Petrology and geochemistry of Pliocene and Quaternary volcanics of the southern Cascade Range, Klamath River Gorge, Oregon

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INTRODUCTION AND GEOLOGIC SETTING

Field mapping in a section of volcanics in the Cascade mountains of southern Oregon revealed ten new basaltic to andesitic units. The field area lies in a transitional province between the High Cascades subduction-related and Basin and Range extension-related volcanic regimes. High Cascades volcanism is related to subduction of the Juan de Fuca plate system off the west coast of North America. The Basin and Range Province is dominated by NW-SE extension along N-NE trending normal faults. By 17 Ma, convergent margin stresses had shifted west, effectively creating a back-arc environment in the northern Basin and Range (Hart and Carlson, 1987). However, the Basin and Range is not the back-arc to the Cascades in the strictest sense, because the major period of Cascades subduction had ended by the time Basin and Range extension began (Guffanti and Weaver, 1988). Lavas in the field area are potentially related to a combination of melts from these two tectonic regimes. Petrographical and geochemical analysis will help to resolve components of melts from the two regimes.

FIELD OBSERVATIONS

The field area consists mostly of low relief terrain, vegetated with either coniferous forest undergoing active logging, or a thick cover of manzanita and other scrub brush. Mapping was accomplished primarily on foot, using mostly the numerous logging roads which lace the area. The Klamath River Gorge, which doubles back on itself in the field area making the topographic 'Long Point', creates 2-3 km of canyon with close to 300 m of relief. The best rock exposures in the field area are in this canyon. However, the steepness of the sides of the canyon makes access to rock exposure difficult, and often impossible. The most voluminous units come from Hayden Mountain and Chase Mountain, two basaltic andesitic cones which lie in or near the field area. The lavas from these two centers interfinger spatially and temporally with flows from the other eight units in the area. Most of the units contain more than one flow, which can be seen in the field by a rubbly layer at the base and high vesicularity at the top of the flow.

ANALYTICAL TECHNIQUES

With the exception of INAA data, all analytical work was performed at The Colorado College. Thirty samples were selected for analysis based on freshness of sample and accurate representation of all the units. Petrographical anaysis, including modal anlyses and plagioclase composition determined by Michel-Levy technique, were performed on thin sections. Loss on Ignition and X-Ray Fluorescence procedures were also performed on the thirty samples. INAA work was performed at Oregon State University through a U. S. Department of Energy University Reactor Sharing Grant on ten samples. The computer modelling program Minpet was used in analyzing the data.

PETROGRAPHY

Hayden Basaltic Andesite This thick, voluminous unit, which remains compositionally consistent over an approximately 2 Ma time span, is characterized in hand sample by up to 20% olivine phenocrysts, 10% plagioclase phenocrysts and minor glomeroporphyritic clumps. In thin section, plagioclase composition is An50, olivine is up to 11.7% and weathered. Clinopyroxene is a minor groundmass constituent.

Chicken Hills Plagioclase Porphyry Basalt This unit is distinguished in hand sample by 35% plagioclase phenocrysts and 20% olivine phenocrysts. In thin section, plagioclase is An53 in phenocrysts, and An60 in groundmass, blocky and euhedral. Olivine in phenocrysts and groundmass is weathered.

Long Point Ophitic Basalt In hand sample, this basalt contains 15% olivine phenocrysts with minor orthopyroxene. The most distinguishing characteristic in thin section is the pronounced ophitic texture of the plagioclase and clinopyroxene. Plagioclase (An49) is present in minor clots.

Long Point Andesite This andesite is characterized in hand sample by 25% plagioclase laths 2-5 mm long and 5-10% olivine phenocrysts. In thin section, the distinguishing feature of this unit is the well defined porphyritic texture. Olivine phenocrysts are very weathered.

Topsy Andesite The distinguishing feature for hand sample of this unit is 40% lath-shaped plagioclase phenocrysts. In thin section, plagioclase phenocrysts (An 52) are 40%, clinopyroxene is 10.8%, and olivine is only a minor constituent.

Klamath Canyon Andesite The hand sample characteristics are 40% plagioclase laths, 10% orthopyroxene and clinopyroxene, and trace amounts of olivine. In thin section, plagioclase phenocrysts (An53) vary from square to lath-shaped. Minor olivine, in groundmass and phenocrysts is weathered.

