The Geology and Petrology of the Brush Mountain - Old Baldy Region, Southern Cascades, Oregon

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Introduction

The Cascade volcanic arc is located inland from the northwestern coast of the United States, and extends from Mt. Lassen in northern California to Mt. Garibaldi in British Columbia. It is bordered to the east by the bimodal extrusives of the Basin and Range Physiographic Province. This study focuses on describing and characterizing the geology, petrography, and geochemistry of the mafic extrusive rocks which cover seven square miles around Brush Mountain and Old Baldy Mountain in the Cascade Range in southern Oregon.

Geological Setting

The tectonic setting of the Cascade volcanic arc is generally associated with the subduction of the Juan de Fuca oceanic plate beneath the North American continental plate. The extruded material, however, is not clearly linked to melting of the subducting plate, or to the extensional regime of the Basin and Range Province. The Southern Cascades in the vicinity of the area in question are characterized by widely spaced large stratovolcanos and topographically less distinct, but volumetrically more significant shield volcanoes, cinder cones, spatter ridges, and their associated lava flows.

Field Observations

Eight lithologic units were distinguished and subsequently mapped in the seven square mile area. Seven potential sources were identified in the forms of exogenous domes (northernmost extent of the Dike in Section 25), vent facies (north ridge of Old Baldy, southern flank of Brush Mountain, knob in Section 12), or topographic highs in combination with either of the prior forms (Brush Mountain, Old Baldy, 6054 Peak, 6054 Dike). Five of the units were olivine-phyric in hand sample. In general the units are noteworthy for their 5-15% of olivine phenocrysts; plagioclase and clinopyroxene are more abundant, but are confined to microphenocryst-groundmass dimensions. Trends of dikes and vent facies were taken wherever possible; data are as follows: jointing of northernmost dike unit (Section 25) N60°W, vents along southern flank of Brush Mountain (Section 23) N20°E, and vents along the north ridge of Old Baldy (Section 13) North-South. Hart and Carlson (1987) have identified north-south, northwest-southeast, and northeast-southwest trends in the Oregon and Columbia Plateaus in the northwestern U.S., which correlate with the measured trends listed above.

Analytical Techniques

Thirty Two samples representing the eight units were selected for petrographic and geochemical analysis. Petrographic reports of mineralogy, texture, mode, and distinctive features were compiled for all samples. Geochemical analyses were conducted using x-ray fluorescence spectrometry (XRF), inductively coupled plasma spectrometry (ICP), loss on ignition (LOI), and iron titration methods.

Petrography

Seven of the eight units are clearly basaltic in thin section. The majority are holocrystalline, vesicular, and diktytaxitic to a greater or lesser extent with up to 50% acicular plagioclase, 15% olivine, and lesser amounts of clinopyroxene and spinel. Spinel is generally poikilitically enclosed in olivine phenocrysts. Iddingsite is a common alteration around the perimeter of olivine phenocrysts and occasionally extends inward along fractures. Orthopyroxene was only present in one sample taken from the Four Corners Olivine-Phyric Basalt unit.

The remaining unit, the Old Baldy Basaltic Andesite, is characterized by 8-10% olivine, 60% plagioclase, 2-3% clinopyroxene, and <1% spinel. It can be easily distinguished from other units by exceptionally well-developed pyroxene coronas surrounding the 1-2mm olivine phenocrysts. Glomeroporphyritic clumps of olivine and plagioclase are common. In some samples two populations of plagioclase phenocrysts are present as infrequent large phenocrysts with cuspate to rounded crystal faces and microlitic laths in the groundmass.

Geochemistry

The geochemical analyses noted above were utilized to help classify the units chemically in addition to hand sample and thin section processes. Using the CIPW norm and the methodology outlined by Irvine and Baragar (1971), the seven basaltic units were classified as olivine tholeiites. The remaining unit, the Old Baldy Basaltic Andesite falls within the Basaltic Andesite domain of the classification scheme of Le Bas, et al. 1986 (Figure 2).

