Chemical and spectrographic analyses, norms, and modes of volcanic rocks in the Beatty area, Nevada

[Analyses Nos. 1, 2, 8, 9, 15, and 17 by Paula M. Montalto; Nos. 4, 5, 6, 10, 11, 12, 24, and 25 by Dorothy F. Power; Nos. 7, 13, 14, 16, 20, and 21 by Ruth Kittrell; Nos. 3, 18, 19, and 22 by George Steiger; No. 23 by Margaret Balazs; and No. 26 by Paul Elmore]

	Lithoidal welded tuff	Lithoidal welded tuff	Lithoidal welded tuff	Basal tuff of welded tuff	Basal glass zone of welded tuff	Lithoidal welded tuff	Basal glass zone of welded tuff	Basal glass zone of flow	Felsitic zone of flow	Tuff	Basal glass zone of flow	Felsitic zone of flow	Glass zone of flow or intrusive	Rhyolite stock	Rhyolite glass intrusive	Rhyodacite dike	Latite flow		Quartz basalt flow	Basalt flow		Analcime basanite	Tuff	Lithoidal welded tuff	Tuff	Welded tuff
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chemical analyses (weight percent)																										
SiO_2	72.57	74.71	77.26	70.29	73.27	75.02	72.99	71.46	75.94	69.46	74.68	76.18	73.89	75.96	74.05	63.95	60.58	63.34	59.72	47.70	50.50	43.62	72.95	74.10	69.82	75.6
Al_2O_3	13.16	13.18	11.54	11.38	12.16	12.56	12.43	12.29	12.40	11.10	12.20	12.32	12.10	12.67	11.85	15.39	17.80	15.46	14.63	16.86	17.36	12.73	10.60	11.59	12.09	12.2
Fe_2O_3	2.06	1.14	.85	.96	.74	.99	.73	.65	.97	.59	.41	.50	.39	.99	.44	1.21	3.35	4.14	3.40	5.86	2.98	4.89	.81	3.36	1.33	.58
FeO	.26	.13	.13	.00	.23	.00	.23	.45	.17	.00	.16	.13	.20	.07	.27	2.24	1.08	.39	2.37	4.10	6.64	4.10	.05	.03	.15	.11
MgO	.27	.22	.20	.49	.12	.13	.31	.32	.19	.51	.11	.20	.09	.11	.21	.93	1.08	.66	2.69	6.62	5.12	9.37	.05	.08	.93	.36
CaO	.58	.44	.58	1.73	.50	.78	.33	1.20	.50	2.10	.38	.94	.48	.31	.74	3.11	4.10	2.01	6.55	9.71	8.76	11.62	.97	.14	2.58	.54
Na_2O	3.07	3.66	2.96	1.19	3.60	4.34	3.65	3.63	3.41	.75	3.42	3.65	3.29	4.24	3.19	3.16	4.27	3.89	3.28	2.98	3.14	2.96	1.46	4.00	1.55	3.2
K_2O	6.48	4.91	4.65	3.77	4.77	4.74	4.94	3.60	5.62	3.91	4.86	4.81	4.72	4.85	4.50	4.68	4.59	5.31	3.33	1.67	1.65	1.30	4.77	5.54	2.44	4.4
H_2O+	.57	.69	.96	4.93	2.95	.36	3.01	5.31	.28	6.15	3.13	.16	3.90	.11	3.59	.97	.53	1.16	1.38	.79	.41	3.94	3.76	.22	5.07	2.9
H_2O-	.20	.36	1.03	4.41	1.07	.18	.64	.58	.09	5.03	.14	.21	.39	.13	.58	.75	.60	1.89	.72	.45	.20	1.91	3.91	.35	3.52	
TiO_2	.30	.13	.18	.15	.14	.15	.15	.17	.17	.09	.09	.09	.10	.15	.12	.50	1.18	1.53	.95	1.79	1.47	1.46	.11	.22	.18	.10
P_2O_5	.07	.00	tr.	.01	.01	.02	.03	.04	.04	.01	.01	.02	.01	.01	.00	.15	.33	.22	.40	.79	1.06	.82	.00	.02	.03	.00
MnO	.09	.05	.03	.12	.09	.10	.10	.06	.06	.06	.07	.07	.07	.07	.05	.12	.09	.04	.10	.16	.18	.12	.05	.15	.05	.06
CO_2	.22	.08	.00	.02	.01	.43	.01	.04	.01	.03	.01	.41	.03	.09	.19	2.51	.05		1.12	.27	.07	.63	.01	.02	.00	.06
F	.05	.03					.11	.03	.06				.08	.02	.04	.07	.15			.10	.09					
Subtotal	99.95	99.73	100.37	99.45	99.66	99.80	99.66	99.83	99.91	99.79	99.67	99.69	99.74	99.78	99.82	99.74	99.78	100.04	100.64	99.85	99.63	99.47	99.50	99.82	99.74	100.
