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Informal Report

Descriptive Summary of the Grande Ronde Basalt Type Section, Columbia River Basalt Group

V. E. Camp
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October 1978

Prepared for the United States
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PRELIMINARY REPORT

NOTICE

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Informal Report

DESCRIPTIVE SUMMARY OF THE GRANDE RONDE BASALT TYPE SECTION, COLUMBIA RIVER BASALT GROUP

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ABSTRACT

The Grande Ronde Basalt type section, located in extreme southeastern Washington, has been measured, sampled, and characterized. The section is 800 meters thick and is comprised of 35 Grande Ronde Basalt flows. These flows are divisible into 3 magnetostratigraphic units termed, in ascending order, the R_1*, the* N_1*, and the* R_2*. The* R_1 *unit is represented by 13 reversely polarized flows; the* N_1 *unit by 13 normally polarized flows; and the* R_2 *by 9 reversely polarized flows. Chemically, the Grande Ronde Basalt flows have been divided into 2 major groups, termed A and B. The compositions of the lower 9 flows, members of Group A, are similar to either the high-Mg Grande Ronde chemical type, the high-Ti Grande Ronde chemical type, or the Pomona chemical type. The compositions of the upper 25 flows, members of Group B, are predominantly similar to the low-Mg Grande Ronde chemical type. Petrographically, the Grande Ronde Basalt flows are generally fine grained and aphyric and have an intergranular or intersertal micro-texture. Major mineral phases include plagioclase (*An_{40-60}*) and augite; minor mineral phases include pigeonite, orthopyroxene, ilmenite, titanomagnetite, and olivine. Group A flows generally contain more olivine and less pigeonite than do Group B flows.*

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INTRODUCTION

A formal revision of the Columbia River Basalt Group stratigraphic nomenclature established by Waters (1961) has recently been outlined by Swanson, et al., (1978). Under this new stratigraphic framework (Figure 1), the Yakima Basalt is raised from formation to subgroup status, and three formations (the Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt, in order of decreasing age) are defined within it. The type section for the Grande Ronde Basalt is designated as a sequence of flows comprising a prominent west-trending spur ridge located near the confluence of the Grande Ronde and Snake rivers, southeast Washington (Figure 2) (Swanson, et al., 1978). This section lies at the intersection of three doctoral dissertation areas and has been sampled jointly and described separately by Camp (1976), Price (1977), and Reidel (1978). In order to provide one central reference publication, a summary of the section data generated by these individuals is presented in this document.

GENERAL SETTING

The type section for the Grande Ronde Basalt is designated as the "prominent west-trending spur ridge extending from the northwest quarter of Section 23 across the north third of Section 22 to the northeast quarter of Section 21, Township 7 North, Range 46 East., Black Butte quadrangle, in the lower part of the Grande Ronde River valley, Asotin County, extreme southeast Washington" (Figure 3) (Swanson, et al., 1978). The section is situated near the eastern margin of the Columbia Plateau physiographic province within the canyon country of the middle Snake River and major tributaries. Lower Grande Ronde Canyon exposures of the Columbia River Basalt sequence are over 1,000 meters thick and are comprised of flows of the Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt (Figure 1) and dikes of the Chief Joseph swarm (Figure 3) (Gibson, 1969; Taubeneck, 1970; and, Price, 1977). Just to the east of the section locality, the base of the Imnaha

