A PETROGRAPHIC AND GEOCHEMICAL STUDY OF HIGH CASCADES VOLCANISM IN SOUTH-CENTRAL OREGON

Heather L. Petcovic
Smith College
Northampton, MA 01063

Introduction

The Cascade Range is a volcanic arc that stretches along the west coast of North America from southern British Columbia to northeastern California and northwestern Nevada. It can be divided into two sub-provinces based on age and style of volcanism: the Late Eocene to Miocene-aged calc-alkaline Western Cascades, and the Plio-Pleistocene stratovolcanoes of the High Cascades. The development of both the Western and High Cascade provinces is associated with the subduction of the Juan de Fuca plate system beneath North America. Variation in eruptive style and magma composition is generally attributed to changes in the angle of dip of the subducting plate. However, it has been suggested that Cenozoic westward migration of Basin and Range-style extensional volcanism has impinged on the Cascade region.

The goal of this study is to characterize petrographically and geochemically a suite of volcanic rocks from southern Oregon in order to examine the genetic relationships within this suite and relationship to the Cascade and Basin and Range tectonic provinces.

Field Location

The ten Oregon Keck III students mapped 71 square miles within the Winema and Rogue River National Forests in southern Oregon. The study area examined in this paper comprises R4E, T38S, Sections 9, 10, 11, 15, 16, 21, and 22 of the Brown Mountain and Little Chinquapin Mountain 7.5 minute USGS quadrangles located within the Rogue River National Forest. Based on outcrop characteristics and hand sample petrography, seven lithologic units were identified in the field.

Lithology and Petrography

Thirty thin sections were analyzed to confirm the petrography of each unit established in the field. Field relationships were used to determine relative ages of flows; ages for each unit were confirmed using K-Ar radiometric dating (Mertzman, 1994-95). Figure 1 shows the geologic map of the field area.

5385 T BUTTE "GRUNGY GREEN" BASALTIC ANDESITE (5.82 ± 0.09 Ma): This unit was originally identified as a basalt; based on geochemical data, however, it has been reclassified as a basaltic andesite. The source for this unit is the unnamed peak at 5385 feet. It outcrops poorly in the study area, with both outcrops and float weathering to a particular "grungy" green color. Outcrops are low, bouldery, and close to the ground occasionally showing a blocky morphology and flow banding. Hand samples are generally non-vesicular with a sacchroidal texture and show excellent flow-alignment of the plagioclase. In thin section acicular zoned plagioclase phenocrysts (0.25-0.4 mm, 83% modal abundance) dominate. Small, rounded olivine phenocrysts (0.1 mm, 15%) generally have rims which are altered to iddingsite. Opaques comprise 2-3% of the rock. Glomeroporphrytic clumps are rare in this unit.

BIG DRAW CREEK OLIVINE PHYRIC BASALT (2.96 ± 0.06 Ma): The source for this unit is a dike and associated vent structures striking N40W in section 9. The first of the four vent structures is located in the SW 1/4 of the NE 1/4 of section 9; the outcrop is elliptical with vertical flow banding and jointing of the basalt surrounding a more massive, highly vesicular center. The remaining three vent structures of the dike are similar to the first. In other locations, this unit forms excellent platy outcrops. Only phenocrysts of olivine, clinopyroxene, and orthopyroxene are visible in hand sample; the acicular plagioclase is confined to the groundmass. In thin section, olivine phenocrysts (1 mm, 30%) are usually highly altered and form the dominant phenocryst type. Phenocrysts of clinopyroxene (<1 mm, 12%) and orthopyroxene (<1 mm, 5%) can be found in scattered glomeroporphrytic clumps with the olivine in some of the thin sections while others have only olivine phenocrysts. Acicular plagioclase (0.1-0.2 mm, 55%) often shows excellent flow banding. Opaques account for 8% of the rock.

OLD BALDY BASALTIC ANDESITE (2.78 ± 0.06 Ma): The source for this unit is Old Baldy, located to the southeast of the study area. Outcrops of this unit generally are low and blocky with lobate morphology. When found as float, this unit forms subrounded and rounded cobbles and boulders. Flows are predominantly vesicular with vesicles generally elliptical to elongate. In hand sample, large (1-2 mm) olivine-dominated glomeroporphrytic clumps are common. In thin section, tabular plagioclase (1-1.5 mm, 60-70%) and olivine (1 mm, 30-40%) are the dominant phenocrysts. The groundmass is mostly composed of smaller plagioclase crystals. Scattered orthopyroxene phenocrysts may be found, but account for less than 1%. Opaques account for 4-5 % of the rock.

