Oligocene Alkaline Volcanic Rocks Along the Eastern Margin of the Columbia Plateau, Northern Idaho

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Contents

Figures

Tables

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ABSTRACT

Recent dates on two extrusive rock units in northern Idaho reassign them to the Oligocene. The rocks are alkaline basalts, previously included in the Miocene Columbia River Basalt Group, and associated trachytes, previously mapped as Eocene Potato Hill volcanics (Challis Volcanics equivalent). These are the first rocks of this age to be recognized in northern Idaho. Four dates on the basalts and one on the trachyte, ranging from 25.3 to 26.32 Ma, establish the basalt units as older than the Columbia River Basalt Group and the trachytes as the same age as the basalts. We propose the name "Potlatch Volcanics" for the Oligocene suite of rocks, and the names "Onaway Member" for the basaltic units and "Hatter Creek Member" for the trachytic units. Chemically, the basalt units are alkali olivine basalt in contrast to the tholeiitic basalt of the Columbia River Basalt Group. On a total alkali-silica diagram, the Onaway basalts plot mostly in the trachybasalt to trachyandesite fields. Hatter Creek trachyte units have high total alkalies and trachyandesite to trachyte composition. The dates on these rocks expand the known extent of Oligocene volcanism in the Pacific Northwest and document a previously unknown alkalic volcanic event that preceded Columbia River basalt eruption.

INTRODUCTION

Recent mapping and dating have identified Oligocene alkaline volcanics in northern Idaho (Kauffman and others, 2003). Although Oligocene volcanic and intrusive rocks are reported in other areas of the northwest, none have formerly been documented in northern Idaho (Figure 1). Most exposures of the newly identified Oligocene volcanics occur in Latah County with rare outcrops in Clearwater County (Figure 2). The volcanics consist primarily of trachybasalt, trachyandesite, trachyte, and alkali trachyte.

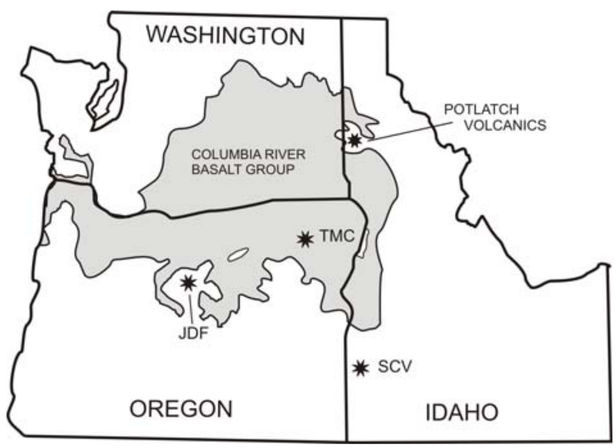

Figure 1. Locations of the Potlatch Volcanics in northern Idaho and the other Oligocene volcanic rocks in central and eastern Oregon and southern Idaho. TMC = Tower Mountain Caldera; SCV = Salmon Creek volcanics; JDF = John Day Formation. Generalized margin of the Columbia River Basalt Group after Reidel and others (1989, Figure 2).

For many years, the basaltic volcanics were thought to be part of the Columbia River Basalt Group (CRBG). Tullis (1944) and Bond (1963) described "late Cenozoic