Within the group of basalts, plots using magnesium number, calculated with the equation [mg# =(100*MgO/(MgO+FeO+0.8998*Fe_2O_3))], as the x-axis were particularly useful in identifying chemical trends. Magnesium numbers for the seven basalts range from (71) to (52). The 6054 Dike Basalt unit has the highest mg# (71-61). High nickel and chromium values are ubiquitous throughout the basaltic units in the section. They range from 235 to 43 ppm for nickel and 553 to 121 ppm for chromium. When plotted versus mg#, the Ni and Cr data provide a strong case for spinel and olivine fractionation within individual units (Figure 3). In several units, but most strikingly in the 6054 Dike Basalt, strontium versus mg# provides evidence that Sr was behaving incompatibly in this sequence (Figure 4). Spider diagrams show an area-wide depletion in high field strength elements (HFSE) which include most notably for this data set Niobium. Their sawtooth pattern is clearly distinct from that of either enriched or normal Mid-Ocean Ridge Basalt (MORB) (Figure 5). The Burton Butte Basalt, which has distinct K_2O, Ni, Cr, and trace element data from the other units, is chemically similar to MORB. It is not depleted in HFSE.

Discussion

In light of K-Ar age dates (Mertzman 1994) and geochemistry, it is clear that although there is a distinct similarity between the modal mineralogy of many of the units, they most likely did not originate from a single magma chamber. Mg# is helpful in distinguishing the extent of fractionation and/or assimilation that may have taken place. Those basalts with a mg# between 69 and 72 are suggestive of a primary melt that at one time was in equilibrium with upper mantle peridotite and has undergone little or no fractionation or assimilation between the upper mantle and the surface (Wilson, 1989). The only unit to fit these criterion is the 6054 Dike Basalt, whose mg#s fall within the range for unfractionated magmas. The MORB-like Burton Butte HAOT is characteristic of back-arc basin basalt; it is probably associated with Basin and Range magmatism (Wilson, 1989). Harker diagrams plotted for all samples depict behavior typical of convergent plate boundaries. The increased silica content in the Old Baldy Basaltic Andesite is likely to be the result of fractionation of primary basaltic magma. Decreasing mg# with increasing silica content suggests fractionation of ferromagnesian phases, presumably magnesian olivine and spinel. This would promote enrichment in the remaining liquid of incompatible elements and silica (Figure 6).

Works Cited

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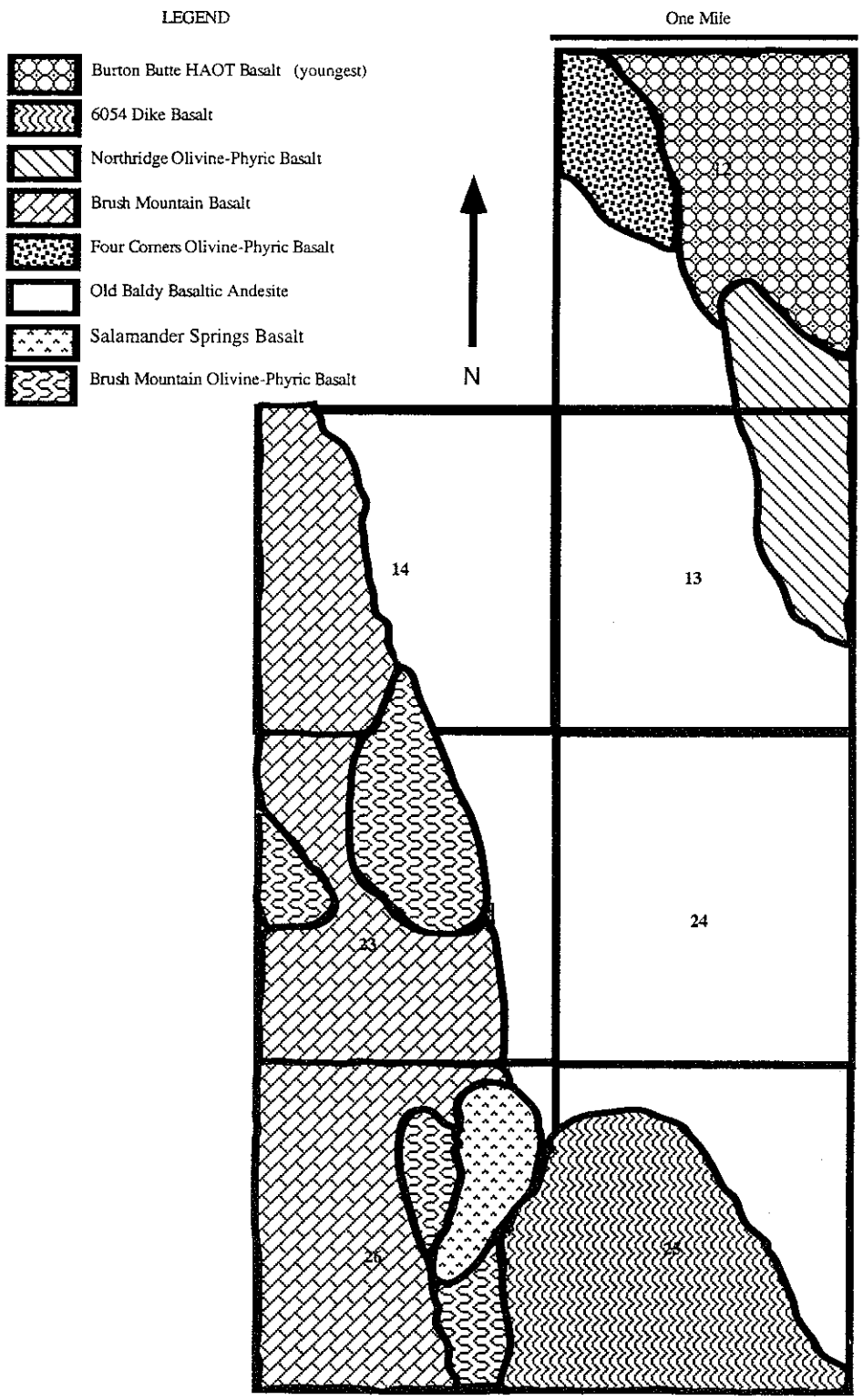
LEGEND
Burton Butte HAOT Basalt (youngest)
6054 Dike Basalt
Northridge Olivine-Phyric Basalt
Brush Mountain Basalt
Four Corners Olivine-Phyric Basalt
Old Baldy Basaltic Andesite
Salamander Springs Basalt
Brush Mountain Olivine-Phyric Basalt
N
One Mile
12
14
13
24
23
25
26