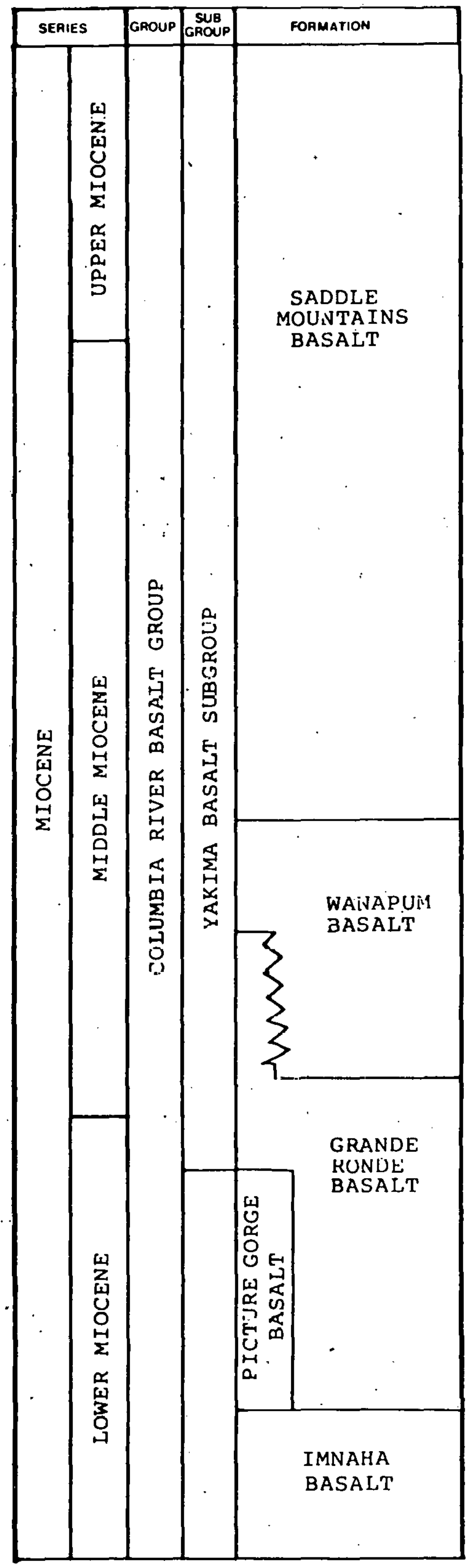


FIGURE 1

COLUMBIA RIVER BASALT GROUP STRATIGRAPHIC NOMENCLATURE

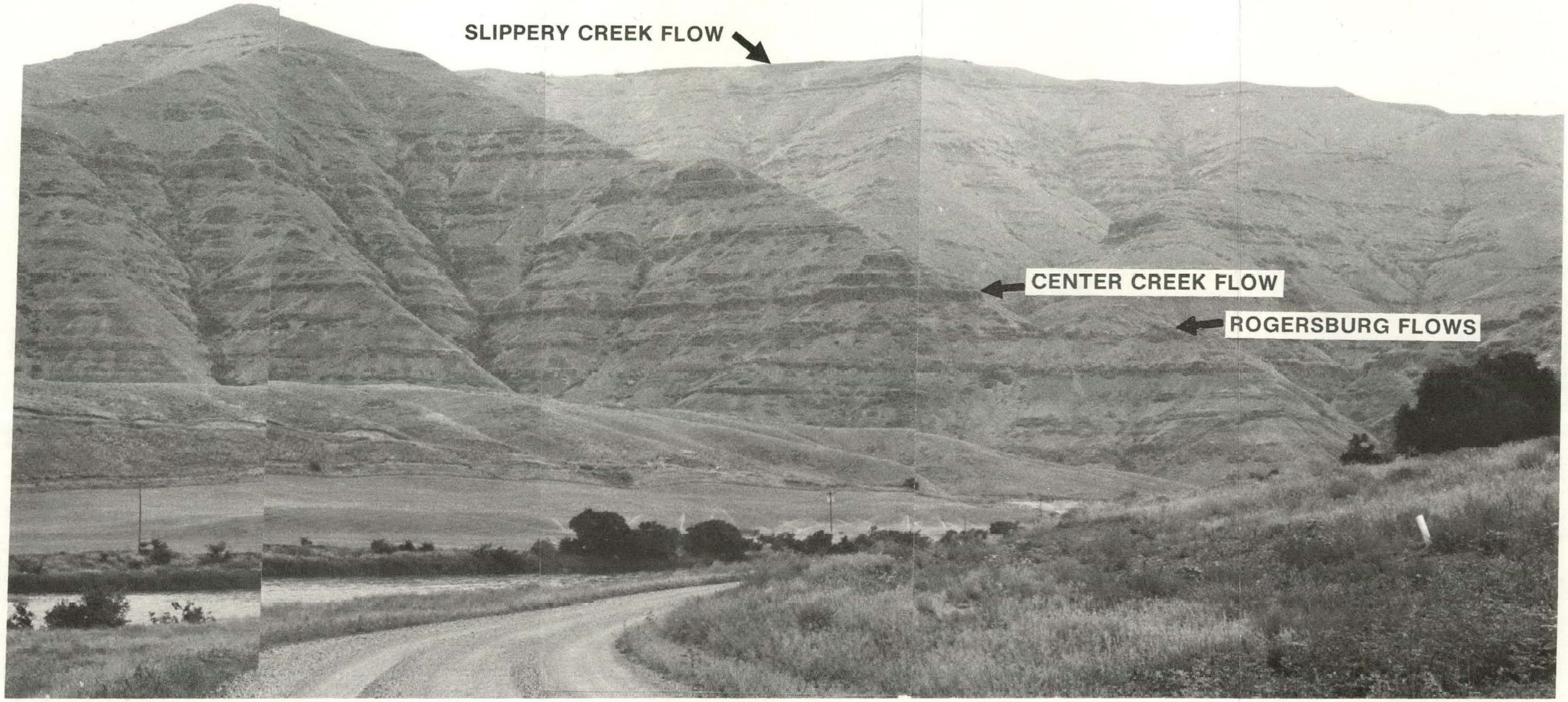


FIGURE 2

PHOTOMOSAIC OF THE GRANDE RONDE BASALT TYPE SECTION

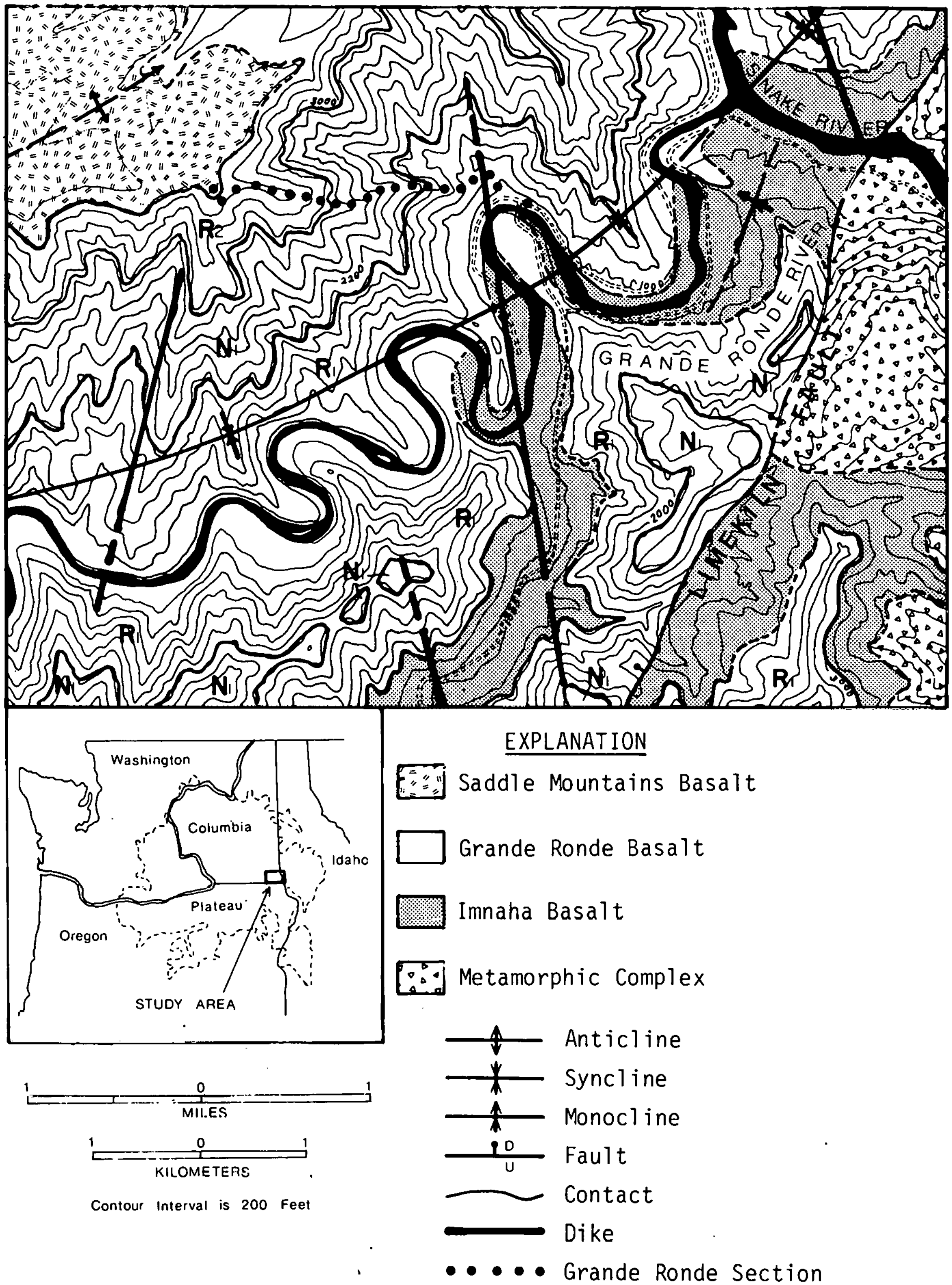


FIGURE 3

GEOLOGIC MAP OF THE SNAKE AND GRANDE RONDE RIVERS CONFLUENCE AREA

Basalt rests unconformably on pre-Tertiary metamorphic rocks (Figure 3). Structurally, the section lies near the eastern terminus of the Blue Mountain uplift and just to the north of the Limekiln fault (Figure 3) (Camp, 1976; Price, 1977; and, Reidel, 1978).

DESCRIPTION OF THE GRANDE RONDE BASALT TYPE SECTION

FIELD PROPERTIES

During section measurement, elevations of flow and interbed contacts were recorded using a surveying altimeter calibrated at two-foot intervals. In general, section samples were collected from the bottom, center, and top of each definable flow. Following sampling, flow outcrop characteristics, hand specimen petrography, and remanent magnetization measurements were recorded. Remanent magnetization measurements were made using a portable flux gate magnetometer.

A graphic representation of the Grande Ronde measured section, including the position of the 61 sample localities, is shown in Figure 4. The section is comprised of an 800-meter thick sequence of 35 Grande Ronde Basalt flows overlain by an interbed and a single 50-meter thick Saddle Mountains Basalt flow. The lower portion of the section is cross-cut by one Grande Ronde Basalt dike (Price, 1977). Just to the east of the section locality, the base of the Grande Ronde Basalt is exposed and overlies the Imnaha Basalt with no apparent unconformity.

The Grande Ronde Basalt flows of the section are predominantly cliff-formers, and are responsible for the stair-step character of the walls of the lower Grande Ronde Canyon (Figure 2). The internal structures of individual flows are variable, ranging from those displaying well-developed colonnades and entablatures to those displaying no such recognizable subdivisions. The Grande Ronde Basalt flows of the section range in thickness from 7 to 70 meters, with an average flow thickness of 16 meters.