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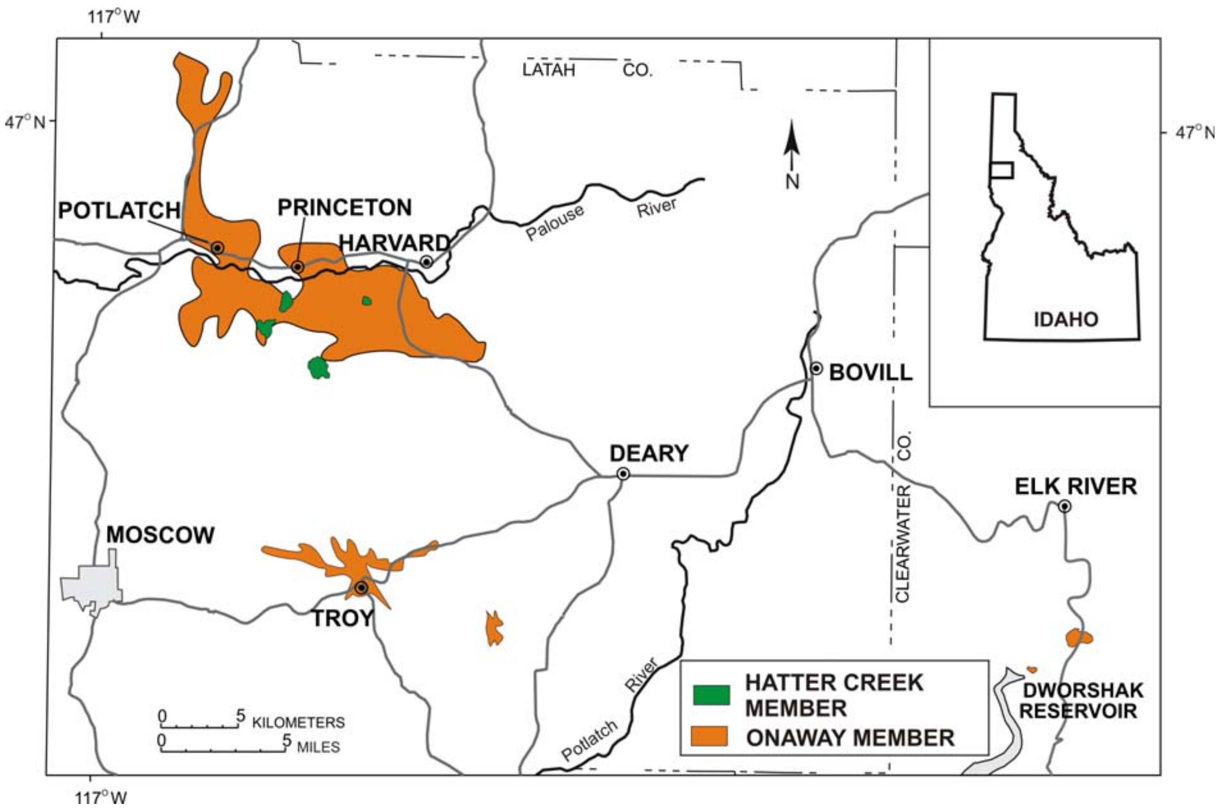

Figure 2. Generalized extent of Onaway and Hatter Creek members of the Potlatch Volcanics, northern Idaho.

flows" in Latah County that they believed to be younger than the Priest Rapids Member of the CRBG. Near Potlatch, Camp (1981) named these the basalt of Potlatch, Onaway Member, CRBG. Ambiguous field relationships included the Onaway in either Wanapum Basalt (Camp, 1981) or Saddle Mountains Basalt (Bush and others, 1995; Bush and Priebe, 1995; Bush and Provant, 1998; Bush and others, 1999; Priebe and Bush, 1999; Duncan and Bush, 1999a; and Duncan and Bush, 1999b). In 1999, two $^{40}Ar/^{39}Ar$ dates on a sample of Onaway basalt from a rock quarry near Harvard gave plateau ages of 26.2 ± 0.2 Ma and 25.6 ± 0.2 Ma (Figures 3a-b). About the same time, we discovered that one of Camp's Onaway samples had been K-Ar dated in 1984, with a resulting age of 25.3 ± 1.2 Ma, which he considered erroneous (V.E. Camp, oral commun., 2003). In 2000, basalt with chemistry similar to the Onaway was found south of Elk River along the Elk River-Dent road on the slopes above Elk Creek. The K-Ar age on this sample was 25.9 ± 0.8 Ma (Lewis and others, 2005).

The trachytic rocks were previously mapped as Eocene Potato Hill volcanics (Swanson and others, 1979). In 1999, an $^{40}Ar/^{39}Ar$ date on hornblende from the trachyte tuff on Hatter Creek gave a plateau age of 26.32 ± 0.17 Ma (Figure 3c). These ages, summarized in Table 1, firmly establish the Onaway basalts and the associated Hatter Creek trachytes as Oligocene rather than Miocene and Eocene, respectively. Recent field work has shown that CRBG flows do indeed overlie the Onaway units. Therefore, we propose the suite of rocks be given the formational name "Potlatch Volcanics," with the basaltic units retaining Camp's name, "Onaway Member," and the trachytic units assigned the name, "Hatter Creek Member." Reference localities for the members are given in the Appendix.

