

APPENDIX 8 - XRF whole rock chemical analyses of igneous rocks

Sample	Amygdaloidal basalt							"member B basaltic-andesite					
	WF-5	AB-38	91-601	91-603	91-606	91-613	93-607	91-607	91-608	93-605	93-614	avg. B	NE Fossil
SiO ₂ ----	51.26	52.08	53.55	52.95	53.54	52.32	52.71	58.17	55.02	55.92	55.01	55.00	51.17
Al ₂ O ₃ ---	15.24	15.30	16.18	15.93	16.03	15.42	17.62	13.93	14.32	14.30	14.17	13.55	14.75
TiO ₂ ----	1.592	1.247	1.265	1.299	1.255	1.259	0.919	1.624	2.448	2.439	2.369	2.1	2.93
FeO*----	8.34	8.09	7.79	7.65	7.84	8.06	14.43	10.74	11.34	11.33	11.38	12.5	4.91
MnO----	0.151	0.225	0.260	0.387	0.222	0.175	0.103	0.179	0.218	0.205	0.186	0.21	0.09
CaO----	9.96	10.06	9.73	10.05	9.35	9.51	3.74	5.56	6.98	6.83	6.65	6.14	6.45
MgO----	9.52	7.52	6.43	6.92	7.55	7.69	1.21	1.62	2.87	2.81	2.77	2.09	2.63
K ₂ O----	0.73	0.60	0.38	0.66	0.37	0.78	1.46	1.63	0.9	1.00	0.82	1.72	1.64
Na ₂ O---	2.65	3.10	3.10	3.06	3.06	3.01	2.94	3.71	3.75	3.79	3.87	3.25	3.6
P ₂ O ₅ ----	0.438	0.355	0.329	0.387	0.332	0.371	0.190	0.59	0.568	0.530	0.511	0.59	0.1
Total---	99.88	98.52	99.01	99.29	99.55	98.60	95.32	97.75	98.41	99.15	97.74	100.18	

Trace elements in ppm

Ni-----	181	159	132	146	133	149	36	3	6	6	9	-
Cr-----	500	460	371	427	375	427	75	7	25	23	21	-
Sc-----	33	27	27	30	28	25	16	31	32	32	37	-
V-----	227	201	200	216	198	208	147	98	226	210	199	-
Ba-----	337	411	344	507	323	396	422	598	463	530	455	-
Rb-----	8	29	12	14	15	24	39	82	66	52	60	-
Sr-----	573	559	519	656	520	578	440	184	197	230	195	-
Zr-----	163	148	139	155	137	151	137	244	234	237	233	-
Y-----	23	20	22	22	20	21	12	57	53	53	53	-
Nb-----	30.6	23.5	21.4	26.8	21.8	23.7	9.3	24.8	25.2	24.1	23.5	-
Ga-----	18	16	16	15	15	17	27	26	22	21	24	-
Cu-----	52	37	39	42	44	39	91	32	38	40	39	-
Zn-----	75	69	73	74	74	68	68	130	125	124	129	-
Pb-----	1	4	4	2	4	1	7	10	5	6	5	-
La-----	36	20	20	33	22	40	8	30	33	24	32	-
Ce-----	71	66	55	59	53	55	35	61	52	61	59	-
Th-----	4	3	5	4	4	4	5	8	5	6	6	-