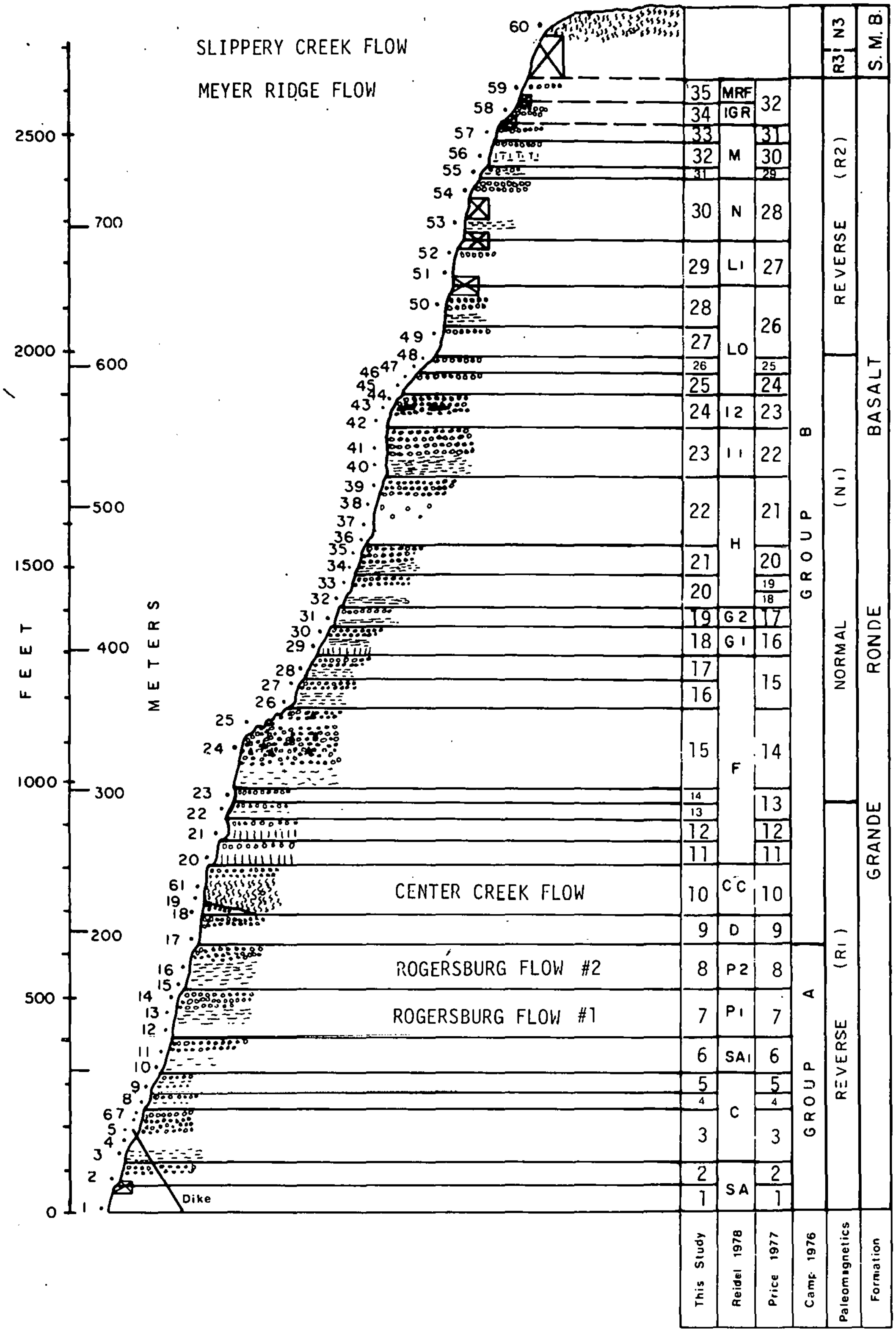


FIGURE 4

GRAPHIC REPRESENTATION OF THE GRANDE RONDE BASALT TYPE SECTION

Three magnetostratigraphic units are definable within the Grande Ronde Basalt sequence at the type locality (Figure 4). Following the terminology suggested by Swanson and Wright (1976), these units are termed, in ascending order, the R_1, N_1, and R_2. The R_1 is represented by a 300-meter thick sequence of 13 reversely polarized flows; the N_1 by a 300-meter thick sequence of 13 normally polarized flows; and, the R_2 by a 250-meter thick sequence of 9 normally polarized flows. Flows of the youngest Grande Ronde Basalt magnetostratigraphic unit, the N_2 (Swanson and Wright, 1976), are not represented within the section. The single Saddle Mountains Basalt flow capping the section has a normal polarity.

Named flows within the section include the Rogersburg flows (Price, 1977) the Center Creek flow (Bond, 1962; Reidel, 1978), the Meyer Ridge flow (Camp, 1976) of the Grande Ronde Basalt, and the Slippery Creek flow (Price, 1977) (the Uniontown-3 flow of Camp, 1976) of the Saddle Mountains Basalt (Figure 4). The Rogersburg flows (the porphyritic flows of Camp, 1976; Reidel, 1978) are part of a distinctive plagioclase-phyric sequence present throughout the canyon country of the middle Snake River and major tributaries (Gibson, 1969; Breeser, 1972; Camp, 1976; Price, 1977; Reidel, 1978; and Ross, 1978). As such, the flow sequence is an important "regional" stratigraphic marker unit. Recognition of the other three named flows is predominantly based on field position and chemical criteria. The areal extent and distinguishing properties of the Rogersburg, Center Creek, Meyer Ridge, and Slippery Creek flows are discussed in detail in the authors' dissertations (Camp, 1976; Price, 1977; and, Reidel, 1978).

CHEMISTRY

The 61 samples collected from the Grande Ronde Basalt type section were analyzed by Reidel for SiO_2, Al_2O_3, TiO_2, total Fe-oxides as FeO, MgO, CaO, Na_2O, K_2O, MnO, and P_2O_5, using Washington State University's wave length dispersive X-ray fluorescence spectrometer. The analytical method employed is described in Hooper, et al., (1976). The X-ray fluorescence analytical results are reported in Camp (1976) and Reidel (1978). Splits of the 61 section samples were also analyzed for the same elements using atomic absorption spectroscopy and color spectrophotometry; these results are reported in Price (1977). Because comparable chemical trends were obtained using both analytical methods, only the X-ray fluorescence analytical results are included in this paper. The average major oxide compositions of the 35 Grande Ronde Basalt flows (as defined in Figure 4) computed from the X-ray fluorescence analytical data base are reported in Table I.

Analytical values for selected trace elements (Zr, Sr, Rb, Ba, V, Sc, Ni, Cr, Cu, and Y) using the X-ray fluorescence analytical technique were determined by Reidel (1978). Analyses for additional trace elements (La, Ce, Sm, Eu, Tb, Yb, Lu, Co, Cr, Hf, Th, Ta, and Cs) using instrumental neutron activation analysis were obtained by Price (1977) and Reidel (1978). Available trace element data are listed in Tables II and III.

An examination of major, minor, and selected trace element analyses for flows comprising the Grande Ronde Basalt type section showed that a chemical break occurs in the vicinity of the Center Creek flow. Camp (1976) termed flows below this chemical break members of Group A and flows above this break members of Group B. This same terminology was also applied by Price (1977) and Reidel (1978). However, Reidel (1978) added one more flow to the Group A sequence (Figure 4).

In general, the compositions of the 9 Group A flows are similar to either the high-Mg Grande Ronde, the high-Ti Grande Ronde, or the Pomona chemical types of Wright, et al. (1973) and Swanson and Wright (1978). With the exception of the Meyer Ridge flow, the chemistry of the 29 Group B flows resembles their low-Mg Grande Ronde chemical type. The composition of the Meyer Ridge flow resembles their high-Mg Grande Ronde chemical type or their Pomona chemical type. In general, Group A flows have a lower SiO_2 (average difference of 2 percent) and a higher MgO (average difference of 0.7 percent) content than do Group B Grande Ronde Basalt flows.

The flows of the Grande Ronde section were further divided on the basis of chemistry by Reidel (1978). This breakdown, based on a more detailed evaluation of observed chemical variation, is noted in Figure 4. Discriminant analysis of these flow categories by Reidel (1978) showed that they have a statistical validity based on the chemical analyses.

