GSA Data Repository Item # 8512

Title of article The Petrology and Geochemistry of the Ocate Volcanic Field, North-Central New Mexico

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see GSA Bulletin v. 96, p. 296 - 312

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Tables A and B

Table A Representative analyses of phases in Ocate lavas

	AOB OC-69						
	olivine		Pyroxene	Plagioclase		Spinel	
	phenocryst core	rim	groundmass	phenocryst core	rim	euhedral in olivine	groundmass
SiO_2	39.17	37.20	49.82	51.55	55.72	0.10	0.13
Al_2O_3	0.04	0.09	3.70	30.74	26.68	33.41	2.63
TiO_2	0.02	0.05	1.67	0.11	0.18	1.48	17.98
FeO^I	19.53	28.90	7.36	1.00	0.18	21.17	45.50
MgO	41.48	32.90	14.68	0.04	0.01	10.95	2.48
CaO	0.21	0.24	21.03	13.55	9.70	0.04	0.19
Na_2O	-	-	0.63	3.54	5.58	-	-
K_2O	-	-	0.03	0.04	0.49	-	-
Cr_2O_3	0.13	0.07	0.11	-	-	14.98	0.53
Total	100.51	99.50	99.02	100.44	99.32	98.70	99.20
$(Fe_2O_3)^2$						18.07	29.76

	Alkali Olivine Basalt OC-206						
	Olivine		Pyroxene		Plagioclase		Spinel
	phenocryst core	rim	phenocryst core	rim	phenocryst core	rim	groundmass
SiO_2	39.61	38.45	48.63	46.95	48.64	50.10	-
Al_2O_3	-	-	5.16	5.99	31.37	30.40	1.96
TiO_2	-	-	1.53	2.12	0.08	-	15.58
FeO^I	16.53	24.24	7.75	8.93	0.67	0.70	41.15
MgO	43.68	36.11	13.90	13.29	0.06	0.07	3.75
CaO	0.23	0.40	22.33	22.12	15.69	14.45	-
Na_2O	-	-	0.41	0.56	2.66	3.19	-
K_2O	-	-	-	-	0.17	0.23	-
Cr_2O_3	0.05	-	0.07	0.11	-	-	0.37
Total	100.15	100.09	99.78	100.08	99.36	99.21	98.80
$(Fe_2O_3)^2$							35.80

Table A. (cont)

Dacite OC-166 (Cerro Montoso type)

	Ortho-pyroxene core	Clino-pyroxene rim on Opx	Olivine	Biotite	Plagioclase embayed core	Plagioclase rim	Plagioclase calcic phenocryst
SiO_2	52.96	51.60	37.51	37.21	59.54	56.82	53.28
Al_2O_3	0.83	3.60	-	13.68	25.30	27.10	28.46
FiO_2	0.18	0.63	-	5.31	-	-	-
FeO[1]	22.25	9.71	28.66	16.20	0.59	0.54	0.92
MgO	21.48	15.69	34.27	14.30	-	-	-
CaO	1.05	18.01	0.22	-	6.52	9.61	12.39
Na_2O	0.06	0.52	-	0.62	6.28	5.79	4.23
K_2O	-	-	-	9.15	2.25	0.74	0.16
Cr_2O_3	0.17	0.25	0.17	0.26	-	-	-
Total	99.01	100.00	100.87	96.48	100.51	100.56	99.86

Dacite OC-59 (Agua Fria Peak type)

	Plagioclase phenocryst rim	Plagioclase core	Amphibole	Ortho-pyroxene	rhyolite inclusion in plag.	Biotite
SiO_2	50.70	60.43	42.55	51.93	79.93	37.89
Al_2O_3	27.89	24.63	10.92	2.43	10.21	15.31
TiO_2	-	-	1.88	0.23	0.30	4.38
FeO[1]	0.35	0.25	16.71	21.58	0.36	14.70
MgO	-	-	11.19	22.43	-	14.03
CaO	10.09	6.21	11.13	1.23	0.50	-
Na_2O	5.60	6.94	1.96	0.05	2.18	0.60
K_2O	0.53	1.34	1.45	-	4.98	8.84
Cr_2O_3	-	-	0.08	0.11	-	0.19
Total	100.79	99.88	97.88	100.08	99.50	95.91

[1] all Fe calculated as FeO

[2] numbers are Fe_2O_3 calculated by balancing the cation sum. FeO is the value obtained by charge balance.

