

# Geochemistry and Petrology of Miocene-Holocene Volcanics in the Klamath River Valley, Southern Oregon

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## INTRODUCTION

The High Cascades volcanic province consists of a narrow N - S trending band of coalescent monogenetic andesitic shield volcanoes within an intra-arc graben (Hughes, 1990, Taylor, 1990) It is located inland from the western coast of North America, extending from Mt. Giribaldi in Southern British Columbia to Mt. Lassen in Northern California. The High Cascades Volcanic Episode, active magmatism from Miocene through Holocene time, is associated with the subduction of the Juan de Fuca plate system beneath the North American plate to the West, and extension in the back-arc environment of the Basin and Range Physiographic Province to the East, and is producing magmas ranging from rhyolite/dacite to basalt (Guffanti and Weaver, 1988). In the summer of 1996, a group of 8 students from 5 different schools each mapped an eight mile E-W transect of the Eastern High Cascades in Southern Oregon. At the end of the field portion of the project the group prepared a 64 square mile composite map, combining all the transects in an attempt to achieve a greater understanding of the processes that lead to compositional diversity of lavas throughout the High Cascades.

## METHODS

Seven units were determined in the eight mile E-W map area based on texture and phenocryst assemblages within hand sample. Using field relationships, a tentative stratigraphic column including all the units in the 64 square miles was completed before students returned to their home institutions. XRF analysis, coupled with Loss on Ignition and Iron Titration techniques were performed on 28 samples at Franklin and Marshal College to determine major and trace element abundances. 28 thin sections were analyzed for modal phenocryst percentages and textures, in order to support or refute field sample unit placement. Subsequent K/Ar dating allowed for a more accurate stratigraphic column to be prepared.

## UNIT DESCRIPTIONS

The strip shown in fig. 3 is divided into two parts east and west of the Klamath river, both characterized by local flows issuing from vents either within the strip, or within a three mile radius. Geochemical analysis indicates that the units are for the most part calc-alkaline (Fig. 2 a) ranging from basalt to basaltic andesite with the tholeiitic Chicken Hills Rim Basalt being the lone exception. All seven units have olivine and plagioclase dominated phenocryst assemblages and lack any hydrous minerals. The units described are in order from oldest to youngest, with all K/Ar age dates provided by Mertzman, S.A. (1996)

**Pre-Hayden Dike** (4.1 +/- 0.1 my) This unit strikes N80°W along the western canyon wall and was exposed by river erosion. In thin section it contains tabular subhedral plagioclase (An 74) laths averaging .4mm, of mostly equal size, which constitute 30% of the whole rock. Subhedral olivine phenocrysts (1mm - 3mm) constitute 5% of the rock. Orthopyroxene is confined to the groundmass, which consists of plagioclase, olivine, orthopyroxene, and clinopyroxene and constitutes 60% of the rock. Ilmenite or magnetite opaques account for 8% of the rock.

**Upper Aqueduct Road Rim Basalt** crops out below Hayden Mountain Lavas along the top of the western rim of the Klamath River canyon in the southern part of the section. In thin section it is bi-modal with large phenocrysts and an almost aphanitic groundmass. Euhedral to subhedral phenocrysts of plagioclase (An 76), olivine, and orthopyroxene are evenly distributed throughout the rock. The plagioclase is short and rectangular in cross-section, forms glomeroporphyritic clumps 1mm - 3mm in diameter, and constitutes 20% of

the rock. The olivine phenocrysts average .6mm but are as large as 4mm in some cases. They are rounded and altered, constituting 3% of the rock. Orthopyroxene ranges from 1mm - 4mm, making up 5% of the rock. The groundmass, 64% of the whole rock, contains plagioclase, olivine, orthopyroxene, and clinopyroxene. Ilmenite or magnetite opaques account for 8% of the rock.

**Lithified Pyroclastics** were most likely erupted from the Boyle Ash Cones to the north (Myra Hill's area). They are overlain by the Hayden Mountain unit and were exposed by a normal fault. No correlation between the lithified pyroclastics and the Upper Aqueduct Road Rim Basalt can be drawn by field relations.

**Hayden Mountain Basaltic Andesite** (3.7 +/- 0.1 my) was erupted from Hayden Mountain, and covers the majority of the western half of the strip. It is characterized by large amounts of plagioclase and olivine clumping into occasional glomeroporphyritic clusters, with sparse orthopyroxene phenocrysts. It has widely varying unit petrography, the result of many distinct flows. Both sample groups contain plagioclase phenocrysts (1mm - 4mm) which account for 45% of the rock. Subhedral rounded olivine phenocrysts (1mm - 3.5mm) constitute 15% of the rock. The plagioclase and olivine appear to have crystallized simultaneously, shown by crystalline intergrowth. Occasional subhedral orthopyroxene phenocrysts (2mm) exist, accounting for 5% of the rock, but orthopyroxene is mostly confined to the groundmass. The groundmass constitutes 15% of the rock and contains plagioclase, olivine, orthopyroxene, and clinopyroxene. Ilmenite or magnetite opaques account for 4% of the rock.