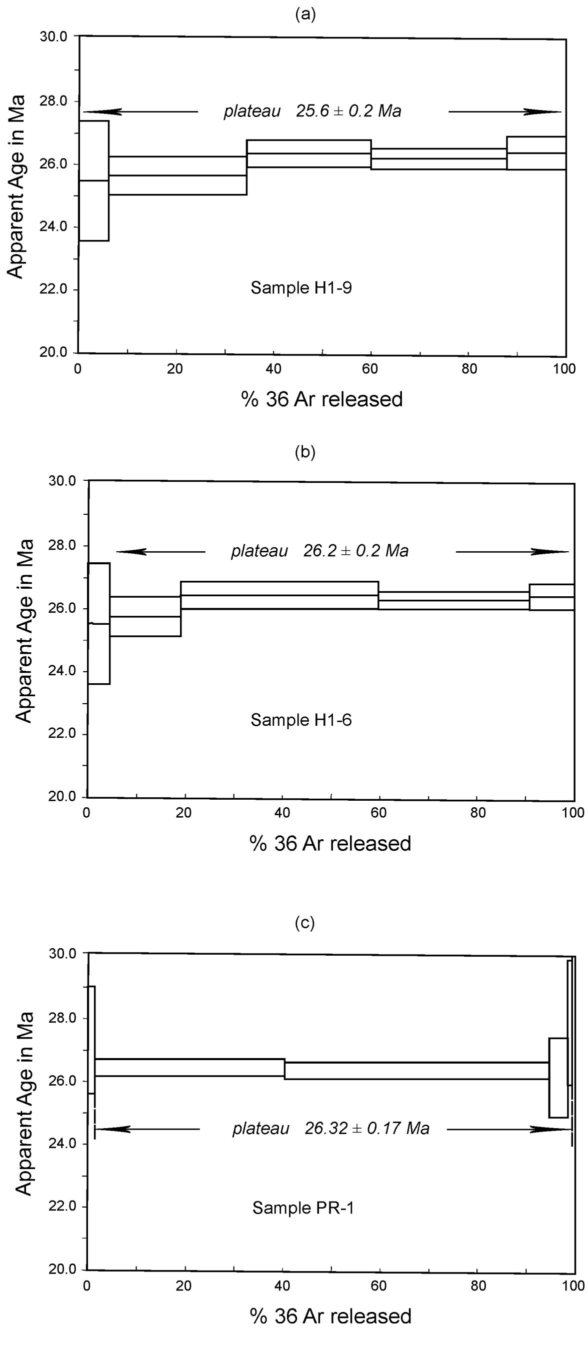

Figure 3. Plateau ages for $^{40}Ar/^{39}Ar$ determinations of Onaway Member (a, b) and Hatter Creek Member (c). H1-9 (a) and H1-6 (b) are whole rock basalt analyses conducted at Oregon State University. PR-1 (c) is a hornblende separate from a trachyte tuff analyzed at the New Mexico Geochronological Research Laboratory.

DESCRIPTION OF UNITS

ONAWAY MEMBER

Outcrops of the Onaway Member occur near the communities of Potlatch, Princeton, Onaway, Harvard, and Troy in Latah County, and south of the town of Elk River in Clearwater County (Figure 2). Overall, the basalt underlies at least 60 square km in Latah County, but the extent of the basalt south of Elk River has not been determined because of limited exposures. Driller logs for the cities of Potlatch and Troy water wells and outcrop exposures indicate the total thickness of basalt flows locally exceeds 170 m. Outcrops occur at higher and lower elevations than nearby CRBG flows of the Grande Ronde Basalt and Wanapum Basalt, which in places form buttress contacts with Onaway basalt. Erosional remnants and water well data indicate that the volcanics were extruded onto a relatively steep topography. In one of the Potlatch city wells, three basalt flows, presumed to be Onaway, are separated by sedimentary interbeds or by weathered basalt.