Sample locations: WF-5 is from the "West Face Cliffs" (NE¼, NE¼ sec 10 T8S R19E; UTM: 703085E 4973782N). AB-38 is from "Black Spur" (SE¼, SE¼ sec 27 T7S R19E; UTM: 703152E 4977502N). Samples collected by Paul Hammond are designated by PH. 91-601 (PH) is a basalt flow (SE¼, SW¼ sec 26 T7S R19E; UTM: 703950E 4977422N). Sample 91-603 (PH) is from "Black Spur" (SE¼, SE¼ sec 27 T7S R19E; UTM: 703152E 4977502N). Sample 91-606 (PH) is a basalt flow (NE¼, SW¼ sec 26 T7S R19E; UTM: 703975E 4977942N). Sample 91-613 (PH) is a basalt flow (SE¼, NE¼ sec 33 T7S R19E; UTM: 701780E 4976603N). Sample 93-607 (PH) is a clast of basalt in a lahar (NW¼, NE¼ sec 34 T7S R19E; UTM: 702763E 4977041N). Sample 91-607 (PH) is an extensive basalt lava flow (SE¼, SE¼ sec 23 T7S R19E; UTM: 704835E 4979263E). Sample 91-608 (PH) is a basaltic dike (SW¼, NE¼ sec 26 T7S R19E; UTM: 704558E 4978420N). Sample 93-605 (PH) is an isolated basalt outcrop or large float block (NE¼, SE¼ sec 27 T7S R19E; UTM: 703365E 497875N). Sample 93-614 (PH) is a basaltic dike (SW¼, NE¼ sec 26 T7S R19E; UTM: 704536E 4978364N). "Avg. B" is the average of three samples from the western facies (from Peck, 1964 and Robinson, 1969). Sample "NE Fossil" is a sample of trachyandesite northeast of Fossil Oregon (from Robinson, 1969).

Alkalic basalts

Clarno tuffs

Sample	Cl-7	Mb-E	Mb-F	Fossil	east	dike 1	dike 2	PH-lava	JDAu-1	JDAu-2	Cr-1	G-1	Cl-5	east-1	east-2
SiO ₂ ----	45.96	45.57	45.76	46.17	44.98	51.6	52.0	47.74	69.33	74.38	76.55	72.75	72.23	79.47	77.47
Al ₂ O ₃ ---	14.74	14.56	14.66	16.2	15.47	13.1	13.7	15.27	12.52	11.16	12.25	12.78	13.19	10.01	10.85
TiO ₂ ----	4.329	3.82	3.51	2.72	3.25	3.05	3.00	3.33	0.167	0.155	0.204	0.215	0.134	0.042	0.044
FeO [*] ----	15.07	15.34	15.12	13.1	14.73	15.1	14.1	15.2	1.18	0.70	1.09	1.69	1.41	1.68	1.4
MnO----	0.212	0.19	0.19	0.23	0.17	-	-	-	0.023	0.029	0.011	0.023	0.015	0.012	0.008
CaO----	7.48	8.42	8.37	9.66	7.61	8.2	8.6	7.57	2.18	2.18	1.98	1.92	3.33	0.92	0.82
MgO----	5.10	4.97	5.2	4.75	4.97	4.7	3.5	4.70	0.60	0.63	0.45	0.33	0.48	1.15	1.14
K ₂ O----	1.19	0.84	0.82	0.55	1.23	0.60	0.75	1.46	4.24	3.37	2.82	5.28	0.60	1.37	1.23
Na ₂ O---	4.23	3.12	2.88	3.04	3.42	3.1	3.0	3.48	1.38	0.55	1.54	1.04	1.49	1.54	1.93
P ₂ O ₅ ----	0.800	0.65	0.5	0.49	0.62	-	-	-	0.034	0.015	0.043	0.041	0.030	0.011	0.007
Total--	99.11								91.65	93.17	96.94	96.07	92.91	96.12	95.27

Trace elements in ppm

Ni-----	24	-	-	-	-	-	-	-	12	13	16	13	11	12	13
Cr-----	34	-	-	-	-	-	-	-	6	3	18	11	10	1	2
Sc-----	25	-	-	-	-	-	-	-	6	2	12	8	10	2	3
V-----	217	-	-	-	-	-	-	-	0	11	31	30	27	0	12
Ba-----	254	-	-	-	-	-	-	-	1787	1196	1472	1210	4034	364	340
Rb-----	16	-	-	-	-	-	-	-	90	67	96	119	19	47	44
Sr-----	435	-	-	-	-	-	-	-	614	812	1027	651	2437	180	148
Zr-----	277	-	-	-	-	-	-	-	219	203	145	194	163	58	59
Y-----	37	-	-	-	-	-	-	-	75	57	22	53	33	13	8
Nb-----	35	-	-	-	-	-	-	-	27.3	22.2	11.8	19.0	11.2	8.3	8.0
Ga-----	26	-	-	-	-	-	-	-	24	17	11	23	14	12	15
Cu-----	26	-	-	-	-	-	-	-	20	16	24	23	15	11	15
Zn-----	160	-	-	-	-	-	-	-	98	82	47	88	48	29	32
Pb-----	1	-	-	-	-	-	-	-	18	16	7	19	9	9	10
La-----	5	-	-	-	-	-	-	-	43	31	12	29	32	3	15
Ce-----	47	-	-	-	-	-	-	-	81	97	52	82	15	31	26
Th-----	2	-	-	-	-	-	-	-	13	14	5	11	11	5	6