**Chase Mountain Basaltic Andesite** (2.51 +/- 0.07 my) covers the majority of the eastern side of the strip. It is older than the Chicken Hills Rim Basalt, as evidenced by a visible contact relationship and age dates. The unit contains tabular plagioclase phenocrysts which average 1mm in length and constitute 25% of the rock. Larger phenocrysts, part of the glomeroporphyritic clumps (2mm - 3mm) account for 5% of the rock. Olivine phenocrysts are subhedral and slightly rounded ranging in size from 0.75mm - 2mm. They compose 10% of the rock, forming large glomeroporphyritic clumps with subsequently formed plagioclase phenocrysts. The intersertal groundmass, containing crystals of plagioclase, olivine, and orthopyroxene accounts for 55% of the rock. Small (.2mm) and not very abundant (5%) pyroxene phenocrysts are mostly confined to the groundmass. Ilmenite or magnetite opaques account for 3% of the rock.

**Aqueduct Basalt** (2.4 +/- 0.1 my) was exposed by blasting done for an aqueduct. This unit is a series of plugs along the western wall of the river canyon. The unit and some pyroclastics overlying it are truncated by erosion and overlain by Pacific Power Rim Basaltic Andesite. In thin section, the unit is characterized by an intergranular, hyperbyssal, and trachytic texture. The sample, taken from a vent exposed by blasting done for an aqueduct, contains 30% (AN 73) sub-anhedral plagioclase in elongate 0.4mm laths. Subhedral olivine (0.3mm) constitutes 10% of the rock. Orthopyroxene (5%) and clinopyroxene (1%) are visible in hand sample as well as in thin section. Ilmenite or magnetite opaques account for 10% of the rock.

**Pacific Power Rim Basaltic Andesite** (1.9 +/- 0.3 Ma) is the only unit that crosses the river in the strip. It was erupted from vents exposed on the eastern wall of the river, and covers a half mile area on both side of the river. The thin sections contain tabular plagioclase (An 75) laths measuring 0.23mm - 1mm which constitute 25-30% of the rock. Subhedral to anhedral olivine phenocrysts range from 0.56mm - 3mm and constitute 5% of the whole rock. Orthopyroxene phenocrysts (.45mm) are evenly distributed throughout the rock, constituting 2% of the whole rock. The groundmass accounts for 55% of the rock, consisting of plagioclase, olivine, orthopyroxene, and clinopyroxene. Ilmenite or magnetite opaques account for 8% of the rock.

**Chicken Hills Rim Basalt** (1.1 +/- 0.2 my) is the youngest unit, is a tholeiite, and was erupted from the Chicken Hills, 3 miles south of the strip. The thin sections contain little or no orthopyroxene and clinopyroxene. Tabular and lath-like plagioclase phenocrysts (0.38mm - 1.5mm) constitute 50% of the whole rock. Subhedral and anhedral olivine phenocrysts (0.18mm - 2mm) appear to have formed subsequent to plagioclase crystallization, constituting 35% of the whole rock. Opaques, most likely ilmenite or magnetite, make up 7% of the rock.

## GEOCHEMISTRY

Twenty five samples plotted on a total alkali vs. silica diagram (Le Bas et. al, 1986) indicate seven rock units ranging from basalt to basaltic andesite in composition: three basalts and four basaltic andesites. In major element oxide variation diagrams,  $K_2O$  and  $Na_2O+K_2O$  show a positive correlation with  $SiO_2$ , forming a smooth, medium-K volcanic series.

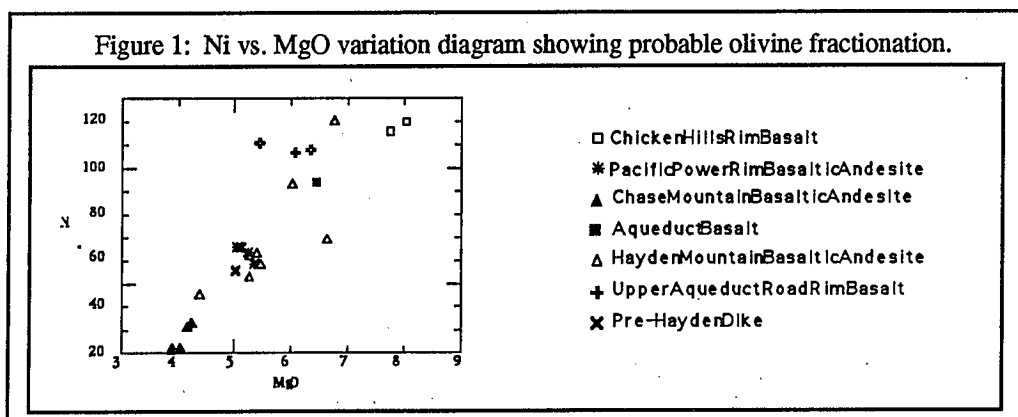
A rock vs. MORB Pearce plot shows depletion of elements of mantle affinity, a trend typical of subduction related arc volcanism, and enrichment of large ion-lithophile (LIL) elements (Fig 2. b), with a positive Th anomaly characteristic of an upper crustal signature. Trace element variation diagrams show near linear trends, indicating crystal fractionation as a possible process for differentiation of the units. A Ni vs. MgO plot (Fig.1) shows a trend indicating probable olivine fractionation.