FOUR CORNERS OLIVINE BASALT (2.63 ± 0.08 Ma): This unit outcrops poorly and is found only as platy float in the northeastern corner of Section 11. It has a holocrystalline texture with an aphanitic groundmass and is non-vesicular. Large euhedral olivines (1 mm, 35%) generally are highly iddingstitized and form the only phenocryst type. Acicular plagioclase (<5 mm, 60%) and small opaques (5%) are confined to the groundmass.

BRUSH MOUNTAIN OLIVINE PHYRIC BASALT: This unit is found only as platy and angular float in a small area of Section 22. Because of the scarcity of this unit, no samples were taken for thin section or geochemical study. In hand sample, the unit is generally non-vesicular with olivine phenocrysts .

BRUSH MOUNTAIN BASALT (1.97 ± 0.06 Ma): The source for this unit is Brush Mountain, whose summit lies just to the east of the study area. Extensive flows cover about the lower third of the study area. Outcrops are generally low, blocky, and rounded yet show excellent lobate flow morphology. This unit generally weathers spheroidally. Hand samples are generally vesicular, and are dominated by very large (1-2 mm) glomeroporphrytic clumps of olivine and plagioclase. In thin section, the plagioclase (1 mm, 60-70%) is usually tabular and zoned. The olivine crystals (0.5 mm, 30-40%) are generally rounded and have altered rims. Opaques account for 3-4% of the rock.

BURTON BUTTE BASALT (0.82 ± 0.08 Ma): The youngest unit, Burton Butte Basalt covers an extensive amount of the entire 1994-95 Keck study area. In this field area, outcrops are poor and the unit was found mostly as highly vesicular subrounded to subangular cobbley float. Samples of this unit often containing xeolites. The more massive samples have a dictytaxitic texture with an aphanitic groundmass. In thin section, euhedral olivine (1.5 mm, 30-40%) form large phenocrysts. While most of the plagioclase is confined to the groundmass, large phenocrysts (1 mm, 60-70%) are common. Occasional orthopyroxene can be found, as well as 2% opaques.

Geochemical Data and Discussion

Thirty samples, the locations of which are shown in Figure 1, were selected for geochemical analysis. Major element geochemistry was performed at the X-Ray Fluorescence (XRF) Lab of the Amherst Campus of the University of Massachusetts. Trace element geochemistry was performed at Franklin and Marshall College using the inductively coupled plasma (IC) method.

Based on geochemical analysis, all of the units can be classified as sub-alkaline. When plotted on an alkali-iron-magnesium (AFM) diagram after Irvine and Barager, all of the units except Burton Butte Basalt fall within the calc-alkaline field. Burton Butte can be classified as a high-alumina olivine tholeiite. The LeBas classification scheme for calc-alkaline rocks plotted on a total alkali vs. silica (TAS) diagram reveals that the units are classified as basalts and basaltic andesites, which is consistent with subduction-related volcanics.

Trace element geochemistry for each unit is shown in Figure 2, a spiderdiagram normalized to MORB composition. The enrichment of LREEs, slight depletion of HREEs, and Nb anomaly are typical of the signature for calc-alkaline volcanics.

An intriguing trend revealed by the geochemical data is that the units tend to become more mafic over time. In general, older units tend to be enriched in silica and alkalis while younger units contain more iron and magnesium. This trend is especially evident in the Harker variation diagrams (Figs. 3a, b, and c). The MgO and CaO plots show a negative SiO_2 correlation while the Na_2O plot shows a positive correlation. The variation diagrams could be compatible with pyroxene-dominated crystal fractionation, or in the case of the MgO plot, olivine fractionation. Certainly this is applicable within each unit; for example, in the MgO plot Big Draw Creek clearly shows a fractionation trend. However, if the units are genetically related, then age trends are reversed from what should be expected. With simple fractionation, units should become less mafic over time rather than more mafic. This may indicate that the units are not genetically related but instead are the results of several fractionation trends. The plots, however, are also consistent with a magma mixing or crustal assimilation process. Figure 4, a plot of Zr/Y vs. Zr, indicates that the units could be related through mixing. In this scenario, early primitive magmas assimilated the crust and became more felsic as they rose to the surface. As later magmas flowed through well-developed conduits, there was less contact with the crust which preserved their more primitive character. In either case, all of the units are geochemically consistent with subduction-related volcanism with the exception of Burton Butte, a possible product of Basin and Range extension.