Table A. (cont)

	Xenocrystic Basaltic Andesite OC-78							
	Olivine		Plagioclase		Plagioclase		Pyroxene	Spinel
	pheon-cryst core	rim	embayed core	rim	pheno-cryst core	rim	ground-mass	euhedral in olivine
SiO_2	40.73	37.50	57.89	56.05	52.61	55.23	51.69	-
Al_2O_3	-	-	25.35	28.23	29.77	27.95	2.08	46.96
TiO_2	0.03	-	0.23	0.16	0.12	-	0.45	0.60
FeO^1	14.46	30.08	1.46	0.80	0.69	0.89	12.64	15.40
MgO	46.10	32.01	0.19	0.11	0.13	-	12.95	14.90
CaO	0.23	0.26	7.85	9.86	12.42	10.54	19.23	-
Na_2O	-	-	5.43	5.21	4.06	4.68	0.51	-
K_2O	-	-	1.61	0.43	0.27	0.87	-	-
Cr_2O_3	0.11	0.09	-	-	-	-	-	16.49
Total	101.75	99.98	100.19	100.85	100.17	100.25	99.63	100.41
(Fe_2O_3)								4.53

	Rhyolite inclusions in XBA OC-78		Olivine Andesite OC-71			
	in embayed plag.	in quartz	Olivine	Ortho-pyroxene	Plagio-clase	Clino-pyroxene
SiO_2	77.59	77.91	39.24	53.28	54.61	50.77
Al_2O_3	11.30	11.12	-	4.36	27.29	3.17
TiO_2	0.66	0.60	-	0.26	-	0.99
FeO^1	1.56	1.55	20.65	10.30	1.41	7.19
MgO	0.04	0.05	40.19	29.02	-	16.22
CaO	0.19	0.14	0.21	1.95	10.36	19.97
Na_2O	1.77	2.12	-	0.12	5.14	0.43
K_2O	5.88	5.76	-	-	0.50	0.03
Cr_2O_3	-	-	-	0.31	-	0.27
Total	98.63	98.88	100.64	99.50	99.42	99.02

Table A (cont.)

	Transitional Olivine Basalt OC-34						
	olivine		Pyroxene	Plagioclase		Spinel	
	phenocryst core	rim	groundmass	phenocryst core	rim	euhedral in olivine	groundmass
SiO_2	39.91	36.72	48.30	51.59	58.46	0.13	-
Al_2O_3	0.07	0.05	3.57	29.76	24.97	41.21	0.79
TiO_2	0.04	0.09	1.43	0.10	0.14	0.77	25.19
FeO^1	16.16	32.66	11.95	0.54	0.69	24.90	54.31
MgO	44.23	30.50	11.72	0.10	-	14.99	0.96
CaO	0.25	0.41	20.36	13.79	7.50	0.04	-
Na_2O	0.02	-	0.79	3.64	6.93	-	-
K_2O	-	-	-	0.11	0.68	-	-
Cr_2O_3	0.13	0.18	0.07	-	-	16.65	1.14
Total	100.80	100.60	99.10	99.70	99.48	99.73	99.89
$(Fe_2O_3)^2$						1.25	17.50

	Norite xenolith in AOB OC-69					Olivine xenocryst in TOB OC-34		
	Orthopyroxene	Clinopyroxene rim	Spinel	Plagioclase		Olivine		Magnetite
				core	rim	core	rim	inclusion
SiO_2	54.14	52.29	-	55.19	51.93	41.63	39.71	-
Al_2O_3	2.62	2.10	7.16	28.00	29.65	-	-	3.23
TiO_2	0.25	0.72	8.10	-	-	-	-	1.29
FeO^1	17.21	9.23	27.52	-	-	6.88	16.03	27.04
MgO	26.77	15.77	4.48	-	-	51.72	45.27	3.44
CaO	0.84	19.23	0.04	10.75	13.35	0.11	0.30	0.13
Na_2O	0.05	0.65	-	5.53	3.88	-	-	-
K_2O	-	-	-	0.16	0.26	-	-	-
Cr_2O_3	0.06	0.09	0.35	-	-	0.07	0.09	0.44
Total	100.93	100.10	98.39	99.92	99.80	100.46	101.32	99.43
$(Fe_2O_3)^2$			48.27					58.09

Table A (cont)