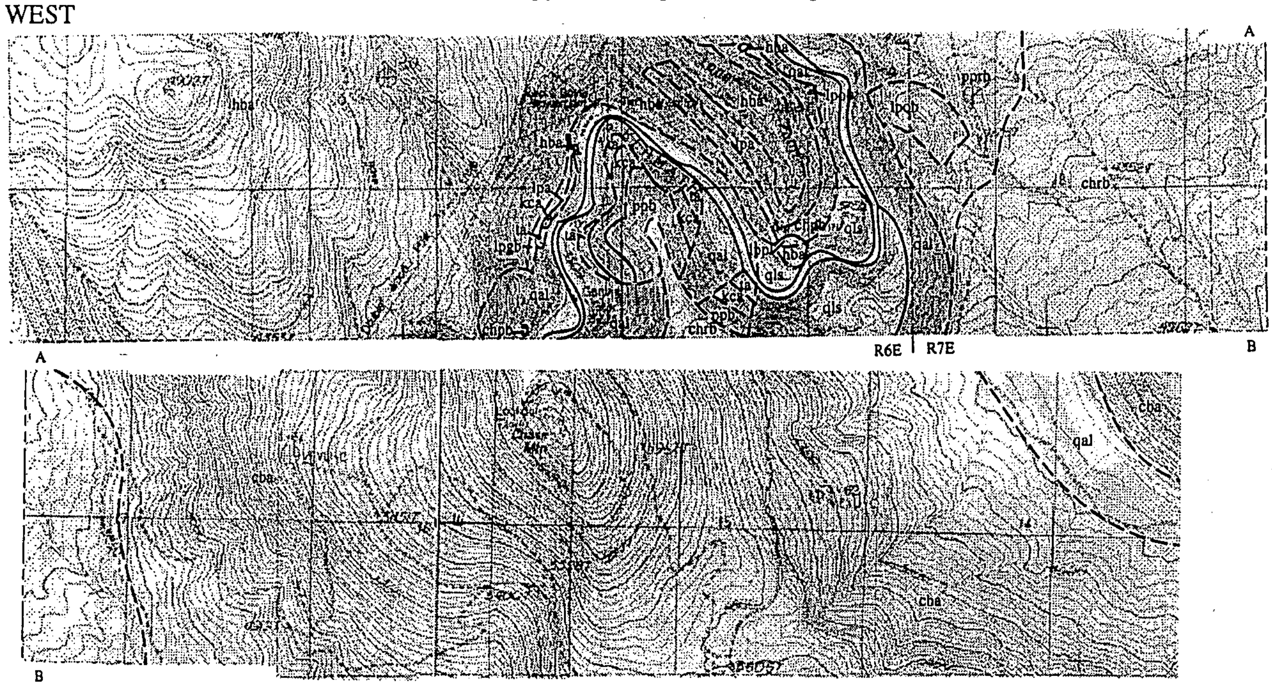
Long Point Glomeroporphyritic Basalt The hand sample for this unit has a very distinctive pattern of star-shaped glomeroporphyritic clumps of plagioclase and olivine, up to 2 cm. In thin section, this unit displays a sub-ophitic texture with olivine phenocrysts.

Pacific Power Rim Basalt The hand sample for this unit contains 15% olivine in varying degrees of freshness, and 15% plagioclase phenocrysts. In thin section, plagioclase (An63) is primarily in groundmass, and olivine occurs primarily as phenocrysts.

Chase Basaltic Andesite This unit is characterized in hand sample by 20-25% plagioclase microphenocrysts and a trace amount of small olivine and clinopyroxene crystals. Thin section is characterized by euhedral plagioclase, and minor olivine and clinopyroxene.

Chicken Hills Rim Basalt This basalt is best characterized in hand sample by 20% olivine, 15% plagioclase phenocrysts, diktytaxitic texture and small glomeroporphyritic clumps. Plagioclase in thin section is An61, olivine phenocrysts are weathered and clinopyroxene is present in the groundmass.