TABLE I

MAJOR OXIDE AVERAGE X-RAY FLUORESCENCE ANALYSES FOR FLOWS OF THE GRANDE RONDE BASALT TYPE SECTION[1]

FLOW[2]	SiO_2	Al_2O_3	TiO_2	FeO^3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	SAMPLE ANALYSES[2]
SM-1[4]	50.17	14.31	2.25	11.02	0.21	10.04	5.33	0.94	3.03	0.42	60
35[5]	52.83	14.91	1.61	8.46	0.19	10.16	5.99	0.95	2.64	0.26	59
34	53.33	15.05	1.80	10.51	0.22	8.62	4.17	1.21	2.81	0.28	58
33	54.76	14.97	2.47	9.35	0.21	7.61	3.58	1.91	2.74	0.41	57
32	53.05	14.29	2.22	11.25	0.21	8.00	4.01	1.82	2.77	0.38	56
31	52.79	14.30	2.25	11.70	0.21	7.88	4.06	1.72	2.72	0.37	55
30	53.50	14.72	2.51	11.21	0.21	7.34	3.52	1.94	2.63	0.39	53, 54
29	55.55	14.48	2.35	11.15	0.20	6.93	3.23	2.02	2.68	0.42	51, 52
28	55.04	14.44	2.22	10.64	0.19	6.98	3.40	1.04	2.79	0.36	50
27	54.45	14.48	2.33	10.27	0.23	7.25	3.31	1.97	3.34	0.36	49
26	53.02	14.52	2.28	11.11	0.21	8.16	4.12	1.43	2.82	0.35	47, 48
25	52.95	14.64	2.36	11.41	0.21	7.92	3.82	1.39	2.92	0.41	45, 46
24	54.26	15.17	1.81	9.34	0.20	8.52	4.61	1.19	2.62	0.27	42, 43, 44
23	53.73	14.79	1.90	10.61	0.21	7.94	4.32	1.39	2.83	0.31	40, 41
22	52.98	14.68	2.10	11.39	0.22	8.14	4.13	1.33	2.69	0.35	36, 37, 38, 39
21	53.39	14.36	2.24	11.44	0.20	7.88	3.82	1.62	2.71	0.38	34, 35
20	53.78	14.85	1.97	10.28	0.22	8.39	4.46	1.36	2.37	0.33	32, 33
19	53.08	15.07	1.78	9.66	0.21	9.18	3.14	1.19	2.43	0.26	31
18	55.64	15.06	1.70	9.13	0.19	7.88	4.29	1.50	2.39	0.23	29, 30
17	54.46	14.38	2.08	11.12	0.20	7.55	3.79	1.69	2.43	0.30	28
16	54.56	14.81	2.12	10.47	0.20	7.44	3.92	1.57	2.65	0.38	26, 27
15	54.81	14.81	2.00	10.31	0.19	7.61	4.02	1.58	2.32	0.28	24, 25
14	56.23	14.79	2.17	9.96	0.19	6.67	3.05	1.98	2.68	0.28	23
13	55.99	14.62	2.20	10.17	0.20	6.72	3.14	2.22	2.46	0.28	22
12	54.07	14.48	2.14	10.61	0.20	7.89	4.18	1.57	2.55	0.31	21
11	54.37	14.20	2.34	10.89	0.22	7.37	3.51	1.90	2.79	0.40	20
10[6]	54.10	14.62	2.21	10.51	0.22	7.58	3.99	1.70	2.71	0.37	18, 19, 61
9[7]	53.51	14.62	2.15	10.18	0.19	8.39	4.64	1.46	2.56	0.30	17
8[7]	53.25	14.68	2.22	10.07	0.20	8.61	4.79	1.35	2.55	0.30	15, 16
7	53.19	14.59	2.35	10.43	0.22	8.37	4.41	1.42	2.66	0.36	12, 13, 14
6	53.06	14.50	2.30	11.12	0.25	8.10	4.17	1.41	2.77	0.35	10, 11
5	53.37	15.18	1.90	9.71	0.22	9.60	5.25	0.91	2.58	0.27	9
4	51.39	15.01	2.32	10.70	0.23	9.41	5.29	0.90	2.45	0.30	8
3	52.11	14.92	2.42	10.25	0.21	9.16	5.00	1.17	2.46	0.33	3, 4, 6, 7
2	52.80	14.84	2.17	10.81	0.22	8.54	4.48	0.97	2.81	0.37	2
1	52.84	14.74	2.31	11.27	0.23	7.94	4.43	1.18	2.67	0.38	1
Dike[8]	53.44	14.67	2.17	11.40	0.20	7.84	3.91	1.68	2.33	0.35	5

[1]Average weight percent compositions computed from XRF analyses reported in Reidel (1978).

[2]See Figure 4 for flow divisions and sample localities.

[3]Fe_2O_3 is expressed as a constant 2.00 weight percent.

[4]Uniontown-3 flow of Camp (1976), Slippery Creek flow of Price (1977); Saddle Mountains Basalt flow.

[5]Meyer Ridge of Camp (1976); Grande Ronde Basalt flow.

[6]Center Creek flow of Reidel (1978).

[7]Rogersburg flows of Price (1977) and porphyritic flows of Camp (1976) and Reidel (1978).

[8]Dike location noted in Figure 4.

TABLE II

TRACE ELEMENT AVERAGE X-RAY FLUORESCENCE ANALYSES FOR FLOWS OF THE GRANDE RONDE BASALT TYPE SECTION[1]

FLOW[2]	Zr	Sr	Rb	Ba	V	Sc	Ni	Cr	Cu	Y	SAMPLE ANALYSES[2]
SM-1[3]	179	233	27	368	333	33	43	30	244	10	60
35[4]	163	347	35	350	308	45	118	145	173	8	59
34	174	340	36	569	282	40	67	70	195	15	58
33	220	390	50	1000	375	34	46	2	128	39	57
32	195	207	47	616	348	38	33	10	105	14	56
31	195	317	44	661	406	40	29	11	185	14	55
30	229	329	45	748	387	34	63	20	92	14	53, 54
29	232	322	51	757	357	33	45	4	12	21	51, 52
28	213	346	47	675	342	32	89	10	75	17	50
27	177	373	54	866	355	35	84	12	1	12	49
26	197	336	38	560	395	40	39	34	17	13	47, 48
25	187	342	39	577	389	39	66	33	29	23	45, 46
24	190	355	36	469	341	40	32	37	63	14	42, 43, 44
23	173	325	43	517	366	40	34	32	50	20	40, 41
22	181	326	39	543	345	39	44	41	83	16	36,37,38,39
21	179	333	40	547	389	39	57	40	50	17	34, 35
20	186	336	36	520	352	39	39	19	54	9	32, 33
19	178	362	37	465	296	39	23	36	1	9	31
18	190	340	42	495	339	36	49	14	57	22	29,30
17	212	313	46	600	411	36	54	18	39	15	28
16	210	334	40	686	410	39	46	17	63	15	26,27
15	208	322	44	565	341	35	33	15	485	9	24,25
14	240	345	45	706	405	33	48	3	111	12	23
13	240	331	51	751	417	30	43	14	92	29	22
12	209	320	41	603	426	37	45	34	23	21	21
11	257	315	42	655	380	36	41	36	137	28	20
10[5]	226	323	34	556	360	35	46	23	157	12	18, 19, 61
9[6]	211	354	44	495	395	35	119	49	178	37	17
8[6]	217	353	38	494	370	35	62	58	205	7	15, 16
7	218	356	40	627	391	36	61	43	170	11	12, 13, 14
6	207	319	39	442	383	39	28	21	174	18	10, 11
5	183	362	39	362	334	39	56	86	223	13	9
4	189	340	30	391	335	37	57	75	65	10	8
3	205	318	37	521	379	38	82	88	118	12	3,4,6,7
2	205	333	30	501	435	44	43	28	191	26	2
1	232	303	40	499	410	42	57	42	125	25	1
Dike[7]	189	333	49	495	467	37	40	38	113	32	

[1] Average value in parts per million computed from XRF analyses reported in Reidel (1978).

[2] See Figure 4 for flow divisions and sample localities.

[3] Uniontown-3 flow of Camp (1976), Slippery Creek flow of Price (1977); Saddle Mountains Basalt flow.

[4] Meyer Ridge flow of Camp (1976); Grande Ronde Basalt flow.

[5] Center Creek flow of Reidel (1978).

[6] Rogersburg flows of Price (1977) and porphyritic flows of Camp (1976) and Reidel (1978).

[7] Dike location noted in Figure 4.