Sample locations: Samples "Fossil", Mb-E, Mb-F, and "east" are from Robinson, 1969 and Hay, 1962a: "Fossil" is the average of two samples from alkalic basalt north of Fossil OR; Mb-E is the average of two samples from member E, western facies; Mb-F is the average of seven samples from member F, western facies; and "east" is the average of four samples of alkalic basalt from the lower part of the John Day Formation, eastern facies. PH-lava is an alkalic basalt from the Painted Hills area interbedded with the middle Big Basin Member (from Taylor, 1981). Dike 1 and dike 2 are from basaltic dikes associated with the Mitchell strike slip fault near Mitchell, Or (from Taylor, 1981). Cl-7 is a sample of the lowest alkalic basalt in the Clarno Unit area (SW¼, SE¼ sec 22 T7S R19E; UTM: 70294E 4978985N). JDAu-1 & 2 is from the poorly welded part of the member A tuff from the Clarno Unit area collected by Paul Hammond (NE¼, SW¼ sec 27 T7S, R19E; UTM: 707625E 4977932N). Cr-1 is a sample of the Current Creek tuff from the Muddy Ranch area (SE¼, SW¼ sec 34 T9S R18E; UTM: 693370E 4966215N). G-1 is a sample of the Muddy Ranch tuff from the Gables (NW¼, NW¼ sec 4, T8S R19E; UTM: 700435E 4975543N). Cl-5 is a tuff sample from below basaltic outcrop on the west side of Indian Canyon (NW¼, NW¼ sec 4 T7S R19E; UTM: 704740E 4978085N). Samples "east-1" and "east-2" are from tuff beds below the "Nut Beds" and collected by Paul Hammond (NE¼, SE¼ sec 27, T7S R19E; UTM: 702841E 4977283N).

Clarno tuffs-continued

Sample	Fern-1	Fern-2	RHW-1	N-7	RHW-13	AB-30	AB-41	CRT-1	green-1	green-2	green-3	olive NB	WF-4	mammal
SiO ₂ ----	75.43	76.85	73.71	76.68	60.89	63.83	63.94	63.28	64.12	64.32	65.40	60.44	66.07	66.97
Al ₂ O ₃ ----	13.04	12.28	13.27	10.96	19.28	17.90	19.80	16.25	17.56	16.72	16.45	17.72	15.60	12.79
TiO ₂ ----	0.337	0.248	0.083	0.068	0.708	0.649	0.728	1.110	0.768	0.594	0.775	1.226	0.662	1.025
FeO ⁺ ----	1.06	0.50	2.22	2.12	4.07	4.08	3.29	5.80	4.93	4.67	5.12	6.11	4.04	7.27
MnO----	0.016	0.013	0.015	0.016	0.010	0.014	0.007	0.034	0.070	0.092	0.056	0.021	0.047	0.073
CaO----	1.57	2.23	1.02	1.16	2.71	1.55	0.94	2.47	3.63	3.75	2.75	2.12	3.16	2.44
MgO----	0.08	0.04	1.48	1.65	1.61	2.04	0.84	1.23	1.31	1.86	1.58	1.35	1.05	1.08
K ₂ O----	3.75	2.44	1.54	0.65	0.62	0.94	3.30	0.55	1.47	1.07	0.71	0.63	4.03	2.48
Na ₂ O----	3.16	3.37	1.55	1.19	1.33	2.20	1.16	1.44	3.40	3.74	2.78	1.26	4.40	0.36
P ₂ O ₅ ----	0.107	0.107	0.030	0.012	0.169	0.018	0.063	0.127	0.156	0.139	0.049	0.145	0.162	0.068
Total---	98.55	98.18	94.92	94.51	91.40	93.22	94.07	92.29	97.41	96.96	95.67	91.02	99.22	94.56