WEST



EAST

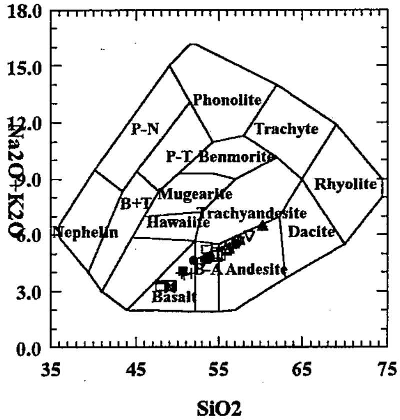
Fig. 1 Geologic map of field study area

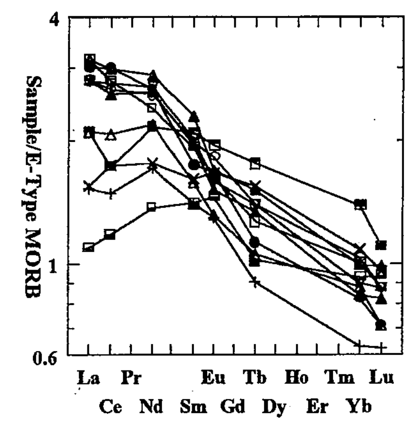
Symbol	Unit Name	Map Label	K-Ar Age *
○	Hayden Basaltic Andesite	hba	3.7 +/- 0.1 Ma
+	Chicken Hills Plagioclase Porphyry Basalt	chpb	
⬒	Long Point Ophitic Basalt	lpob	
▲	Long Point Andesite	lpa	
△	Topsy Andesite	ta	
▽	Klamath Canyon Andesite	kca	4.4 +/- 0.2 Ma
⬓	Long Point Glomeroporphyritic Basalt	lpgb	4.1 +/- 0.2 Ma
●	Pacific Power Rim Basalt	pprb	4.4 +/- 0.4 Ma
□	Chase Basaltic Andesite	cba	2.51 +/- 0.07 Ma
×	Chicken Hills Rim Basalt	chrb	1.1 +/- 0.2 Ma

Fig. 2 Table of unit names, ages, unit labels used on map, and symbols used on geochemistry plots
* K-Ar ages by Mertzman, personal communication, 1995-96

GEOCHEMISTRY

The units are classified as basalt, basaltic andesite and andesite based on a Na2O+K2O vs. SiO2 plot (Fig. 3). On the same plot all the units are subalkaline. On a FeOt/MgO vs. SiO2 plot, Long Point Glomeroporphyritic Basalt, Long Point Ophitic Basalt, Chicken Hills Rim Basalt, Chicken Hills Plagioclase Porphyry Basalt and Topsy Andesite plot in a tholeiitic field, while the rest of the units plot as calc-alkaline (Fig. 6). Chicken Hills Plagioclase Porphyry Basalt, Long Point Ophitic Basalt, Long Point Glomeroporphyritic Basalt, and Chicken Hills Rim Basalt are olivine and hypersthene normative; the rest of the units are quartz and hypersthene normative. LREE are 1-3 times EMORB enriched, and HREE are 0.6-1 times EMORB enriched (Fig. 4). Spiderplots show 2-20 times EMORB enrichment for highly incompatible elements, and 0.3-2 times EMORB enrichment for less incompatible elements (Fig. 5). All units are an excellent match for an EMORB source. Spiderplots and REE plots show a separation of the tholeiitic units from the calc-alkaline units.





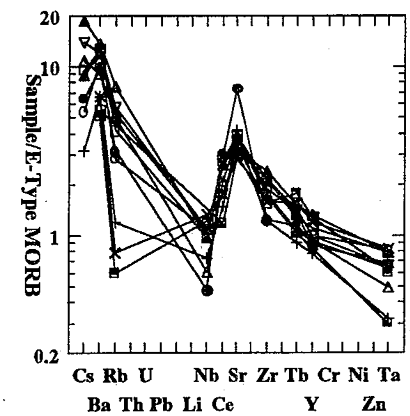
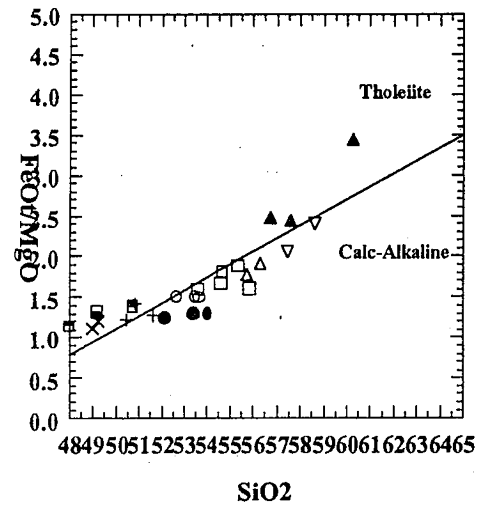
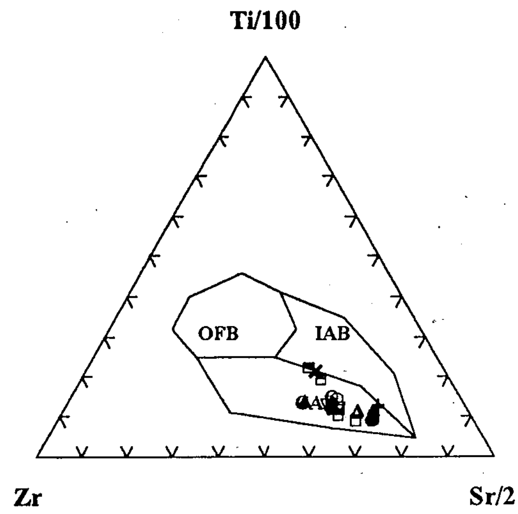