Outcrop characteristics vary, but the basalt commonly forms large, crude, poorly defined columns 1-3 m in diameter. Wavy flowlike structures or partings are common and spaced 1-3 cm apart and approximately perpendicular to the columnar jointing. Scoriaceous flow tops are rare. In the Harvard quarry, well-formed and in places fanning columns grade upward into ones that are poorly developed and deeply weathered. An outcrop 1 km east of Princeton exposes at least two different flows. At the exposure south of Elk River, the spheroidally weathered base of one flow rests on the weathered top of another. The lower flow is relatively massive with little evidence of columnar jointing, but has narrowly spaced subvertical curvilinear partings. Locally, the basalt is extensively weathered to light gray, tan, purplish gray, or rust orange, and in places weathering depth may exceed 10 m.

The source or sources of the basalt are uncertain. Potter (2001) described one Onaway dike that crosscuts schist and gneiss in Big Bear Creek southwest of Deary. Kirkham (1927) and Scheid (1937) described a cinder cone 0.5 mile east of Princeton. The basalt at that locality is Onaway, although the cinder cone cannot be confirmed because the exposures have been modified by highway development and the regrowth of timber and grasses.

Several outcrops in the Harvard-Princeton-Potlatch

Table 1. Age determinations for samples of Potlatch Volcanics.

Sample No.	**H1-6**	**H1-9**	**PR-1**	**00JK068**	**VC79-003**
Member	Onaway	Onaway	Hatter Creek	Onaway	Onaway
Latitude	46.9119	46.9119	46.8656	46.7087	46.9155
Longitude	-116.7383	-116.7383	-116.8054	-116.1651	-116.8176
Date (Ma)	26.2 ± 0.2	25.6 ± 0.2	26.32 ± 0.17	25.9 ± 0.8	25.3 ± 1.2
Method	$^{40}Ar/^{39}Ar$ (whole rock)	$^{40}Ar/^{39}Ar$ (whole rock)	$^{40}Ar/^{39}Ar$ (hornblende)	K/Ar (whole rock)	K/Ar (whole rock)
Laboratory	Oregon State	Oregon State	New Mexico	Geochron	Geochron

Laboratories:
Oregon State: College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon.
New Mexico: New Mexico Geochronological Research Laboratory, New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico.
Geochron: Geochron Laboratories, Krueger Enterprises, Inc., Cambridge, Massachusetts.

area were cored and found to have normal polarity. Camp (1981) also reported normal polarity from fluxgate magnetometer readings on the Onaway basalt. Our fluxgate magnetometer readings for the flows south of Elk River also indicate normal polarity. However, the number of flows related to this eruptive event is unknown, and it has not been verified that all flows have normal polarity.

In hand specimen, the Onaway is typically dense, fine to medium grained, and sparsely phyric to phyric. The phenocrysts are dominantly plagioclase and generally 0.25 to 0.75 cm in length, with some exceeding 1 cm. Pyroxene crystals as long as 1 cm were noted at one location. In places, calcite, aragonite, and chabazite amygdules are common (Rossenbach, 1994). Fresh rock typically is dark gray to black and has a satiny luster.

Tullis (1944), Camp (1981), and Potter (2001) reported that the approximate composition is 60 percent plagioclase, 15 percent olivine, 15 percent augite, and 10 percent opaque oxides. Plagioclase (1-2 mm) and olivine (0.5-1 mm) phenocrysts compose approximately 30 percent of the rock. Phenocrysts are enclosed in a groundmass of moderately to strongly aligned plagioclase laths. This alignment, which gives the rock its satiny luster, was also noted in a thin section from one of the units south of Elk River (Figure 4). Large phenocrysts (>5 mm) are typically embayed and in many places aligned, and may be xenocrysts. Tullis (1944) concluded that the smaller plagioclase phenocrysts and the groundmass plagioclase range from sodic labradorite to calcic andesine and that the larger phenocrysts are more calcic. Rossenbach (1994) determined that phenocrysts at two locations are labradorite in composition.