Less O	.02	.01					.05	.01	.03				.03	.01	.02	.03	.06			.04	.04					
Total	99.93	99.72	100.37	99.45	99.66	99.80	99.61	99.82	99.88	99.79	99.67	99.69	99.71	99.77	99.80	99.71	99.72	100.04	100.64	99.81	99.59	99.47	99.50	99.82	99.74	100.
Powder density	2.62	2.62		2.29	2.37	2.62	2.40	2.37	2.62	2.23	2.38	2.62	2.36	2.63	2.43	2.66	2.69			2.91	2.99					
Bulk density	2.52	2.36					2.21	2.31	2.48				2.33	2.50	2.34	2.59	2.56			2.81	2.71					
Differentiation index[1]	93.3	93.6		[2]80.9	[2]92.9	95.6	[2]93.2	[2]86.3	95.6	[2]78.5	92.9	94.6	91.3	96.8	91.4	80.5	73.4			35.2	37.5	28.4	84.9	92.1	72.1	91.6
Quantitative spectrographic analyses [Analyst, Paul R. Barnett]																										
B	<0.001	<0.001		0	0.001	0.001	0.001	0.003	0.003	0	0.0057	0.0024	0.004	0	0.003	0	0.001			0	0					
Ba	.10	.050		.020	.0042	.0058	.0049	.032	.032	.0044	.0005	.0014	.0007	.0057	.005	.18	.20			.14	.16					
Be	.0004	.0003		.0002	.0005	.0004	.0003	.0004	.0005	.0002	.0006	.0006	.0004	.0002	.0004	.0002	.0003			0	0					
Co	.0002	<.0001		0	0	0	0	.0001	<.0001	0	0	0	0	0	<.0001	.0004	.0005			.0034	.0028					
Cr	.0006	.0002		0	0	0	0	.0008	.0005	0	0	0	0	.0001	.0001	.0002	.0004			.017	.014					
Cu	.0003	.0002		.00006	.00004	.00009	.00008	.0002	.0001	.00009	.00004	.00017	.00004	.00009	.0001	.00042	.0008			.0057	.0071					
Ga	.002	.001		.0014	.0020	.0022	.0021	.001	.001	.0012	.0017	.0017	.0018	.0021	.001	.0026	.002			.0018	.0018					
La	.009	.006		.004	.004	.003	.003	.004	.004	0	0	0	0	.003	.003	.009	.012			.011	.020					
Li							.004						.003	.004		.005				.002	.002					
Mo	<.0001	<.0001		0	0	0	.0003	.0002	.0001	0	.0005	.0003	.0004	0	.0002	.0004	.0003			0	0					
Nb	.002	.002		.0020	.0028	.0032	.0030	.002	.002	.0024	.0033	.0033	.0032	.0032	.002	.0019	.002			0	0					
Ni	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0			.0087	.0054					
Pb	.003	.003		.0032	.0044	.0044	.0053	.003	.003	.0026	.0033	.0035	.0041	.0044	.003	.002	.003			0	0					
Sc	.0003	<.0002		.0003	0	0	0	.0003	.0003	.0004	.0004	.0004	.0004	.0005	.0003	.0005	.0011			.0029	.0026					
Sr	.02	.02		.0045	.0040	.0015	.0014	.01	.01	.0074	.0002	.0007	.0004	.0012	.004	.045	.1			.10	.092					
V	.003	.0005		0	0	0	0	.001	.001	0	0	0	0	0	.0004	.0040	.008			.028	.021					
Y	.004	.004		.0058	.0066	.0060	.0060	.003	.003	.0040	.0051	.0055	.0052	.0055	.002	.0050	.003			.0038	.0053					
Yb	.0003	.0003		.00046	.00050	.00050	.00051	.0003	.0003	.00046	.00054	.00055	.00051	.00046	.0003	.00048	.0003			.00035	.00049					
Zr	.038	.015		.022	.024	.023	.024	.010	.010	.0086	.0085	.0077	.0084	.020	.008	.040	.031			.029	.040					
Looked for but not detected	(3)	(3)		(4)	(4)	(4)	(5)	(3)	(3)	(4)	(4)	(4)	(5)	(5)	(3)	(5)	(3)			(5)	(5)					
Norm's (weight percent)																										