## DISCUSSION

Although linear trends on variation diagrams exist, the older units are not necessarily more mafic than the younger units. A model of cyclic replenishment of a parental magma chamber by a more primitive source could account for the fluctuating of element concentration over time if the lavas were not erupted over such a wide time span. Variation diagrams for both major element oxides and trace elements are consistent with subduction related arc volcanism trends for all units except the Chicken Hills Rim Basalt. The tholeiitic nature of this unit, along with its age, indicates that it could have been extruded in a back-arc extensional environment. The proximity of the study area to the Basin and Range provides support for this hypothesis.

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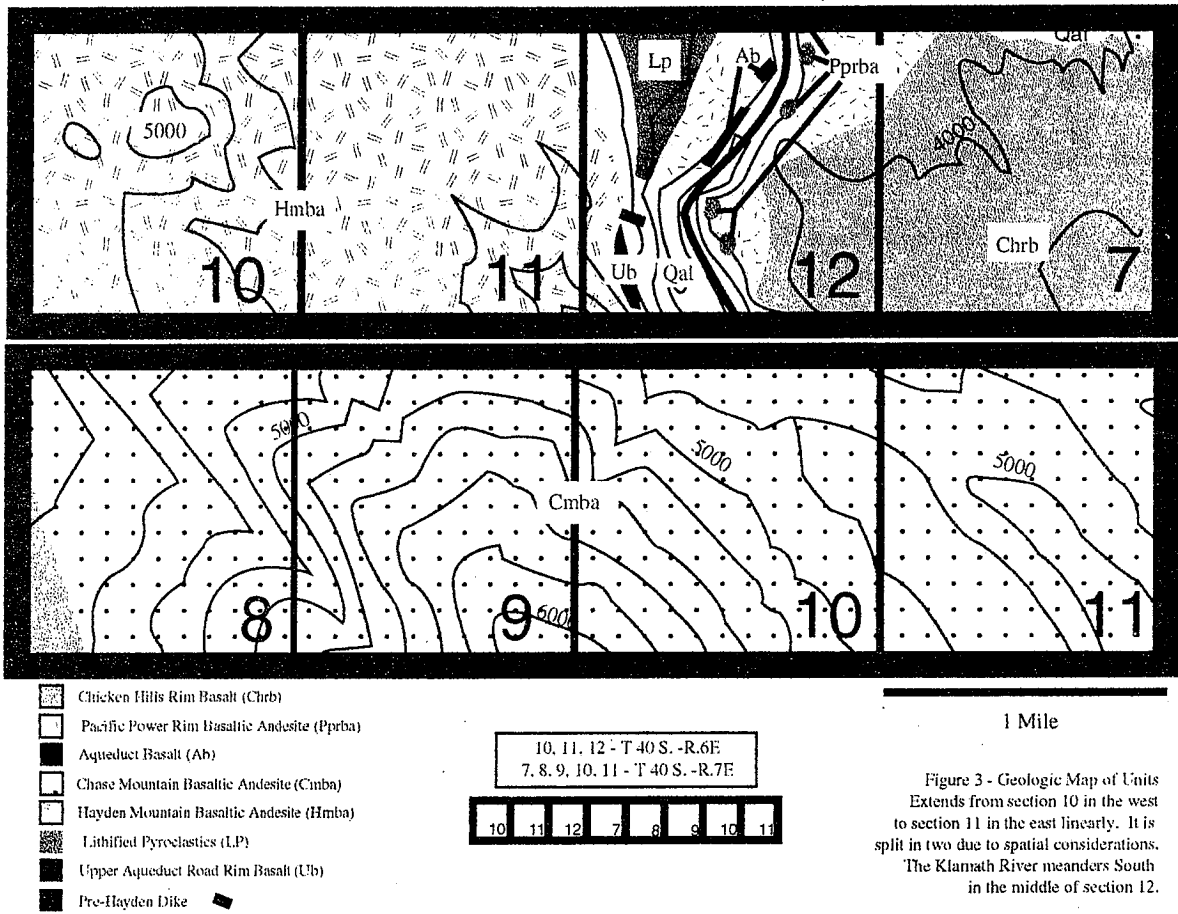


Figure 2: Geochemical data plots. (a) An AFM compositional variation diagram, after Irvine and Baragar, 1971. (b) Trace element composition plot showing enrichment of LILs.