TABLE III

TRACE ELEMENT AVERAGE INSTRUMENTAL NEUTRON ACTIVATION ANALYSES FOR FLOWS OF THE GRANDE RONDE BASALT TYPE SECTION[1]

FLOW[2]	La	Ce	Sm	Eu	Tb	Yb	Lu	Co	Cr	Hf	Th	Ta	Cs	SAMPLE ANALYSES[2]
SM-1[3]	29.7	ND	6.7	2.1	1.2	4.7	ND	44	45.4	4.5	4.6	2.0	ND	60
35[4]	18.2	24.7	4.5	1.5	0.8	3.6	ND	36	141.0	3.5	3.4	1.5	0.5	59
34	25.1	29.8	6.3	1.9	1.0	ND	ND	ND	75.4	3.6	3.4	1.2	ND	58
33	29.1	59.4	6.9	2.1	1.0	5.2	ND	44	8.6	5.3	5.9	1.4	1.0	57
32	26.7	40.2	7.8	2.2	ND	ND	ND	ND	16.8	3.0	4.3	1.9	1.6	56
31	26.3	38.2	7.2	2.1	ND	ND	ND	ND	16.5	4.9	5.1	2.0	1.1	55
30	25.6	44.6	6.8	1.9	ND	ND	0.61	34	13.7	5.0	5.1	1.4	1.6	53, 54
29	30.1	44.6	6.9	2.1	1.0	4.1	ND	28	10.0	5.6	5.2	1.4	1.5	51
28	26.3	45.3	6.2	2.3	1.2	ND	ND	ND	6.1	5.2	7.5	1.8	1.5	50
27	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
26	22.8	ND	6.6	2.0	1.0	4.1	ND	45	17.3	4.6	4.7	1.6	ND	47, 48
25	25.2	63.9	7.2	2.4	ND	ND	ND	ND	22.4	4.3	4.8	1.5	1.0	46
24	22.9	52.7	5.8	1.9	1.0	ND	ND	ND	19.5	4.5	3.7	1.6	1.1	43
23	20.0	49.2	4.9	1.8	0.8	5.6	ND	33	32.3	4.5	3.6	1.3	ND	40,41
22	21.2	50.5	6.2	2.0	ND	ND	ND	ND	41.6	4.2	3.9	1.2	0.6	37
21	23.0	51.9	6.5	2.1	1.2	ND	ND	ND	29.1	3.7	4.2	1.0	ND	35
20	18.5	45.4	5.1	1.8	1.2	ND	ND	ND	ND	3.4	3.3	1.5	0.4	32
19	20.7	42.6	5.3	1.6	1.0	3.2	ND	36	38	4.4	4.0	1.2	ND	31
18	20.8	47.5	5.6	1.8	0.8	ND	ND	ND	ND	3.7	4.3	1.9	ND	29
17	20.1	50.2	5.3	2.0	1.1	ND	ND	ND	ND	4.3	3.8	1.6	ND	28
16	ND	62.5	ND	2.2	ND	ND	ND	ND	ND	5.1	3.5	1.7	ND	26
15	21.3	51.3	5.5	1.9	1.0	3.5	ND	35	14	4.8	5.1	1.4	ND	25
14	23	ND	6.4	2.0	ND	ND	ND	33	ND	5.7	6.1	ND	ND	23
13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
12	29.4	58.6	7.2	2.0	ND	ND	ND	ND	47.8	4.9	4.4	1.8	ND	21
11	25.6	53.5	6.8	2.0	1.5	6.4	ND	33	35.5	5.5	4.5	1.7	1.6	20
10[5]	27.8	66.5	7.9	2.5	1.1	ND	ND	ND	13.9	5.6	5.0	2.3	ND	61
9[6]	19.9	48.8	5.7	1.9	1.1	ND	ND	ND	70.5	4.0	3.6	1.0	ND	17
8[6]	21.6	47.9	6.2	1.8	0.9	3.7	ND	37	64.1	4.9	4.5	1.2	ND	15, 16
7	24.1	50.9	6.4	2.0	1.0	5.0	ND	35	45.9	4.9	4.0	1.3	0.8	12, 13
6	23.2	57.2	7.1	2.2	1.0	ND	0.60	39	34.9	5.5	4.1	1.4	ND	10, 11
5	20.8	42.0	6.3	1.9	ND	ND	ND	ND	82.5	3.7	2.5	0.9	ND	9
4	19.5	44.5	5.6	1.8	1.0	3.9	ND	41	114.0	4.3	3.6	1.1	ND	8
3	22.3	53.7	5.8	2.1	1.0	4.7	ND	37	78.3	4.6	4.1	1.4	ND	3, 4
2	27.0	54.3	6.6	2.1	1.1	ND	ND	ND	45.8	4.9	2.3	1.6	ND	2
1	24.1	49.6	6.5	2.0	1.7	8.5	ND	33	33.6	5.7	2.9	1.6	ND	1
Dike[7]	ND	61.9	ND	1.9	1.5	ND	ND	ND	30.8	4.9	5.0	1.6	ND	5

[1] Average value in parts per million computed from INAA analyses reported in Price (1977) and Reidel (1978).

[2] See Figure 4 for flow divisions and sample localities.

[3] Uniontown-3 flow of Camp (1976), Slippery Creek flow of Price (1977); Saddle Mountains Basalt flow.

[4] Meyer Ridge flow of Camp (1976); Grande Ronde Basalt flow.

[5] Center Creek flow of Reidel (1978).

[6] Rogersburg flows of Price (1977) and porphyritic flows of Camp (1976) and Ridel (1978).

[7] Dike location noted in Figure 4.

[ND] Value undetermined.

A study conducted by Price (1977) showed that at least 32 dikes (Figure 5) exposed within the vicinity of the type section are chemically similar to Grande Ronde Basalt. Chemical, field, petrographic, and paleomagnetic data further indicated that most of these dikes could have sourced the sequence of Group B Grande Ronde Basalt flows (Figure 4).

PETROGRAPHY

The Grande Ronde Basalt flows of the type section are generally fine grained and aphyric. Hand specimen samples are generally blue-black in color and contain occasional plagioclase phenocrysts and plagioclase-clinopyroxene glomerocrysts. The only notable exceptions are the two Rogersburg flows (Figure 4) which contain approximately 15 percent plagioclase phenocrysts averaging 1/2 centimeter in length (Figure 6). The only other phyric flow in the section is the single Saddle Mountains Basalt flow, the Slippery Creek, which contains approximately 10 percent olivine phenocrysts averaging 1/4 centimeter in size. Olivine phenocrysts are rare within the underlying Grande Ronde Basalt flows of the section.

In thin section, the Grande Ronde Basalt flows of the type locality generally display a hypocrystalline-intersertal or intergranular texture (Figure 6). The most common microphenocryst minerals include plagioclase (An_{40-60}) and augite. The most common groundmass minerals (listed in general order of abundance) include plagioclase, augite, ilmenite and titanomagnetite, pigeonite and olivine, and orthopyroxene (see Reidel, 1978, for orthopyroxene discussion). Microphenocrysts and microlites are generally set in a matrix of tachylitic glass. Average electron microprobe analyses for minerals and intersertal glass constituents of selected Grande Ronde Basalt flows are listed in Table IV. Modal analyses and petrographic descriptions of flows of the section, as determined by Camp (1976), are listed in Tables V and VI, respectively. Camp (1976) found that, in general, Group A flows contain more olivine and less pigeonite than do Group B flows. Camp (1976) also concluded that the texture can vary with intraflow sample location and that individual Grande Ronde Basalt flows within the section cannot be distinguished on the basis of modal analyses.