Quartz	28.74	33.72		44.64	32.76	31.14	31.74	33.48	33.42	45.84	35.16	35.34	35.76	32.22	36.72	25.08	9.30				0.72		43.92	30.48	44.58	38.22
Orthoclase	38.36	28.91		22.24	28.36	27.80	29.47	21.13	33.36	22.80	28.91	28.36	27.80	28.91	26.69	27.80	27.24			10.01	10.01	7.78	28.36	32.80	14.46	26.13
Albite	26.20	30.92		9.96	30.39	36.68	30.92	30.92	28.82	6.29	28.82	30.92	27.77	35.63	27.25	26.72	36.15			25.15	26.72	15.20	12.58	28.82	13.10	27.25
Anorthite	1.39	1.67		8.62	2.50	1.11	1.11	5.84	1.95	10.56	1.95	2.22	2.22	.83	2.22		15.85			27.80	28.36	13.07	4.73		12.79	2.78
Acmite																								4.62		
Nepheline																						5.40				
Corundum	.51	1.22		2.24	.10		.61	.31		1.84	.61	.31	.82	.20	.92	5.10						1.63	1.22		2.24	1.12
Wollastonite																	.70			5.45	3.13			.35		
Enstatite	.70	.50		1.20	.30	.30	.80	.80	.50	1.30	.30	.50	.20	.30	.50	2.30	2.70			13.90	12.80	31.05			2.30	.90
Ferrosilite								.13							.13	2.51					7.52					
Forsterite																				1.82		7.12				
Fayalite																										
Magnetite					.23		.23	.93			.46	.46	.70		.70	1.86				8.35	4.41	7.19				
Ilmenite	.61	.30			.30		.30	.30	.30							.91	2.28			3.50	2.89	2.74			.30	
Hematite	2.08	1.12		.96	.48	.96	.48		.96	.64	.16	.16		.96			3.36			.16				.80	1.76	1.28	.64
Apatite																	.67			2.02	2.69	2.02				
Calcite	.50	.20				1.00						.90		.20	.50	5.60				.60						
Fluorite							.16		.16				.07				.31									
Rutile				.16		.16								.16										.24	.08	
H_2O	.77	1.05		9.34	4.02	.54	3.65	5.89	.37	11.18	3.27	.37	4.29	.24	4.17	1.72	1.13			1.24	.61	6.50	7.67	.57	8.59	2.9
Total	99.86	99.61		99.36	99.44	99.69	99.47	99.73	99.84	100.45	99.64	99.54	99.63	99.65	99.80	99.60	99.69			100.00	99.86	99.70	99.28	99.64	99.72	99.94
Modes (volume percent)																										
Groundmass	79.3	79.4	76.0	94.7	91.6	94.7	96.7	97.5	97.3	93.2	94.7	92.4	94.2	96.7	87.1	66.6	81.0				6.6		91.9	96.0		83.6
Quartz	1.7	4.8	10.9	.2		.1	tr.	1.2	.3	1.0	1.8	4.6	1.4		5.7								3.1	.4		4.9
Plagioclase	16.3	7.0	3.6	.4			tr.	.3	.6	1.5	.7	1.4	2.6		.9	27.7	16.9			58.4	61.1		2.8	.2		3.8
Sanidine	.9	7.9	8.9		[6]5.0	[6]4.3	2.1	.1	.2		2.7	1.5	1.7	[7]3.1	6.2	.6							1.6	1.2		7.4
Magnetite	1.1	.6	.1	.1	.1	.1	.1							.2		2.1	1.6			7.3	6.6		.3	.3		.1
Pyroxene																	.5			21.0	23.4					
Olivine																				11.6	2.3					
Biotite	.7	.3	.4	.1				.4	.1		.1	.1	.1		.1	3.0				1.7			.3	.3		.2
Amphibole					.2	.1	.3																			
Xenoliths			.1	4.5	3.1	.7	.8	.5	1.5	4.3														1.6		
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0			100.0	100.0		100.0	100.0		100.0
Approximate plagioclase composition	An_{10}	An_{20}	An_{20}	An_{15-20}				An_{45}		An_{15-20}	An_{20}	An_{20}	An_{25}		An_{25}	An_{40}	An_{45}	An_{25-30}	An_{45-55}	An_{50-55}	An_{70}	An_{40-45}				

[1] Differentiation index of Thornton and Tuttle (1960).