References

Guffanti, M., and Weaver, C.S. 1988. Distribution of Late Cenozoic volcanic vents in the Cascade range: Volcanic arc segmentation and regional tectonic considerations. Journal of Geophysical Research, 93: 6513-6529.

McBirney, A.R. 1993. Igneous Petrology, Second Edition. Boston & London: Jones and Bartlett, Publishers.

Mertzman, S.A. 1994-95. Unpublished data.

Pallon, J.E. 1993. A Petrological and Geochemical Reconstruction of the Cascade Range in the Region of the Mt. Lakes Wilderness Area, Winema National Forest, Klamath County, Oregon. Smith College Honors Thesis.

Rhodes, J.M. 1994-95. Personal communication.

Wilson, M. 1989. Igneous Petrogenesis: A Global Tectonic Approach. London: Unwin Hyman.

Figure 1: Geologic map and stratigraphic column showing distribution of lithologic units in field area.

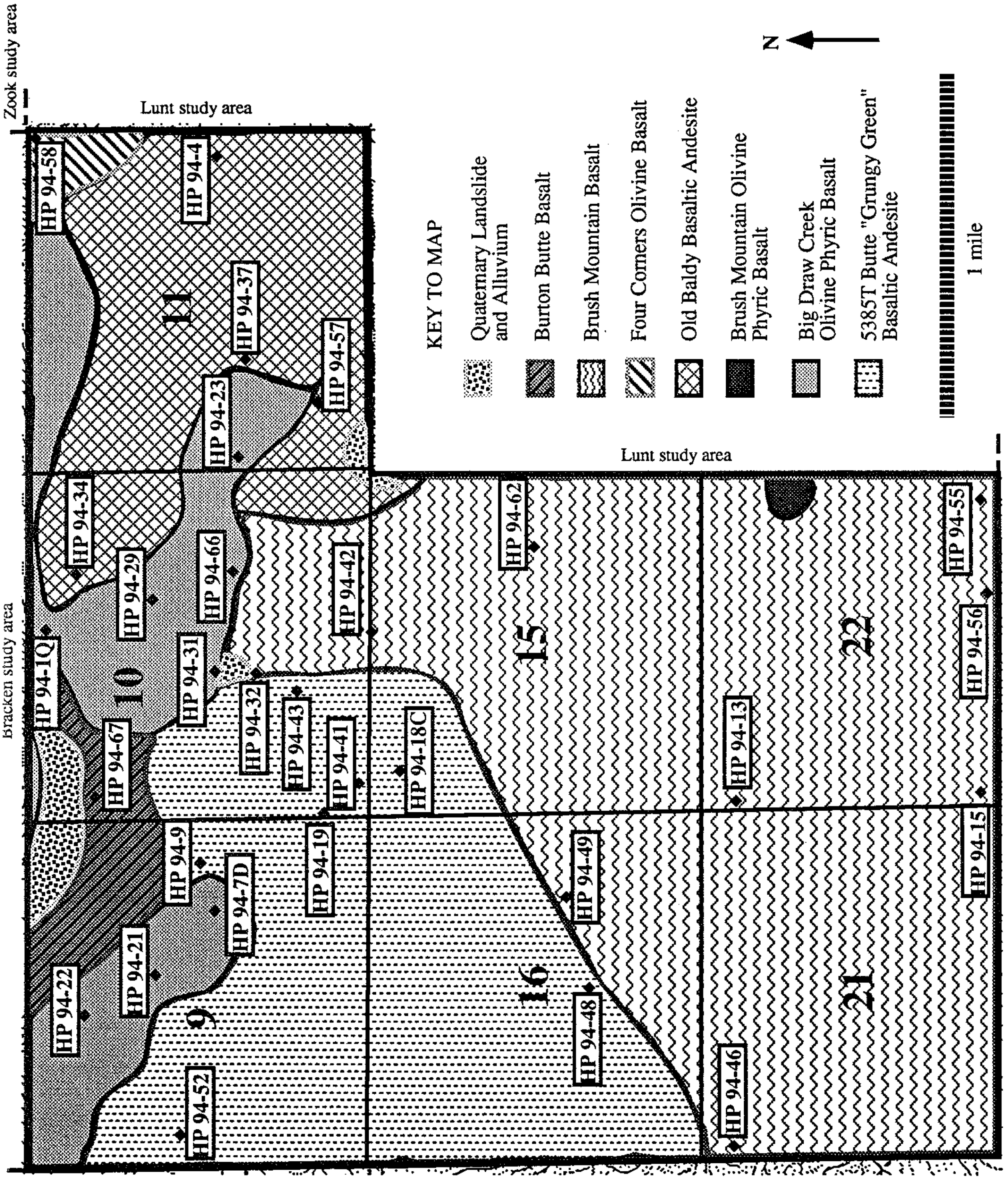
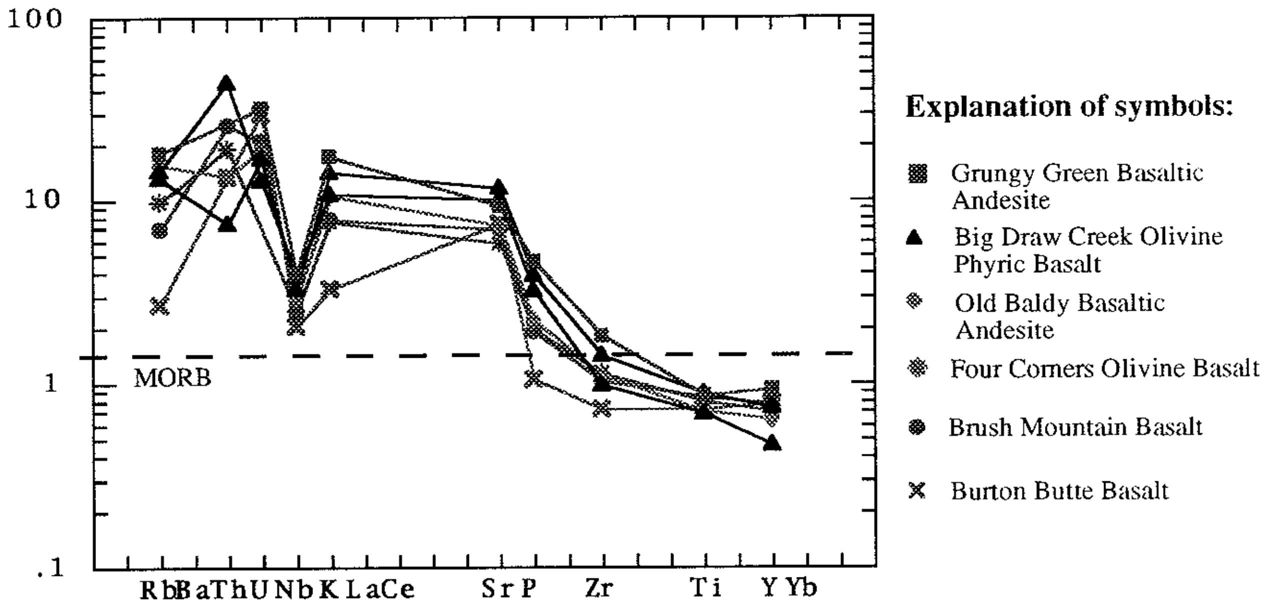
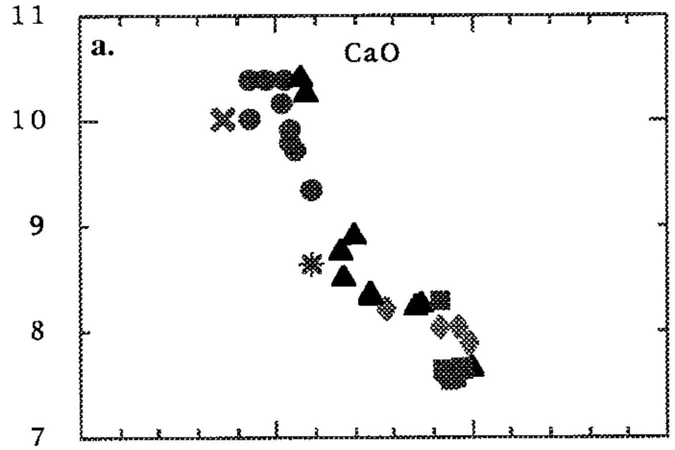
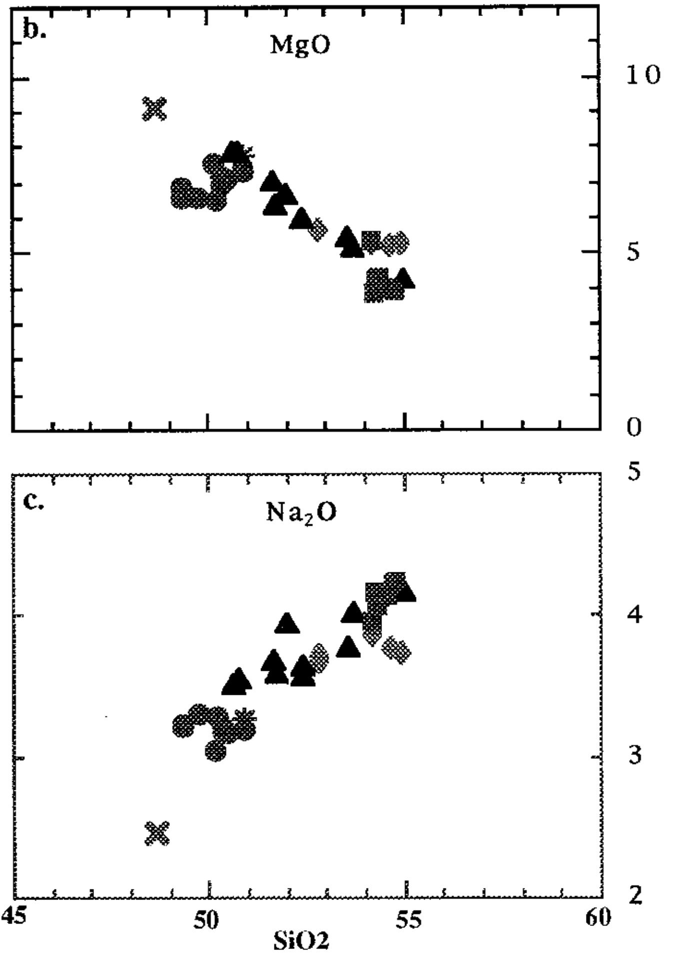