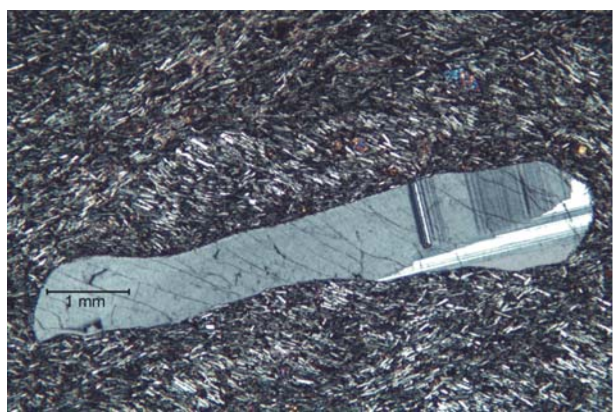

Figure 4. Thin section of Onaway Member basalt from outcrop south of Elk River. Groundmass has aligned plagioclase crystals. Large plagioclase crystal is probably a xenocryst. Scale bar is 1 mm.

HATTER CREEK MEMBER

The Hatter Creek Member is exposed 1-5 km south of Princeton primarily along Hatter Creek, a tributary of the Palouse River, and has an aerial extent less than 9 square km (Figure 2). Exposures consist predominantly of pyroclastic trachyte and minor trachyte lava. The pyroclastic units include crystal tuff and crystal-lithic tuff. Both contain 1-3 mm sandine crystals, flattened pumice, and clasts of crystal tuff and minor quartzite; one exposure has fresh hornblende crystals. Electron microprobe data from one crystal tuff exposure indicate anorthoclase as a groundmass phase. Field relations between the trachyte and basalt are not readily apparent, although the basalt overlies a weathered lithic tuff at one locality. Kirkham (1927) reported that the basalt occurred above the tuff. At one location between Deary and Harvard, a crystal tuff appears to be overlain and underlain by Onaway basalt. Several trachyte dikes cross-cutting Belt Supergroup metasediments are north of Sand Mountain about 32 km east of Potlatch and 19 km east of Hatter Creek (Lewis and others, 2005). Although trachytic in composition, the dikes cannot be directly linked to the trachytic units on Hatter Creek.

CHEMISTRY

Forty-seven samples of the basalt have been analyzed for major oxide and trace element chemistry (Kauffman, 2004); average values are given in Table 2. Using the scheme of Irving and Baragar (1971), the Onaway units are best classified as alkali olivine basalt in contrast to the tholeiitic basalt typical of the CRBG. On the total alkali-silica (TAS) diagram (Le Maitre, 1984), the Onaway units plot mostly in the trachybasalt and trachyandesite fields, whereas the CRBG basalts plot in the basalt, basaltic andesite, and andesite fields (Figure 5). The units south of Elk River fall into the potassic subdivision of Le Maitre's classification, whereas those in the Potlatch area are in the sodic subdivision. Onaway units are characterized by elevated values of Al_2O_3, TiO_2, and P_2O_5; they are also enriched in the trace elements Sr, Zr, and Nb compared to most CRBG units. Camp (1981) concluded there were several Onaway chemical units, and Duncan (1998) reported at least three chemical types. Compositional variation of our samples also indicates several chemical types.

Six samples of the trachytic rocks from the Hatter Creek area were analyzed for major oxide and trace element chemistry (Kauffman, 2004); average values are given in Table 2. Overall, the chemical analyses indicate high total alkalies and trachytic composition, and the

Table 2. Average major oxide and trace element chemistry for Onaway and Hatter Creek members, Potlatch Volcanics, a trachyte dike near Sand Mountain, and the Priest Rapids Member, Columbia River Basalt Group.

Unit	Major elements (Weight %)										
	n	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
Onaway Member	46	49.12	3.64	16.90	11.75	0.17	4.43	7.55	3.66	1.92	0.81
Hatter Creek Member	6	65.22	0.46	17.93	3.44	0.05	0.13	1.11	6.05	5.43	0.14
Sand Mountain dike	2	64.09	0.55	15.74	7.22	0.20	0.32	3.00	5.02	3.73	0.12
Priest Rapids Member	140	50.32	3.29	13.70	13.41	0.23	5.14	9.28	2.69	1.15	0.79