[2] Calculated after subtraction of H_2O^-.
[3] Ag, As, Au, Bi, Cd, Ge, In, Ni, Pt, Sb, Sn, Ta, Th, Tl, U, W, Zn, and where zero is written.
[4] Ag, As, Au, Bi, Cd, Co, Cr, Ge, In, Ni, Pt, Sb, Sn, Ta, Th, Tl, U, V, W, Zn, and where zero is written.
[5] Ag, As, Au, Bi, Cd, Ge, In, Pt, Sb, Sn, Ta, Th, Tl, U, W, Zn, and where zero is written.
[6] Anorthoclase and sanidine.
[7] Anorthoclase.

1. Lithoidal welded tuff (sample BC 100), first (lowest) cooling unit of the welded tuff in the Bullfrog Hills caldera.
2. Lithoidal welded tuff (sample BC 149), second cooling unit of the welded tuff in the Bullfrog Hills caldera.
3. Lithoidal welded tuff (sample B 374, Ransome and others, 1910), fourth cooling unit of the welded tuff in the Bullfrog Hills caldera.
4. Basal nonwelded tuff (zeolitized to clinoptilolite) of welded tuff (sample MC 274a), probably the third cooling unit (analyses 4, 5, 6) of the welded tuff in the Yucca Mountain sequence.
5. Basal vitrophyre zone of welded tuff (sample MC 274b), probably the third cooling unit (analyses 4, 5, 6) of the welded tuff in the Yucca Mountain sequence.
6. Lithoidal welded tuff, devitrification zone (sample MC 274c), probably the third cooling unit (analyses 4, 5, 6) of the welded tuff in the Yucca Mountain sequence.
7. Basal vitrophyre zone of welded tuff (sample MC 299), late cooling unit of the Yucca Mountain sequence.
8. Basal vitrophyre zone of rhyolitic flow (sample BC 72b), same flow as analysis No. 9, upper part of Bullfrog Hills caldera sequence.
9. Felsitic zone of rhyolitic flow (sample BC 72c), same flow as analysis No. 8, upper part of Bullfrog Hills caldera sequence.
10. Zeolitized (clinoptilolite) tuff (sample MC 170a), probably lower part of Bullfrog Hills caldera sequence.
11. Basal vitrophyre zone of rhyolitic flow (sample MC 170b), same flow as analysis No. 12, probably lower part of Bullfrog Hills caldera sequence.
12. Felsitic zone of rhyolitic flow (sample MC 170c), same flow as analysis No. 11, probably lower part of Bullfrog Hills caldera sequence.
13. Vitrophyre zone of rhyolitic flow or intrusive (sample MC 295), probably lower part of Bullfrog Hills caldera sequence.
14. Rhyolite stock (sample MC 175), Yucca Mountain sequence.
15. Vitrophyric zone of rhyolite intrusion (sample MC 336), Yucca Mountain sequence.
16. Porphyry dike (sample MC 275) probably late Tertiary, intrudes Paleozoic sedimentary rocks.
17. Porphyritic latite flow (sample BC 148), upper part of Bullfrog Hills caldera sequence.
18. Porphyritic latite flow (sample B 172, Ransome and others, 1910), upper part of Bullfrog Hills caldera sequence.
19. Porphyritic quartz basalt flow (sample B 314, Ransome and others, 1910), upper part of Bullfrog Hills caldera sequence.
20. Basalt flow (sample MC 211), probably lower part of Bullfrog Hills caldera sequence.
21. Recent basalt flow (sample MC 297).
22. Analcime basanite (sample B 107, Ransome and others, 1910), probably alteration facies of a basalt flow in the Bullfrog Hills caldera sequence.
23. Zeolitized (clinoptilolite) tuff (sample TU–1), unit No. 3 of the Oak Spring Formation, Nevada Test Site, Nye County, Nev.
24. Lithoidal welded tuff (sample DDH 3–1029), unit No. 6 of the Oak Spring Formation, Nevada Test Site, Nye County, Nev.
25. Zeolitized (clinoptilolite) tuff (sample DDH 3–889), unit No. 7 of the Oak Spring Formation, Nevada Test Site, Nye County, Nev.
26. Welded tuff (sample DDH 3–251), unit No. 8 of the Oak Spring Formation, Nevada Test Site, Nye County, Nev.