Trace elements in ppm

Ni-----	10	11	11	10	18	23	30	20	14	22	26	20	9	17
Cr-----	7	6	7	6	19	40	29	40	18	27	35	36	14	57
Sc-----	5	10	7	5	12	12	13	17	13	12	17	21	11	12
V-----	46	26	24	17	90	44	115	209	79	75	83	92	112	97
Ba-----	1089	803	322	277	49	282	330	294	518	405	331	139	509	389
Rb-----	87	59	54	31	24	38	82	37	38	39	29	41	146	97
Sr-----	206	259	135	163	381	271	149	409	493	492	391	387	316	200
Zr-----	136	116	63	58	163	244	153	293	193	138	142	348	127	213
Y-----	12	13	13	10	32	32	65	31	20	12	19	35	16	44
Nb-----	7.1	6.3	6.4	9.4	13.5	24.7	12.9	26.4	15.1	10.8	10.4	30.8	10.4	18.0
Ga-----	10	11	16	18	25	27	28	21	21	21	20	25	15	19
Cu-----	32	19	23	12	36	40	79	46	25	36	36	40	14	31
Zn-----	21	13	68	48	96	117	104	83	65	68	66	96	46	66
Pb-----	9	5	10	11	8	13	8	9	7	7	7	8	5	8
La-----	19	9	6	17	19	40	119	22	36	9	25	22	16	46
Ce-----	35	24	37	33	52	73	254	72	55	41	44	82	30	76
Th-----	6	3	9	6	6	12	8	8	6	4	4	11	4	5

Sample locations: Samples collected by Paul Hammond designated by PH. Samples "Fern-1" and Fern-2" are from the "Fern Quarry" (SW, SW T7S R19E; UTM: 703705E 4977528N). Samples RHW-1 and RHW-13 are from the "Red Hill" west section (NW¼, NE¼ sec 34 T7S R19E; UTM: 702763E 4977052N). Sample N-7 is from a tuff that crops out at the base of the "Nut Beds" trench (NE¼, SE¼ sec 27, T7S R19E; UTM: 702841E 4977283N). Samples AB-30 and 41 are from the lower "Black Spur" trench (SE¼, SE¼ sec 27 T7S R19E; UTM: 703105E 4977520N). Sample CRT-1 is the "Red Hill" tuff from the middle of the "Red Hill" claystones (SW¼, SE¼ sec 27 T7S R19E; UTM: 702762E 4977423N). Sample "green 1" (PH) is a green tuff below the "Palisades Cliffs" (SE¼, SW¼ sec 35 T7S R19E; UTM: 704262E 4976250E). Sample "green-2" (PH) is a green tuff below the Pine Creek andesite (SW¼, SW¼ sec 35 T7S R19E; UTM: 703540E 4976075N). Sample "green-3" (PH) is a green tuff in the "lower Clarno conglomerates" (SE, NW sec 34 T7S R19E; UTM: 702535E 4976595N). Sample "olive NB" is a green tuff below the "Nut Beds" (SW¼, SE¼ sec 27 T7S R19E; UTM: 702763E 4977361N). Sample WF-4 is from the "West Face Cliffs" (NE¼, NE¼ sec 10 T8S R19E; UTM: 703045E 4973760N). Sample "mammal" is a tuff in the mammal quarry beds (NE¼, SE¼ sec 27 T7S R19E; UTM: 703260E 4978105N).