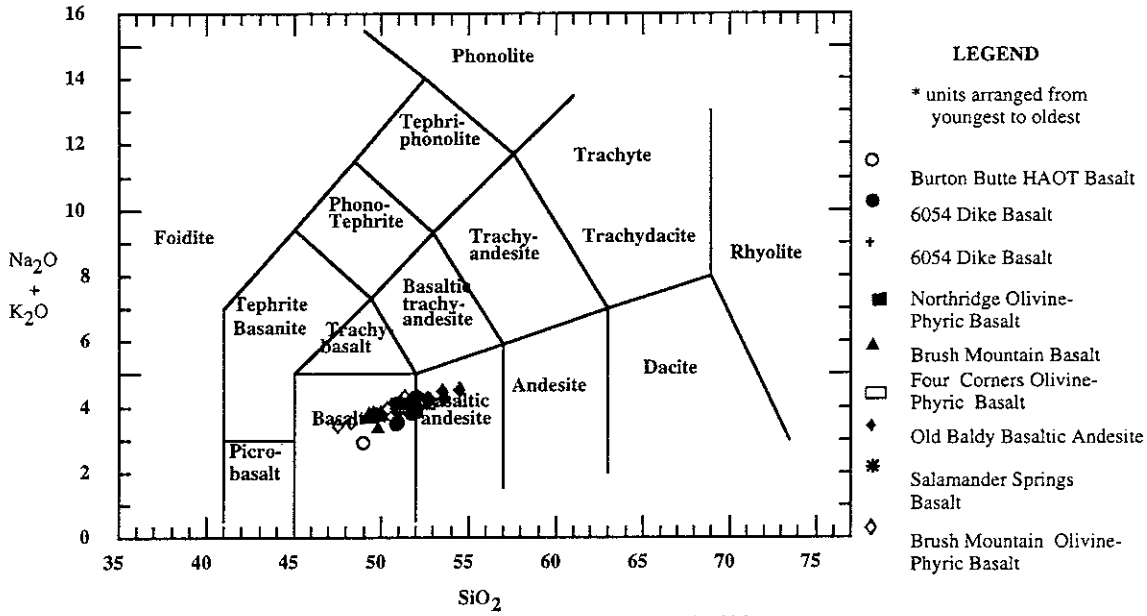

Figure 2: Compositional variation diagram after Le Bas et al. 1986