Unit	Trace elements (ppm)																	
	n	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Sn	Pb	La	Ce	Th
Onaway Member	46	10	15	20	218	552	26	667	334	33	57.5	25	12	136	3	37	92	4
Hatter Creek Member	6	9	1	7	10	760	144	160	1010	64	158	35	2	179	10	131	229	18
Sand Mountain dike	2	4	0	41	8	1773	97	248	473	40	29.2	22	14	100	6	51	94	10
Priest Rapids Member	140	37	99	37	376	542	26	290	184	46	16.7	22	37	143	4	24	60	4

n = number of samples analyzed.
Selection of Priest Rapids Member samples from Kauffman (2004) includes Lolo and Rosalia chemical types.
Major elements normalized on a volatile-free basis, with total Fe expressed as FeO.
All analyses performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

units plot in the trachyandesite and trachyte TAS fields of Le Maitre (1984; Figure 5). Analyses of two samples from one of the dikes near Sand Mountain suggest correlation, although total alkali content is lower than that of the Hatter Creek trachytes (Table 2). To our knowledge, alkali trachytes have not previously been reported in Oligocene rocks in the Pacific Northwest.

REGIONAL PERSPECTIVE

Oligocene volcanic rocks have been reported elsewhere in southern Idaho and central and eastern Oregon. These include the Salmon Creek volcanics in the Owyhee Mountains of southern Idaho (Norman and others, 1986), volcanic units in the John Day Formation of Oregon (Walker and Robinson, 1990; Robinson and others, 1990), and the recently discovered Tower Mountain volcanic field in northeast Oregon (Ferns, 2002). The Salmon Creek volcanics (30.9-26.0 Ma) are similar to the Potlatch Volcanics in that they consist of trachybasalt and trachyandesite (Norman and others, 1986). The John Day Formation volcanic units range in age from about 30 Ma to 20 Ma and include rhyolite flows and domes as well as flows of alkali basalt and trachyandesite (Walker and Robinson, 1990; Robinson and others, 1990). The Tower Mountain volcanic field differs from the Potlatch Volcanics in that it consists of early tholeiitic basalt and alkali olivine basalt (about 30 Ma) followed by porphyritic dacite and andesite lavas, rhyolite ash-flow tuffs, rhyolite domes, and caldera-filling silicic masses; silicic volcanism ceased at about 22 Ma with dacite and andesite lava eruption (Ferns, 2002). More distant exposures include volcanic, intrusive, and volcaniclastic Oligocene rocks reported in the Coast Range of Oregon (MacLeod and Snavely, 1973) and the Ohanapecosh Formation of the Cascade Range in Washington (Dragovich and others, 2002). These widespread occurrences of compositionally varied Oligocene volcanic, intrusive, and volcaniclastic rocks indicate a significant regional episode rather than localized, isolated eruptive events.

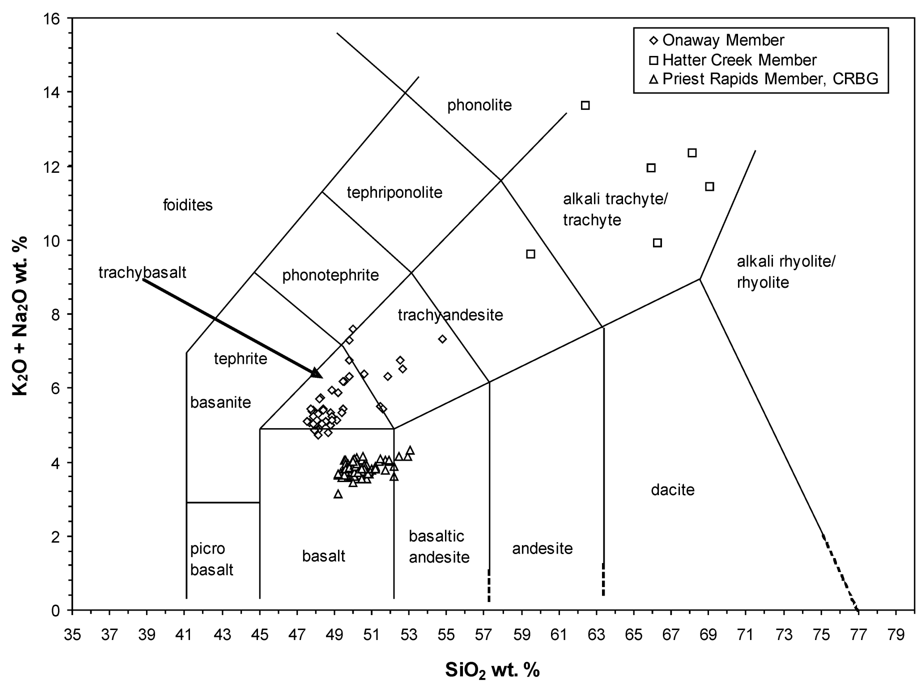

Figure 5. Total alkali-silica (TAS) diagram (after Le Maitre, 1984) for Onaway and Hatter Creek members, Potlatch Volcanics versus Priest Rapids Member, Columbia River Basalt Group.