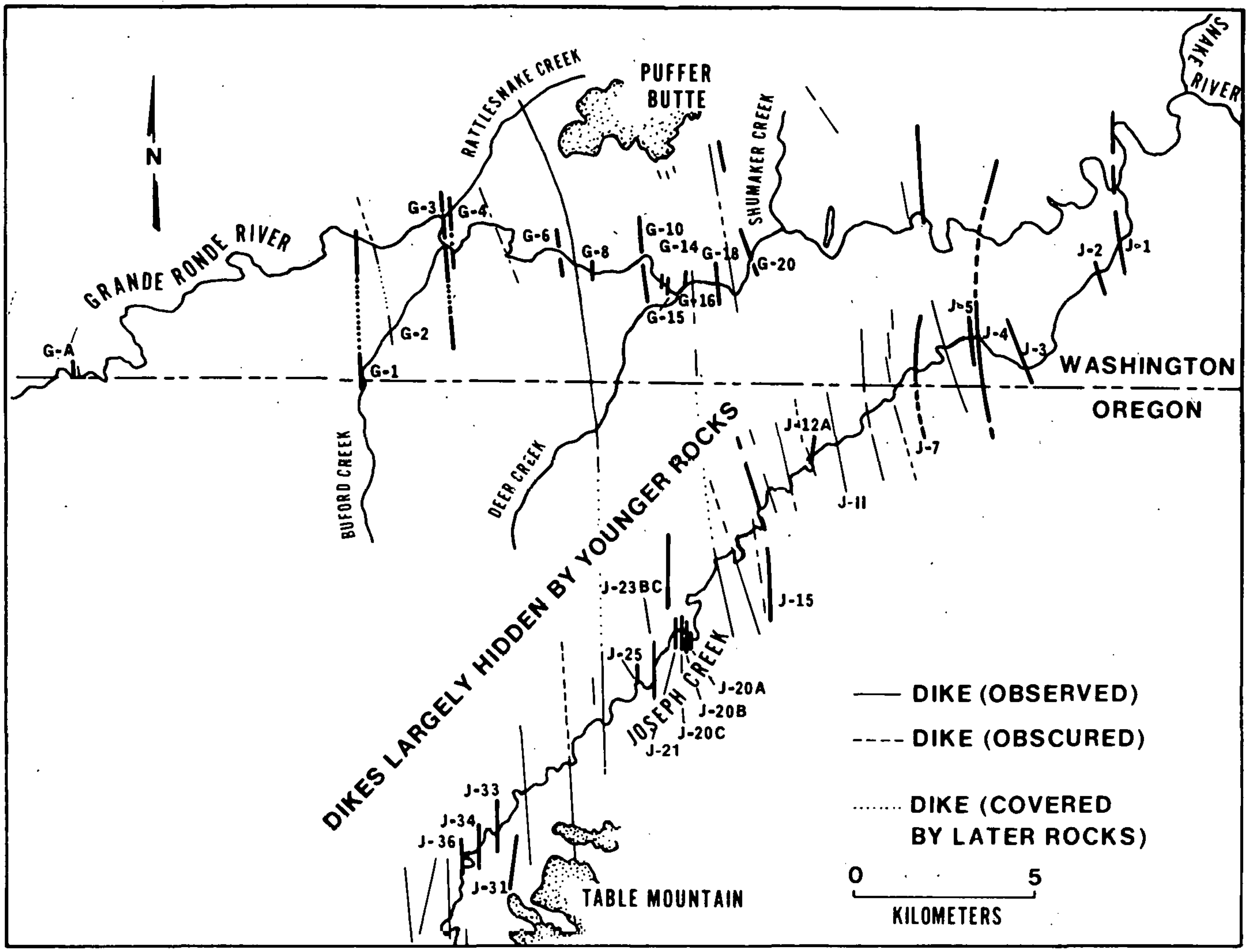
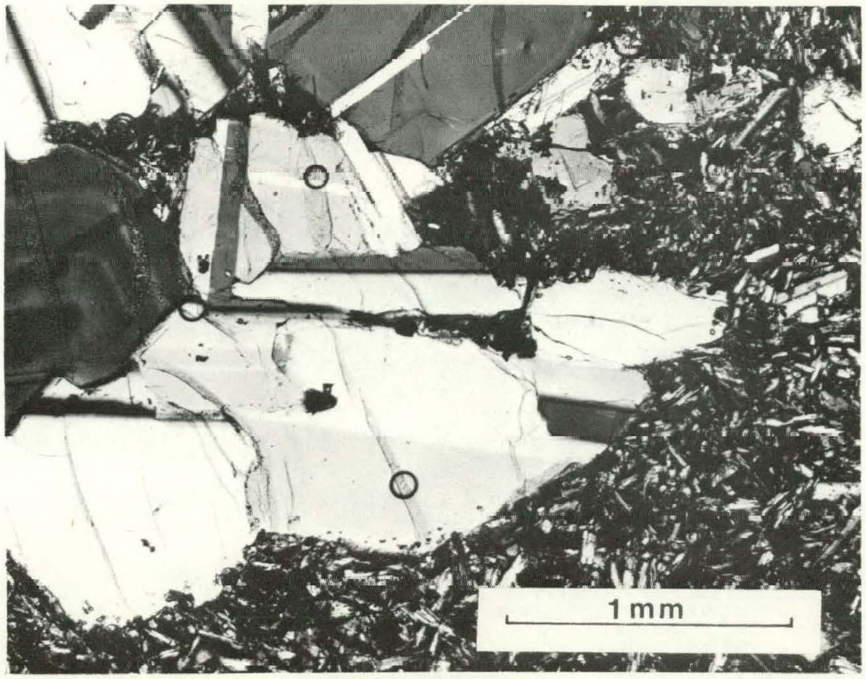


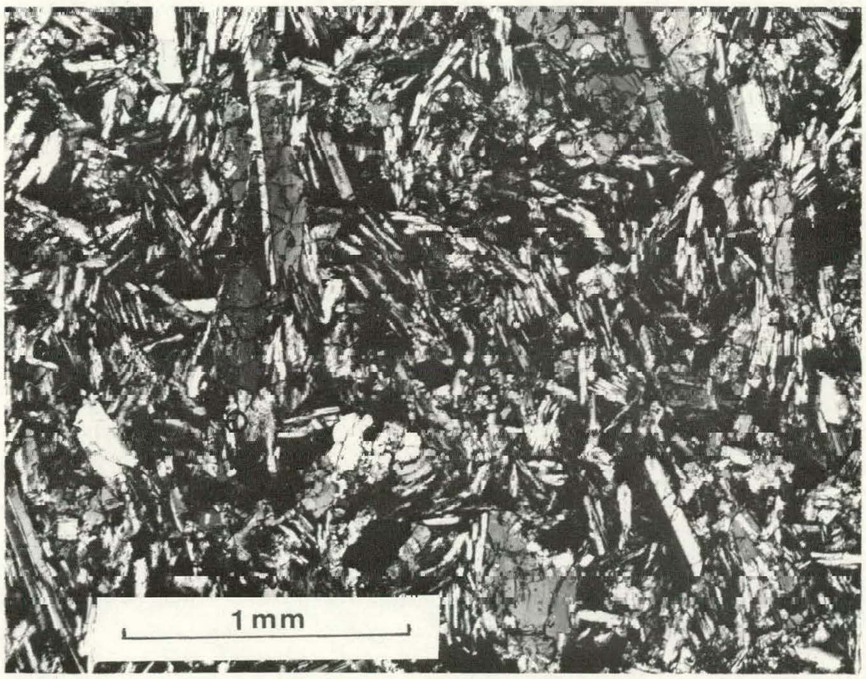
FIGURE 5

LOCATION OF COLUMBIA RIVER BASALT DIKES OF THE GRANDE RONDE CHEMICAL TYPE IN SOUTHEASTERN WASHINGTON AND NORTHEASTERN OREGON

(Grande Ronde Basalt dikes identified by number.)