Andesite of Pine Creek

Hancock Dacite Dome

Sample	A1-603	A1-604	A1-618	DB-1	DB-2	DB-3	A2	RHW-0	Han-606	Han-612	Han-617	Han-602	AB-1	AB-1
SiO ₂ ----	57.60	57.44	57.46	60.98	61.84	60.73	60.35	58.31	75.61	70.10	71.0	67.01	64.9	68.43
Al ₂ O ₃ ---	15.93	16.52	16.47	17.47	16.77	18.04	17.61	18.55	16.15	16.27	16.42	16.36	18.2	18.72
TiO ₂ ----	0.747	0.776	0.774	0.804	0.890	0.809	0.928	0.780	0.406	0.417	0.369	0.372	0.408	0.409
FeO [*] ----	6.12	6.48	6.36	5.64	5.66	5.30	6.29	7.13	0.61	1.12	1.47	2.86	6.38	3.09
MnO-----	0.117	0.119	0.125	0.111	0.137	0.108	0.160	0.274	0.012	0.069	0.013	0.052	0.046	0.014
CaO-----	6.87	7.15	7.06	6.36	6.01	6.60	6.21	6.54	0.8	4.48	2.47	3.56	2.27	1.34
MgO-----	7.19	6.4	5.85	2.87	3.24	2.81	2.94	0.65	0.15	0.20	0.52	0.39	0.65	0.97
K ₂ O-----	1.02	1.05	1.08	1.29	1.61	1.58	1.31	1.62	1.92	1.96	1.99	1.95	2.22	2.2
Na ₂ O----	3.58	3.59	3.66	3.96	3.66	3.88	4.09	3.97	3.28	4.08	3.27	3.45	4.64	4.14
P ₂ O ₅ ----	0.201	0.213	0.220	0.188	0.167	0.193	0.228	0.183	0.105	0.133	0.143	0.182	0.141	0.142
Total---	99.38	99.74	99.06	99.67	99.98	100.05	100.12	98.01	99.04	98.83	97.72	96.19	99.86	99.46

Trace elements in ppm

Ni-----	174	183	188	36	12	22	14	11	13	10	8	1	6	11
Cr-----	264	267	265	63	57	26	25	22	2	3	2	4	3	5
Sc-----	22	17	16	19	17	15	13	18	3	8	4	7	4	6
V-----	142	150	147	123	137	133	127	147	36	35	30	1	17	36
Ba-----	363	349	360	324	383	368	394	458	490	600	529	526	553	444
Rb-----	22	23	25	36	43	41	30	41	50	43	53	49	60	68
Sr-----	591	618	620	470	450	596	475	572	115	418	398	422	277	169
Zr-----	126	131	133	150	128	138	150	131	164	155	161	155	168	173
Y-----	13	13	13	14	14	16	17	13	10	8	9	12	14	14
Nb-----	10.0	10.9	10.2	9.5	9.5	8.2	11.9	7.6	11.2	8.8	9.8	11.0	11.2	10.8
Ga-----	18	18	17	22	22	18	21	24	16	17	20	19	20	22
Cu-----	70	66	67	52	27	69	27	42	15	15	12	15	11	13
Zn-----	63	67	67	79	72	62	73	77	54	36	82	41	54	50
Pb-----	1	4	5	5	7	3	4	3	6	8	9	6	6	5
La-----	32	20	28	28	20	10	7	14	30	17	11	25	26	10
Ce-----	47	24	41	28	44	44	48	45	43	47	48	64	39	51
Th-----	3	2	2	4	3	4	3	2	4	5	4	6	4	6

Sample locations: Samples collected by Paul Hammond designated by PH. Samples A1-603 (PH) and A1-604 (PH) are of a andesite lava flow (SE¼, SW¼ sec 34 T7S R19E; UTM: 702420E 4976098N). Sample A1-618 (PH) is an andesite lava flow (SW¼, SW¼ sec 35 T7S R19E; UTM: 703545E 4976115N). Samples DB-1 and DB-2 are from a large cliff at the base of the "Dumbbell" section (SE¼, SW¼ sec 32 T7S R20E; UTM: 709160E 4976110N). Sample DB-3 is from an andesite flow from the "Dumbbell" section (SE¼, SW¼ sec 32 T7S R20E; UTM: 709342E 4976290N). Sample A2 is from the "West Face Cliffs" (SE¼, NW¼ sec 10 T8S R19E; UTM: 702780E 4973500N). Sample RHW-0 is a basaltic clast from the lahar at the base of the section (NW¼, NE¼ sec 34 T7S R19E; UTM: 702763E 4977041N). Sample Han-606 (PH) is a dacite igneous body (SW¼, SW¼ sec 26 T7S R19E; UTM: 703570E 497775N). Sample Han-612 (PH) is a dacite igneous body (SE¼, SE¼ sec 27 T7S R19E; UTM: 703110E 4977430N). Sample Han-617 (PH) is a dacite igneous body (SE¼, SE¼ sec 27 T7S R19E; UTM: 703115E 4977364N). Sample Han-602 (PH) is a dacite igneous body (SE, SE sec 27 T7S R19E; UTM: 703095E 4977340N). Samples AB-1 are from core stones from the base of the section on "Black Spur" (SE¼, SE¼ sec 27 T7S R19E; UTM: 703105E 4977520N).