SUMMARY

Alkaline basaltic and trachytic volcanic rocks in northern Idaho, previously thought to be Miocene and Eocene, respectively, have been dated as Oligocene. These are the first rocks of this age to be recognized in northern Idaho. The Onaway Member basalts are chemically distinct from the Miocene CRBG, plotting in the TAS diagram fields of trachybasalt and trachyandesite rather than in the basalt, basaltic andesite, and andesite fields. The Hatter Creek Member consists of trachyandesite and alkali trachyte. The discovery of these rocks, coupled with those in southern Idaho and Oregon, expands the known extent of Oligocene volcanism in the Pacific Northwest and indicates a regional volcanic episode. The compositional variation during the Oligocene at these separate locations must be considered in regional models of tectonic and volcanic activity.

ACKNOWLEDGMENTS

We thank Victor E. Camp for sharing his thoughts about early ambiguities regarding the stratigraphic position of the Onaway basalt and the problematic nature of the date on his sample. We also appreciate helpful discussions and comments provided by Stephen P. Reidel.

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APPENDIX: Reference Localities for Members of the Potlatch Volcanics

The Onaway Member basalts and the Hatter Creek Member trachytes have only been found together at one poorly exposed location, and no outcrop has been found with a well-exposed section. In fact, the stratigraphic relation of the two members is uncertain. Therefore, rather than describing "type section" localities, we offer the following reference localities for the members.

ONAWAY MEMBER REFERENCE LOCALITIES

The basaltic rocks of the Onaway Member are best exposed in roadcuts and rock quarries near the towns of Potlatch, Princeton, Harvard, and Onaway, Idaho, and along the Elk River-Dent road in the Elk Creek drainage south of Elk River, Idaho.

The Onaway Member is well exposed in roadcuts along State Route 6 from Potlatch to Harvard. Dated sample VC79-003 is from an outcrop along this road near Princeton. The best exposures are in two rock quarries, one about 1 km west of U.S. 95 in sec. 1, T. 42 N., R. 5 W., Mission Mountain 7.5-minute quadrangle (47.00979°N, 116.90376°W), and the other just east of State Route 9 about 1 km south of Harvard in sec. 8, T. 41 N., R. 3 W., Harvard 7.5-minute quadrangle (46.912223°N, 116.738109°W). Dated samples H-6 and H-9 are from the latter quarry. Other exposures are near Deary and Troy, Idaho. Thickness and number of individual flows has not been determined.

South of Elk River, the basalt is exposed in a roadcut and outcrops along the Elk River-Dent road on the east slope of Elk Creek in sec. 24, T. 39 N., R. 2 E., Elk Creek Falls 7.5-minute quadrangle (46.708718°N, 116.165098°W). An elevation station on the topographic map near the outcrop is labeled "2888" (feet). Dated sample 00JK068 is from the upper of two flows at this location. The contact between flows is in the road embankment. Approximately 30 m of the lower flow is exposed, but the base is covered. Float of the upper flow continues up the slope from its basal contact at least 70 m, but no outcrops were found.

HATTER CREEK MEMBER REFERENCE LOCALITIES

The trachytic rocks of the Hatter Creek Member are best exposed along Hatter Creek and its tributaries beginning about 1 km south of the town of Princeton, Idaho. The best exposures are in road cuts about 5 km south of Princeton in secs. 26, 27, 34, and 35, T. 41 N., R. 4 W., Moscow Mountain 7.5-minute quadrangle. Dated sample PR-1 is from this locality as are several of the chemistry samples. Other chemistry samples were collected from exposures west of Hatter Creek about 1 km south of Princeton in secs. 9, 16, and 21, T. 41 N., R. 4 W., Princeton 7.5-minute quadrangle. Exposures of the member are insufficient to determine the number or thickness of individual units.