ROGERSBURG FLOW



APHYRIC GRANDE RONDE BASALT FLOW

FIGURE 6

PHOTOMICROGRAPH OF ROGERSBURG FLOW AND
TYPICAL APHYRIC GRANDE RONDE BASALT FLOW

TABLE IV

MINERAL AND GLASS AVERAGE ELECTRON MICROPROBE ANALYSES FOR FLOWS OF THE GRANDE RONDE BASALT TYPE SECTION[1]

Constituent:	Plagioclase	Clinopyroxene: Augite	Clinopyroxene: Pigeonite	Ilmenite	Titanomagnetite	Olivine	Glass
Flow No:	(1, 3, 7, 8, 26, 30, 32)	(1, 3, 7, 8, 26, 30, 32)	(8, 30)	(3)	(1, 3, 7, 8, 30, 31, 32)	(7)	(1, 3, 7, 8, 30, 31, 32)
(%)							
SiO_2	55.2	53.5	53.8	0.70	1.0	38.2	74.2
Al_2O_3	27.2	2.0	0.20	0.50	1.8		13.9
FeO	0.70	13.5	21.8	46.5	65.2	44.7	1.5
MgO		13.3	18.0	1.3	1.1	16.2	2.7
CaO	10.4	16.7	4.8	0.20	0.20	0.30	1.1
Na_2O	5.4						
K_2O	0.50						6.8
MnO				0.20	0.40	0.60	
TiO_2		0.20	0.30	50.6	30.4		0.30
P_2O_5		0.40	0.30				0.20
Mole	$An_{52}Ab_{48}$	$En_{40}Fs_{26}Wo_{35}$	$En_{46}Fs_{44}Wo_{10}$			$Fo_{37}Fa_{63}$	

[1]As reported in Price (1977); average of analyses from flows 1, 3, 7, 8, 26, 30, 31, and 32 (Figure 4).

TABLE V

MODAL ANALYSES FOR SAMPLES FROM THE GRANDE RONDE BASALT TYPE SECTION[1]

FLOW NO.	SAMPLE NO	Ol	Cpx	Plag	Opq	Glass[2]	Alt	Plag/Cpx[3]
SM-1[4]	60	5.00	27.75	32.25	gl	34.50	0.50	1.16
35[5]	59	..	38.25	45.00	5.25	4.50	7.00	1.18
34	58	4.25	13.25	29.00	gl	52.00	1.50	2.19
33	57	..	29.50	42.50	13.75	8.50	5.75	1.44
32	56	2.75	34.00	47.50	11.50	0.75	3.50	1.40
31	55	1.50	26.25	53.00	11.75	3.50	4.00	2.02
30	54	3.25	18.75	42.50	8.75	26.75	x	2.27
30	53	..	35.00	46.75	8.00	8.75	1.50	1.34
29	52	..	29.00	29.50	14.50	24.00	3.00	1.02
29	51	..	5.00	6.75	0.50	85.75	2.00	1.35
28	50	..	31.75	51.00	6.75	8.75	1.75	1.61
27	49	..	3.86	7.86	gl	84.71	3.57	2.04
26	48	..	25.75	37.00	5.75	23.50	8.00	1.44
26	47	..	34.00	49.00	5.25	11.25	0.50	1.44
25	46	x	14.75	32.00	9.00	38.00	6.25	2.17
24	44	1.25	27.50	50.50	6.75	9.00	5.00	1.84
24	43	0.25	41.50	40.25	7.00	11.00	x	0.97
24	42	..	31.00	50.75	4.75	13.50	x	1.64
23	41	..	3.10	3.90	gl	92.00	1.00	1.26
23	40	..	39.53	49.41	7.29	2.12	1.65	1.25
22	39	3.43	14.00	25.71	4.43	48.86	3.57	1.84
22	38	..	3.45	5.90	gl	86.76	3.17	1.71
22	37	..	38.50	41.25	8.00	11.50	0.75	1.07
22	36	..	34.50	46.45	9.00	3.00	7.25	1.34
21	35	2.00	22.75	39.75	5.00	17.50	13.00	1.75
21	34	x	35.25	40.00	12.75	10.25	1.75	1.13
20	33	x	26.25	43.75	15.00	9.50	5.50	1.67
20	32	..	36.35	39.25	8.25	12.25	4.00	1.08
19	31	x	36.00	42.25	11.25	8.75	1.75	1.17
18	30	..	3.40	9.80	gl	85.20	1.60	2.88
18	29	..	37.00	45.80	8.40	7.40	1.40	1.24
17	28	..	17.80	24.00	gl	52.80	5.40	1.35
16	27	..	25.00	32.75	7.00	32.75	2.50	1.31
16	26	..	33.25	39.50	10.75	6.25	10.25	1.19
15	25	..	31.75	39.50	8.50	8.50	11.75	1.24
15	24	..	26.25	31.00	16.00	26.75	x	1.18
14	23	..	43.25	34.25	11.25	11.25	x	0.79
13	22	..	36.50	38.75	7.50	17.25	x	1.06
12	21	3.25	27.50	42.50	8.75	7.25	10.75	1.55
11	20	..	40.78	34.31	13.53	8.43	2.94	0.84
10[6]	19	..	11.00	20.40	gl	58.80	9.80	1.85
10	18	..	25.00	44.50	10.50	10.00	10.00	1.78
9[7]	17	2.00	28.00	45.75	9.00	8.00	7.25	1.63
8[7]	16	..	28.25	37.25	11.00	12.00	11.50	1.32
8	15	..	28.00	55.00	5.50	x	11.50	1.96
7	14	..	35.25	53.25	5.50	6.00	x	1.51
7	13	3.00	22.00	54.50	3.75	7.25	9.50	2.48
7	12	1.00	27.50	44.50	8.00	6.00	13.00	1.62
6	11	..	32.50	44.75	11.50	2.25	9.00	1.38
6	10	..	31.00	45.00	11.25	8.25	4.50	1.45
5	9	2.00	25.00	47.00	5.75	7.50	12.75	1.88
4	8	1.75	37.50	38.25	8.00	x	14.50	1.02
3	7	0.50	21.50	31.25	2.50	32.00	12.25	1.45
3	6	3.25	29.00	46.75	6.00	1.75	13.25	1.61
3	5	..	23.50	39.00	6.00	25.75	5.75	1.66
3	4	..	34.75	44.75	4.00	5.25	11.25	1.29
3	3	..	33.25	54.25	4.50	1.25	6.75	1.63
2	2	..	27.59	52.41	5.82	3.29	10.89	1.90
1	1	..	27.13	59.46	5.95	1.39	4.16	2.04

1 Modal analyses as reported in Camp (1966); Ol = olivine; Cpx = clinopyroxene; Plag = plagioclase; gl = percent included in glass content; x = present in small amounts; Alt = alteration.

2 Glass value may include cryptocrystalline material and microlites.

3 Plag/Cpx = plagioclase-clinopyroxene ratio.

4 Uniontown-3 flow of Camp (1966), Slippery Creek flow of Price (1977); Saddle Mountains Basalt flow.

5 Meyer Ridge flow of Camp (1976); Grande Ronde Basalt flow.

6 Center Creek flow of Reidel (1978).

7 Rogersburg flows of Price (1977) and porphyritic flows of Camp (1976) and Reidel (1978).

TABLE VI

PETROGRAPHY OF BASALT SAMPLES FROM THE GRANDE RONDE BASALT TYPE SECTION[1]