	Rhyolite inclusions in dacite OC-166		Basaltic xenolith in dacite OC-166				Granitic xenolith in dacite OC-166	
	in embayed plag.	in quartz	olivine	pyroxene	plagio-clase	spinel in olivine	K-feldspar	Oligo-clase
SiO_2	77.83	74.13	38.14	50.71	53.28	-	64.83	60.86
Al_2O_3	10.69	12.45	-	2.87	28.46	40.96	19.00	23.77
TiO_2	0.62	0.78	-	0.95	0.11	0.76	-	-
FeO^1	1.32	2.21	26.24	9.05	0.92	24.51	0.81	0.65
MgO	0.22	-	36.27	15.58	-	10.81	-	-
CaO	0.35	0.48	0.23	20.40	12.39	-	0.22	5.28
Na_2O	2.36	2.34	-	0.37	4.36	-	3.57	6.83
K_2O	5.25	5.83	-	-	0.16	-	11.46	2.17
Cr_2O_3	-	-	0.15	0.29	-	16.65	-	-
Total	98.74	98.37	100.98	100.22	99.86	100.16	99.16	99.56
Fe_2O_3						6.46		

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TABLE B. MAJOR AND TRACE ELEMENT COMPOSITIONS OF REPRESENTATIVE OCATE LAVAS. Major elements were determined by XRF analysis at the Johnson Space Center (samples 18, 21, 191, 196, 70, 171, 176, 206, 19, 71, 59, 83, 114) and at the Department of Geology, University of Massachusetts (samples 52, 131, 166, 55, 57, 75, 64, 211). (Mg # is molar MgO/MgO+0.9* total Fe.) Normative mineralogy is in wt % (CIPW). Neutron activation was used to determine the elements FeO, Na_2O, Co, La, Ce, Sm, Eu, Tb, Yb, Lu, Sc, Hf. The elements Rb, Sr, Y, Zr, Nb, Ba, Cr, Ni were determined by energy dispersive XRF.

Sample #	18	21	191	196	70	171
Rock type	TOB	TOB	TOB	TOB	AOB	AOB
SiO_2	48.89	48.79	48.25	49.38	46.84	47.40
TiO_2	1.40	1.54	1.46	1.21	1.60	1.50
Al_2O_3	16.38	16.90	15.94	16.95	15.13	15.88
Fe_2O_3	1.07	1.41	1.13	1.11	1.07	1.14
FeO	8.70	10.05	9.17	9.00	8.70	9.26
MnO	0.13	0.17	0.17	0.20	0.18	0.20
MgO	7.00	6.81	7.67	6.92	8.05	9.02
CaO	8.65	9.73	8.94	9.71	9.06	9.51
Na_2O	3.80	3.30	3.30	3.15	3.53	3.23
K_2O	1.09	0.67	1.18	0.94	1.50	1.31
P_2O_5	0.21	0.22	0.20	0.20	0.48	0.42
H_2O	1.16	1.27	1.29	1.07	1.30	1.15
Total	98.48	100.86	98.65	99.84	98.44	99.32
Mg #	59	54	60	58	62	63
QTZ	-	-	-	-	-	-
OR	6.44	3.96	6.97	5.56	8.89	7.74
AB	29.08	27.92	25.72	26.66	20.58	20.19
AN	21.69	29.32	25.20	29.34	21.01	23.03
NE	1.67	-	1.19	-	5.04	3.87
DI	16.38	14.56	14.72	14.51	17.22	17.67
En	4.60	3.76	4.20	3.94	5.13	5.31
Fs	3.43	3.43	3.01	3.20	3.27	3.30
Wo	8.35	7.37	7.51	7.37	8.82	9.05
HY	-	0.20	-	2.72	-	-
En	-	0.10	-	1.50	-	-
Fs	-	0.09	-	1.22	-	-
OL	16.39	18.38	18.74	15.65	17.79	20.25
Fo	8.99	9.17	10.45	8.26	10.45	12.02
Fa	7.40	9.20	8.27	7.39	7.37	8.23
MT	1.56	1.82	1.64	1.61	1.56	1.66
ILM	2.66	2.92	2.77	2.30	3.04	2.85
AP	.46	0.48	0.44	0.44	1.05	0.92

TABLE B (cont)