Figure 2: Spiderdiagram of trace elements normalized to MORB







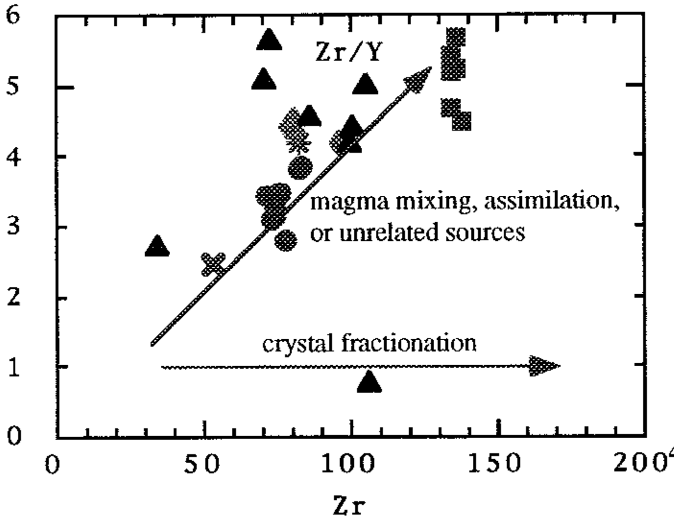


Figure 4: Plot of Zr/Y ratio plotted against Zr showing various geochemical trends.

Figures 3a, 3b, and 3c: Harker variation diagrams showing wt % of various oxides plotted against wt % SiO2.