MgO	CaO	Na₂O	K₂O	Total
	B4/191	250.5	shard	45.89	2.18	17.95	0.24	9.49	0.12	12.00	11.60	0.33	0.11	99.91
	D3/204	349.5	shard	51.84	2.06	15.72	0.13	9.19	0.12	8.08	9.97	0.29	0.21	97.60
	D6/207	300	shard	42.68	3.9849	14.39	0.3642	15.31	0.2033	9.57	11.21	0.4774	0.1015	98.29
	F2/217	300	shard	42.77	3.94	15.41	0.36	12.76	0.19	10.15	11.20	0.45	0.11	97.34
	F3/218	199.5	shard	48.85	1.88	16.47	0.30	8.97	0.14	9.40	10.36	0.61	0.49	97.47
	H2/231	324	shard	44.27	3.7300	14.65	0.3196	14.30	0.1888	9.85	11.21	0.4696	0.1058	99.10
	J3/246	324	shard	41.01	8.3250	10.40	0.4228	17.69	0.2666	8.92	10.76	0.3662	0.0740	98.24
	L5/262	199.5	shard	49.73	1.8228	15.48	0.1702	10.54	0.13	8.60	10.04	0.703	0.7935	98.00
Apollo 17 71501,262	Glass Sample	Estimated Size (m)	Shape	wt% SiO₂	TiO₂	Al₂O₃	Cr₂O₃	FeO	MnO	MgO	CaO	Na₂O	K₂O	Total
	B1/289	199.5	sphere	43.59	5.58	14.28	0.3998	14.23	0.2027	10.37	11.45	0.3971	0.1143	100.62
	N3/375	250.5	shard	48.99	3.27	16.53	0.1998	10.40	0.1271	9.63	9.97	0.3452	0.3264	99.78
Apollo 16 66041,127	Glass Sample	Estimated Size (m)	Shape	wt% SiO₂	TiO₂	Al₂O₃	Cr₂O₃	FeO	MnO	MgO	CaO	Na₂O	K₂O	Total
	C5/419	150	shard	49.80	2.40	16.84	0.18	10.75	0.13	8.57	11.07	0.34	0.16	100.25
	L5/482	195	shard	47.69	2.48	14.37	0.25	13.30	0.19	9.38	10.40	0.13	0.08	98.26
	P4/509	150	shard	44.99	0.53	12.47	0.01	14.54	0.28	11.24	11.17	1.86	0.21	97.29
	Q3/515	195	shard	44.21	4.27	13.78	0.42	14.56	0.23	10.34	10.69	0.63	0.11	99.25

Table S2. K₂O (wt%), X(NBO), and age data for Apollo 14, 16, and 17 lunar impact glasses. "ND" means not determined. Assessment of argon release patterns are "good" if >50% ³⁹Ar was used in the age and most of the steps were concordant; "fair" if some of the steps were concordant; and "poor" if none of the steps were concordant.

	Sample #	K ₂ O (wt%)	X (NBO)	Age (Ma)	± 2 (Ma)	# Steps, % ³⁹ Ar Used in Age	Notes on Ages	Assessment of Age	Size (m)	Shape
Apollo 14 14259,624	37	0.58	0.24	4344	750	1, 30		poor	199.5	shard
	114	0.28	0.23	259	348	1, 93		poor	300	shard
	117	0.30	0.30	287	213	4, 100		poor	199.5	sphere
	162	0.60	0.19	2159	330	1, 23		poor	250.5	½ sphere
	172	0.60	0.31	ND	ND	N/A	N/A	poor	276	
	177	0.14	0.50	4172	791	2, 51	plateau	poor	276	shard
	179	0.35	0.24	ND	ND	N/A	N/A	poor	300	shard
Apollo 16 64501,225	217	0.11	0.33	1274	1224	2, 69	weighted	poor	300	sphere
	218	0.49	0.27	ND	ND	N/A	N/A	poor	199.5	shard
	246	0.07	0.35	516	677	2, 60	plateau	poor	324	shard
Apollo 16 66041,127	419	0.16	0.27	1352	2619	1, 82		poor	150	shard
	482	0.08	0.32	645	1575	1, 45		poor	195	shard
	509	0.21	0.45	ND	ND	N/A	N/A	poor	150	shard
	515	0.11	0.35	ND	ND	N/A	N/A	poor	195	shard