Sample #	52	19	71	131	166	55
Rock type	OA	OA	OA	OA	dacite	dacite
SiO_2	53.02	54.27	53.92	56.46	67.28	68.14
TiO_2	1.55	1.26	1.30	1.36	0.69	0.37
Al_2O_3	16.68	16.45	16.73	16.85	14.26	16.05
Fe_2O_3	1.16	0.75	0.81	1.15	0.57	0.44
FeO	8.44	6.15	6.56	6.71	3.74	3.01
MnO	0.15	0.10	0.13	0.14	0.08	0.08
MgO	4.45	3.8	3.54	3.33	2.14	1.26
CaO	8.00	6.74	7.03	6.18	3.59	2.47
Na_2O	3.51	3.90	4.05	4.09	3.19	3.47
K_2O	1.73	2.56	2.72	2.71	4.00	4.66
P_2O_5	0.36	0.25	0.53	0.55	0.15	0.15
H_2O	-	1.32	1.37	-	-	-
Total	99.05	99.56	98.69	99.43	99.80	100.16
Mg #	48	52	49	46	50	42
QTZ	0.20	0.94	-	2.62	21.37	21.13
OR	10.22	15.13	16.07	16.02	23.64	27.54
AB	29.70	33.00	34.27	34.61	26.99	29.36
AN	24.65	19.82	19.44	19.62	12.78	11.37
NE	-	-	-	-	-	-
DI	10.74	10.03	10.22	6.50	2.91	-
En	2.51	2.57	2.45	1.47	0.70	-
Fs	2.83	2.38	2.63	1.77	0.74	-
Wo	5.40	5.07	5.15	3.26	1.46	-
HY	18.27	13.29	10.55	15.05	9.55	7.99
En	8.57	6.89	5.09	6.82	4.63	3.14
Fs	9.70	6.40	5.47	8.22	4.92	4.85
OL	-	-	1.96	-	-	-
Fo	-	-	0.90	-	-	-
Fa	-	-	1.06	-	-	-
MT	1.53	1.10	1.17	1.24	0.69	0.55
ILM	2.95	2.39	2.47	2.58	1.31	0.70
AP	.79	.55	1.16	1.20	0.57	0.33

TABLE B (cont)

Sample #	176	206	57	75	64	211
Rock type	AOB	AOB	XBA	XBA	XBA	XBA
SiO_2	47.29	46.00	53.06	55.17	56.30	53.63
TiO_2	1.54	1.43	1.48	1.35	1.25	1.47
Al_2O_3	15.88	14.66	15.13	15.81	15.81	16.48
Fe_2O_3	1.14	0.99	1.41	1.31	1.17	1.17
FeO	9.26	8.02	7.29	7.41	6.63	7.63
MnO	0.20	0.19	0.14	0.14	0.13	0.14
MgO	8.63	10.89	7.44	6.07	6.75	7.35
CaO	9.35	10.35	7.86	7.62	6.75	7.35
Na_2O	3.37	3.00	3.48	3.38	3.31	3.75
K_2O	1.44	1.46	2.14	1.97	2.38	2.00
P_2O_5	0.46	0.40	0.45	0.34	0.32	0.42
H_2O	1.05	1.35	-	-	-	-
Total	99.62	99.12	100.06	100.15	99.81	99.45
Mg #	62	71	63	58	58	55
QTZ	-	-	-	0.44	3.60	-
OR	8.51	8.63	12.59	11.41	13.95	11.84
AB	19.44	10.44	29.28	28.43	27.76	31.65
AN	23.95	19.98	19.19	22.03	21.17	22.27
NE	4.92	10.39	-	-	-	-
DI	16.10	23.20	13.78	11.06	8.27	9.65
En	4.74	7.79	4.17	3.06	2.31	2.58
Fs	3.09	3.46	2.54	2.38	1.75	2.18
Wo	8.24	12.05	7.06	5.63	4.21	4.90
HY	-	-	9.44	21.24	19.97	15.58
En	-	-	5.86	11.94	11.36	8.44
Fs	-	-	3.57	9.30	8.61	7.14
OL	20.07	20.18	9.80	-	-	3.36
Fo	11.72	13.55	5.86	-	-	1.74
Fa	8.35	6.63	3.94	-	-	1.64
MT	1.66	1.44	1.38	1.40	1.26	1.40
ILM	2.92	2.54	2.79	2.54	2.36	2.79
AP	1.01	0.87	0.96	0.74	0.70	0.92

TABLE B (cont)

Sample #	59	83	114
Rock type	dacite	dacite	dacite
SiO_2	65.47	65.57	62.86
TiO_2	0.63	0.76	0.78
Al_2O_3	15.43	15.96	15.14
Fe_2O_3	0.40	0.45	0.53
FeO	3.22	3.64	4.26
MnO	0.02	0.11	0.11
MgO	1.27	1.80	2.47
CaO	3.26	3.46	4.19
Na_2O	3.65	3.83	3.45
K_2O	3.65	3.99	3.62
P_2O_5	0.13	0.18	0.18
H_2O	1.09	0.55	1.23
Total	98.21	99.30	98.92
Mg #	40	47	49
QTZ	19.72	15.32	14.85
OR	21.57	23.58	21.39
AB	30.89	32.41	29.19
AN	14.94	14.57	15.13
NE	-	-	-
DI	0.39	1.28	3.80
En	0.08	0.29	0.93
Fs	0.12	0.34	0.95
Wo	0.20	0.64	1.92
HY	7.54	9.10	10.57
En	3.08	4.19	5.22
Fs	4.46	4.91	5.35
OL	-	-	-
Fo	-	-	-
Fa	-	-	-
MT	0.58	0.65	0.76
ILM	1.28	1.44	1.48
AP	0.28	0.39	0.39