Andesite of Horse Mountain

Sample	A3-609	A3-610	A3-C10	A3-C16	A3-602	A3-C14	WF-6	DB-4	G-2
SiO ₂ ----	58.62	59.20	59.26	59.54	65.37	62.46	57.85	68.76	60.69
Al ₂ O ₃ ---	17.02	17.11	17.17	17.17	16.83	18.93	15.95	14.20	16.42
TiO ₂ ----	0.964	0.959	0.964	0.956	0.617	0.669	0.886	0.622	0.884
FeO ⁺ ----	6.43	6.02	6.03	5.67	4.24	5.41	6.82	4.64	6.32
MnO-----	0.118	0.121	0.119	0.149	0.291	0.041	0.129	0.038	0.133
CaO-----	7.00	6.87	7.04	7.58	4.45	4.18	7.62	3.06	6.84
MgO-----	3.77	3.46	3.50	4.08	1.27	0.31	5.42	0.96	4.22
K ₂ O-----	1.67	1.85	1.65	0.98	1.65	2.79	1.07	3.39	0.92
Na ₂ O---	3.71	3.66	3.98	3.87	4.16	5.02	3.70	3.36	3.71
P ₂ O ₅ ----	0.202	0.203	0.207	0.202	0.135	0.00	0.156	0.164	0.182
Total---	99.50	99.45	99.92	100.20	99.01	99.96	99.60	99.69	100.32

Trace elements in ppm

Ni-----	24	24	25	24	11	8	71	24	56
Cr-----	77	69	77	70	26	23	169	59	91
Sc-----	22	27	22	22	14	16	30	15	24
V-----	149	150	142	147	86	47	180	78	139
Ba-----	392	411	405	399	535	1008	276	936	412
Rb-----	58	63	52	62	48	65	25	119	43
Sr-----	298	304	307	323	425	428	477	358	325
Zr-----	158	160	157	158	134	146	116	137	143
Y-----	25	23	24	24	11	15	15	14	22
Nb-----	11.7	11.8	12.9	12.8	10.4	8.4	6.9	10.2	11.5
Ga-----	20	21	18	17	20	20	19	18	19
Cu-----	36	31	19	33	34	22	59	40	57
Zn-----	65	68	65	67	63	38	72	49	71
Pb-----	4	5	5	5	7	9	6	7	9
La-----	26	25	12	24	22	4	19	20	20
Ce-----	65	30	57	47	33	27	11	54	51
Th-----	5	4	6	6	6	3	4	7	4

Sample locations: Samples A3-609 (PH) is an andesite flow from hill 2066 (SE¼, SW¼ sec 26 T7S R19E; UTM: 704045E 4977530N). A3-610 (PH) is an andesite flow from hill 2066 (SE¼, SW¼ sec 26 T7S R19E; UTM: 704085E 4977545N). Sample A3-C10 is an andesite flow from upper Hancock Canyon (NE¼, SW¼ sec 26 T7S R19E; UTM: 704220E 4977920E). Sample A3-C16 is from the flow that caps Horse Mountain above the "West Face Cliffs" (NE¼, NW¼ sec 11 T8S R19E; UTM: 703915E 4974030N). Sample A3-602 is an andesite flow just below hill 2066 (SE¼, SW¼ sec 26 T7S R19E; UTM: 704015E 4977465N). Sample A3-C14 is an andesite flow just below hill 2066 (SE, SW sec 26 T7S R19E; UTM: 703960 4977530N). Sample WF-6 is from the thick flow sequence that caps Horse Mountain (NE¼, NE¼ sec 10 T8S R19E; UTM: 703155E 4973805E). Sample DB-4 is from the lava flow that caps the "Dumbbell" (NW¼, SE¼ sec 32 T7S R20E; UTM: 709550E 4976409N). Sample G-2 is from the Gables (SW¼, SW¼ sec 33 T7S R19E; UTM: 700450E 4975725E).