Flow Number[2]	Sample Number	Matrix Grain Size*	Plag.	Ol	Cpx	Cpx (2Vγ ± 2°)	Opaque Form	Glass	Remarks, Texture
SM-1[3]	GR 60	0.10-0.30	g	a	mp	47.0, 48.0, 48.0, 48.0	equant to elongate	opaque	hyaloophitic
35[4]	GR 59	0.10-0.50	g	. .	g	47.0, 43.0-48.5†, 43.5-5.0†	equant to elongate	pale	intergranular
34	GR 58	0.10-0.30	g	a	g	47.0, 47.0, 48.0, 48.0	(?)	red	hyaloophitic
33	GR 57	0.05-0.15	phen	. .	g	46.0-19.0†, 47.0	equant	pale	intergranular
32	GR 56	0.10-0.50	g	g	g	46.0-21.0†, 40.0, 46.0	equant	pale	intergranular
31	GR 55	0.10-0.40	g	g	mp	47.0	equant	brown	intergranular
30	GR 54	0.10-0.25	phen	a	g		equant to elongate	pale	intersertal
30	GR 53	0.10-0.30	g	. .	mp	39.0-15.0†, 41.0	equant	brown	intergranular
29	GR 52	0.05-0.20	mp	. .	mp	46.0	equant	brown	intergranular
29	GR 51	0.05-0.20	mp	. .	g	51.5-40.0†, 48.0-33.0†, 45.0	equant	opaque	pilotaxitic
28	GR 50	0.10-0.30	mp	. .	mp	43.5, 13.0	equant	pale	intergranular
27	GR 49	0.05-0.15	mp	. .	mp	33.0-8.5†, 42.0	equant	brown	intergranular
26	GR 48	0.10-0.30	mp	. .	mp	40.0	equant	brown	intergranular
26	GR 47	0.10-0.50	g	. .	g	47.0, 47.0-27.0†, 46.0-23.0†, 47.0-21.0†, 47.0-29.0†	equant	brown	intergranular
25	GR 46	0.10-0.30	mp	g	g	47.0	equant to elongate	brown	intersertal
24	GR 44	0.10-0.40	mp	g	g	46.0-36.0†, 48.0, 40.0, 47.0	equant to elongate	pale	intergranular
24	GR 43	0.10-0.40	mp	g	mp	48.0-35.0†, 50.0-34.0†, 50.0-35.0†, 46.0, 49.5	equant to elongate	brown	intergranular
24	GR 42	0.10-0.40	g	. .	g	41.0-23.0†, 47.0-11.0†, 39.0-48.0†, 37.0-50.0†	equant	brown	intergranular
23	GR 41	0.03-0.15	g	. .	g	40.0-14.0†, 41.0-21.0†, 41.0	equant	brown	variolitic
23	GR 40	0.03-0.20	mp	. .	g	41.0-13.5†, 42.0	equant	brown	intergranular
22	GR 39	0.03-0.15	g	a	g	45.0, 36.0-8.0†, 45.0	equant	red	intersertal
22	GR 38	0.03-0.15	mp	. .	mp	49.5, 48.0, 43.0, 41.0	equant	brown	pilotaxitic
22	GR 37	0.05-0.20	g	. .	g	47.0-35.0†, 43.0-13.5†, 14.5	equant	brown	intergranular
22	GR 36	0.05-0.20	g	. .	g	43.0-10.0†, 40.0-15.5†	equant	pale	intergranular
21	GR 35	0.10-0.40	g	g	g	38.0-17.5†, 45.0-20.0†, 43.0-19.0†, 46.0-31.0†, 45.0, 49.0	equant	brown	intersertal
21	GR 34	0.10-0.40	g	g	g	38.0-50.0†, 43.0, 46.0, 46.0	equant	brown	intergranular
20	GR 33	0.10-0.40	g	g	mp	40.0-13.5†, 43.0, 43.0, 48.0, 40.0-43.5†	equant	brown	intergranular
20	GR 32	0.05-0.20	g	. .	g	42.0-48.0†, 22.0-6.0†	equant	brown	intergranular
19	GR 31	0.10-0.40	g	g	g	48.0-41.0†, 44.0-49.5†, 45.0, 43.0, 40.0	equant	brown	intergranular
18	GR 30	0.03-0.10	g	. .	g		equant	brown	pilotaxitic
18	GR 29	0.05-0.25	g	. .	g		equant	brown	intergranular
17	GR 28	0.05-0.15	mp	. .	g	42.0-49.5†, 35.5-48.0†, 43.0, 7.0	(?)	opaque	hyaloophitic
16	GR 27	0.10-0.25	g	. .	g	41.0	equant	brown	intergranular
16	GR 26	0.10-0.40	g	. .	g	43.0, 42.0-10.0†	equant	pale	intergranular
15	GR 25	0.05-0.20	g	. .	mp	40.0, 40.0, 32.0-46.0†	equant	pale	intergranular
15	GR 24	0.03-0.15	mp	. .	g	38.0-10.5†, 47.0-32.0†, 46.0-29.0†, 44.0-30.0†	equant	brown	intergranular
14	GR 23	0.05-0.20	g	. .	g		equant	brown	intergranular
13	GR 22	0.07-0.30	g	. .	g	34.5-12.0†, 34.5-41.5†, 40.0	equant	pale	hyaloophitic
12	GR 21	0.10-0.30	g	a	g	49.5, 48.0	equant to elongate	brown	intergranular
11	GR 20	0.10-0.25	g	. .	g		equant	brown	intergranular
10[5]	GR 19	0.05-0.15	phen	. .	g	46.5, 48.0	equant	brown	intersertal
10	GR 18	0.10-0.30	phen	. .	g	46.0, 46.0	equant	brown	intergranular
9[6]	GR 17	0.05-0.20	mp	g	g	43.0, 43.0, 42.0	equant	brown	intergranular
8[6]	GR 16	0.03-0.10	phen	. .	g	34.0-10.0†, 45.0, 46.0, 40.0	equant	opaque	intergranular
8	GR 15	0.05-0.20	phen	. .	g	34.0-14.5†, 43.5, 42.0, 47.0, 42.0	equant to elongate	. .	intergranular
7	GR 14	0.10-0.30	g	. .	g	42.0, 45.0, 39,0, 39.0	equant	brown	intergranular
7	GR 13	0.10-0.30	phen	a	g	47.0, 43.5, 41.0	equant	brown	intergranular, porphyritic
7	GR 12	0.10-0.30	phen	g	g	43.0	equant	brown	intergranular, porphyritic
6	GR 11	0.05-0.20	mp		g	42.0-29.0†, 40.0-25.5†, 40.0-12.0†, 38.0	equant	brown	intergranular
6	GR 10	0.05-0.15	mp	. .	mp	31.0-11.5†, 43.0, 31.0, 40.8, 39.0, 42.0	equant	brown	intergranular
	GR 9	0.10-0.40	g	g	g	48.5, 48.5, 48.0	elongate to equant	pale	intergranular
4	GR 8	0.15-0.25	g	g	g	46.0, 42.0, 48.5, 48.0	elongate	pale	intergranular
3	GR 7	0.05-0.20	mp	g	g	43.0, 41.0, 46.0, 41.0	elongate	opaque	intersertal
3	GR 6	0.05-0.20	mp	a	g	45.0, 46.0, 47.0	elongate	pale	intergranular
3	GR 5	0.15-0.50	g	. .	g	41.0, 43.5, 41.0, 41.0	equant	pale	hyaloophitic
3	GR 4	0.05-0.25	g	. .	g	43.5, 45.0, 40.0, 43.5	equant to elongate	brown	intergranular
3	GR 3	0.05-0.25	mp	. .	g	42.0-17.0†, 43.0-18.0†	equant	pale	intergranular
2	GR 2	0.05-0.25	g	. .	mp	46.0, 45.5	equant	pale	intergranular
1	GR 1	0.10-0.40	g	. .	g	43.0, 46.0-23.0†, 46.0, 20.0, 15.0	equant	pale	intergranular

[1] Petrographic descriptions as reported in Camp (1976); plag = plagioclase; phen = phenocrysts; Ol = olivine; Cpx = clinopyroxene; mp = microphenocryst (>5x matrix grains); g = groundmass grains; a = abundant; va = very abundant.

[2] See Figure 4 for flow divisions and sample localities.

[3] Uniontown-3 flow of Camp (1976), Slippery Creek flow of Price (1977); Saddle Mountains Basalt flow.

[4] Meyer Ridge flow of Camp (1976); Grande Ronde Basalt flow.

[5] Center Creek flow of Reidel (1978).

[6] Rogersburg flows of Price (1977) and porphyritic flows of Camp (1976) and Reidel (1978).

* Average length of plagioclase laths in matrix (millimeters).

† Zoned from margin to core.

APPLICATION OF SECTION DATA

This document was compiled to provide a framework upon which more regional stratigraphic and petrogenetic studies of the Grande Ronde Basalt can be based. The Grande Ronde Basalt type section lies near the approximate center of an over 6,500-square-kilometer area of the Columbia Plateau in which flows and dikes of the Columbia River Basalt Group have recently been examined in detail by Camp (1976), Price (1977), Reidel (1978), and Ross (1978). As such, the Grande Ronde Basalt type section is only one of nearly 50 basalt sections which have been measured within this area. Paleomagnetic, petrologic, and chemical data are available for at least 25 of these sections. It is anticipated that integration and interpretation of these data will provide a better understanding of the relation between Grande Ronde Basalt flows and source dikes located near the eastern margin of the Columbia Plateau and Grande Ronde Basalt flows currently being esamined by Rockwell Hanford Operations within the Pasco Basin.

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