TABLE B (cont)

Sample #	18	21	191	196	70	171	176	206
Rock type	TOB	TOB	TOB	TOB	AOB	AOB	AOB	AOB
FeO(%)	9.9	10.05	9.65	9.83	9.87	10.7	10.1	9.18
Na_2O(%)	3.29	3.3	3.30	3.15	3.53	3.22	3.37	3.05
Co	52	49	63	51	51	49	52	56
La*	59	71.5	65.5	68.5	150	151	135	140
Ce*	44	51	47	49.5	95	97	88	97
Sm*	26	32	26	25.4	41.5	37	37.6	38.5
Eu*	20.2	25.5	20.3	20.3	32.6	29.3	29	27.5
Tb*	18.5	17	15.1	14.2	22.1	21.5	14.5	12.6
Yb*	12	11.3	10.5	11.3	12.4	12.5	10	12.6
Lu*	11.1	10.3	9.4	9.4	11.1	11.2	10.9	10.9
Sc	24.5	25.0	25.2	27.3	23.9	23.6	25.4	25.2
Hf	3.7	3.67	3.4	3.1	4.8	3.6	3.8	4.2
Rb	32	19	31	22	47	42	36	45
Sr	479	593	585	492	1267	1349	981	1317
Y	28	19	20	21	13	13	17	15
Zr	141	146	137	107	200	164	184	173
Nb	18	23	19	18	32	24	27	24
Ba	429	520	495	475	933	901	775	1119
Cr	218	146	214	163	169	166	147	165
Ni	94	97	113	92	121	144	125	207

Sample #	57	75	64	211	52	19	71	131
Rock type	XBA	XBA	XBA	XBA	OA	OA	OA	OA
FeO(%)	8.31	8.70	7.58	8.90	9.16	6.19	7.52	7.33
Na_2O(%)	3.45	3.65	3.65	3.75	3.75	4.25	4.04	4.15
Co	51	44	45	51	38	37	38	77
La*	112	95	100	108	85	109	231	164
Ce*	73	60	73	76	64	81	146	102
Sm*	35	29	31	34	31	37	55	41
Eu*	26	21	22	26	23	25	36	28
Tb*	17	19	17	22	19	20	26	22
Yb*	10	12	12	11	12	13	13	13
Lu*	10	11	10	11	11	13	12	13
Sc	22.0	22.1	19.0	20.6	23	19	19	15
Hf	16	11.5	12	4.7	6.4	9.8	5.5	5.5
Rb	47	52	56	46	56	61	72	79
Sr	758	681	553	678	1211	690	1716	1275
Y	24	26	27	24	27	24.5	18	21
Zr	174	190	160	206	233	196	270	243
Nb	21	22	21	23	34	27	27	29
Ba	794	705	608	699	1235	826	1628	1392
Cr	200	191	127	113	83	58	27	25
Ni	130	126	87	66	41	39	17	17

TABLE B (cont)

Sample #	166	55	59	38	114
Rock type	Dacite	Dacite	Dacite	Dacite	Dacite
FeO(%)	3.55	3.10	3.77	3.79	4.44
Na_2O(%)	3.25	3.45	3.65	3.83	3.45
Co	25	17	20	19	27
La*	178	127	128	167	140
Ce*	113	77	75	102	98
Sm*	38	25	28	38	75
Eu*	21	18	18	23	33
Tb*	14.4	9	9	18	21
Yb*	13	6	7	13	19
Lu*	13	4	7	12	13
Sc	7.6	6.3	7.32	8.60	13
Hf	6.0	4.9	5.3	5.9	6.0
Rb	74	93	118	120	69
Sr	388	460	590	486	466
Y	24	14	20	32	26
Zr	144	177	213	217	189
Nb	25	14.1	18	27	35
Ba	762	1385	1282	1155	1147
Cr	45	21	32	60	37
Ni	29	15	12	63	21

*Chondrite normalized