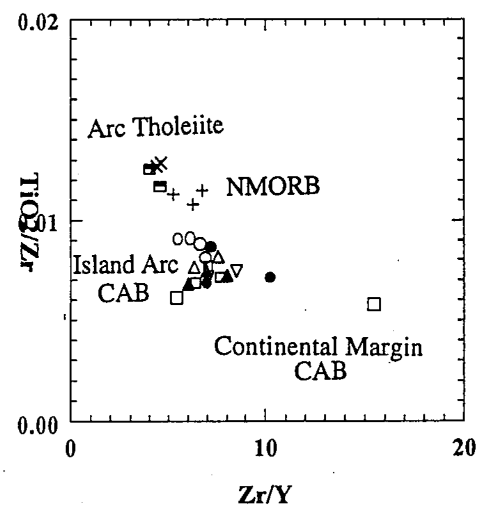
Fig. 3 Na2O+K2O vs. SiO2 rock discrimination plot
Fig. 4 Rare Earth Element plot showing normalization to EMORB
Fig. 5 Spiderplot of incompatible elements showing normalization to EMORB

DISCUSSION

On many discriminant diagrams for tectonic setting (Ti/100-Zr-Sr/2, TiO2/Zr-Zr/Y, TiO2-Zr), Hayden Basaltic Andesite, Topsy Andesite, Long Point Andesite, Klamath Canyon Andesite, Pacific Power Rim Basaltic Andesite and Chase Basaltic Andesite plot consistently as calc-alkaline. These units are all clearly lavas from a subduction-related orogenic setting. Long Point Ophitic Basalt, Long Point Glomeroporphyritic Basalt, Chicken Hills Rim Basalt and Chicken Hills Plagioclase Porphyry Basalt almost always plot in a cluster, often in a tectonic setting separate from the calc-alkaline units. Zr is particularly useful in discriminating tectonic environments (Figs. 7, 8, 9). These four units which plot separately from the calc-alkaline units are similar to literature descriptions of Basin and Range high alumina olivine tholeiite (HAOT) (Hart, *et al*, 1984; McBirney, 1993). However, it is unclear whether they are can be attributed entirely to Basin and Range extensional volcanics. Mineral compositions and isotope data are necessary to evaluate fully this possibility.







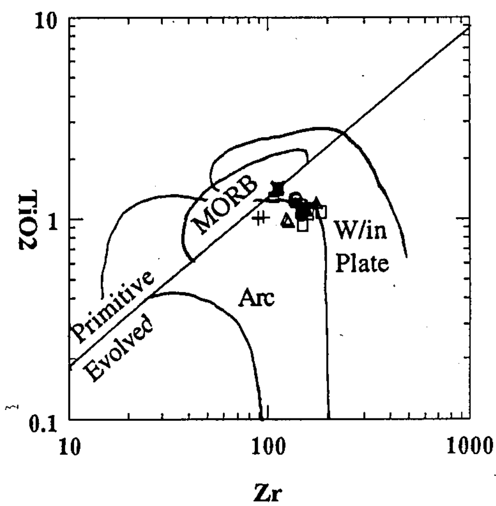


Fig. 6 FeOt/MgO vs. SiO2 binary plot showing separation of calc-alkaline and tholeiitic units
Fig. 7 Ti/100-Zr-Sr/2 ternary plot showing clustering in units as discussed in text. OFB-ocean floor basalt, IAB-island arc basalt (analogous to low-K tholeiite), CAB-calc-alkaline basalt
Fig. 8 TiO2/Zr vs. Zr/Y binary plot showing tectonic setting and clustering of units
Fig. 9 TiO2 vs. Zr binary plot showing tectonic setting and clustering of units, right hand cluster corresponds to High Cascade geochemical data, left-hand clusters correspond to Basin and Range geochemical data
Note: Plots shown in figs. 7-9 are basalt discriminant diagrams, and therefore may not be applicable to the andesitic units, shown as triangles. The andesitic data is plotted in order to have representation of all the units in the study area.

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