Geology, Petrology and Geochemistry of the Western Flank of Mt. McLoughlin
High Cascade Mountains, Oregon

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Introduction

Mt. McLoughlin is situated in the High Cascade Mountains of southern Oregon. The High Cascades extend from northern California to southern British Columbia. Mt. McLoughlin is a Quaternary composite volcano and is part of a series which starts with Lassen Volcanic Peak in Northern California and terminates in British Columbia at Mt. Garibaldi. High Cascade volcanism is typically calc-alkaline with an episodic eruption history starting in the late Miocene and continuing into the Quaternary (McBirney, 1974). During the summer of 1991, ten students and three Keck Consortium faculty members [Steve Weaver (Beloit College), Rick Hazlett (Pomona College) and the project leader Stan Mertzman (Franklin and Marshall College)] descended upon Mt. McLoughlin. The ultimate goal of our project is to begin to unravel the volcanic stratigraphy of the area surrounding Mt. McLoughlin. With the help of our data, future groups, such as the one for the summer of 1992, can begin to compile a complete transect across the High Cascade magmatic arc. My field area was the north-west extent of mapping by our team. Jon Nauert and Jill Baum mapped the areas directly south of me. The line defining the western most extent of the proposed High Cascade transect runs north-south between T36S R4E Sec. 7 and T37S R4E Sec. 18. Mertzman and Gooding mapped and studied the petrography and geochemistry of Mt. McLoughlin summit flows in 1988. The purpose of my project is to compare and contrast the flank eruption (North Tip) to the McLoughlin summit.

Field Techniques

All field mapping was done on foot traverse with a Brunton compass. I plotted eighty localities on the Butte Falls Ranger District; Rogue River National Forest Map (scale 1:64,000). Occasional use of an altimeter greatly facilitated mapping. Dense underbrush (manzanita) made mapping in some areas difficult if not impossible. I was unable to map Sec. 9 of T36S R4E. After spending two futile days battling the underbrush, I ascertained it would be more advantageous to map another section and I added Sec. 5 of T36S R4E to my field area. Due to my limited exposure to the outcrops in Section 9 all contacts are implied. I collected eighty specimens from the eighty localities to do petrographic and geochemical analysis after I returned to Beloit College. Using field relations and hand sample examination, I mapped five units within and extending out of my field area.

Analytical Methods

I selected thirty specimens for thin section analyses. Of these thirty, I chose twenty samples for geochemical analysis. At the present time, only sixteen of the geochemistry totals are within the acceptable margin of error. The major elements are measured as percentages and the total percentage composition must fall between the range of 98.5%-101.0% to be statistically accurate. I analyzed major elements using the Inductively Coupled Argon Plasma Spectrometer (ICAP) at Beloit College and the X-ray Florescence unit (XRF) at Carleton College. The trace element values were determined using Beloit's ICAP. Potassium-argon (K/Ar) dating was performed on my sample KWW-25-91. Stan Mertzman performed the (K/Ar) dating of samples at Case Western Reserve for all the members of the Keck group.

Petrographic Analysis

The units in my area classify as basalts and basaltic andesites on the Total Alkali vs. Silica diagram (Fig. 1) (Lebas, et. al., 1986). The mineralogical composition varies inconsequentially within the

two groups but the textural and grain-to-grain relationships vary widely. The major mineral constituents of the basalts are plagioclase, olivine, orthopyroxene, and clinopyroxene (augite). The basalts contain about 40 modal percent phenocrysts. Of these phenocrysts, plagioclase is the dominant at 85% with olivine, clinopyroxene, augite, and spinels making up the remainder. The groundmass is predominantly composed of plagioclase, augite, and FeTi oxides. The textures range from intergranular to intersertal and pilotaxitic to trachytic. Glomeroporphrytic clumps of olivine are common.

The basaltic andesites contain the same mineralogic constituents as the basalts but in different modal percentages. Plagioclase is still the dominant phenocryst. Some samples contain grains with sieve and resorbtion textures, evidence of disequilibrium. Clinopyroxene or orthopyroxene occur next in modal phenocryst percentage, followed by olivine. Textures range from pilotaxitic to trachytic. Depending on the unit, the basaltic andesites may also be glomeroporphrytic. One unit has a strange mineralogic assemblage. This unit is found only in the southern most portion of my field area and largely crops out in Nauret's area; the best exposure being an unnamed quarry. The rock will be called the Hornblende Quarry Unit (5.62±09 my) (Mertzman, unpublished data). The Hornblende Quarry Unit contains crystals of hornblende in contact with grains of olivine. This texture suggests the hornblende and the olivine crystallized at the same time. The cotectic crystallization of olivine and hornblende forces me to look at modified theoretical models. Using experimental data, Yoder and Tilley (1962) constructed a phase diagram which illustrates the effect of increased water pressure on the basalt mineral assemblages. Their experimental data allows for the simultaneous crystallization of hornblende and olivine when the P_{H2O} is greater than approximately twelve kilobars. This suggests that the magma was hydrous and that crystallization started at lower crustal depths of at least 42 km followed by a rapid ascent of the magma.

Geochemistry

The mineralogic and petrographic characteristics of the basaltic andesite flank eruptions are very similar, however I did not have access to the thin sections of the Mt. McLoughlin Summit lavas (150,000 yrs -.08 ±03 my) (Mertzman and Gooding, 1988) to compare with the petrography of the flank eruption (North Tip .66±02 my) (Mertzman, unpublished data). I do, however, have abundant geochemical data with which to compare and contrast the two "units".

I plotted Harker diagrams using the major element data from the ICAP and XRF. In comparing (North Tip) to the Summit there is very little variation. For plots of FeO*, P_2O_5 and TiO_2 against SiO_2 the two data groups plotted within a very limited area (Fig.2-4). Various other plots of major elements and trace elements yielded similar results. Older Mt. McLoughlin flows (2.42 ±.15 my) (Mertzman and Gooding, 1988) seem distinct from North Tip and the Summit in both major and trace element concentrations (Fig. 2-4) . The other units in my field area are: Mosquito Andesite, Hornblende Quarry, Rye Spring and Rye Spring Prime. When I plotted all my available data against SiO_2 and MgO apparent trends became noticeable. Linear decreases exist in the relative amounts of FeO*, P_2O_5, TiO_2 and others, as the silica content increases (Fig. 2-4). The "linear" decrease may be accounted for in two ways. It is possible the apparent trend indicates crystal fractionation or mixing of magmas. The alkali contents of the older units appear higher, especially in McLoughlin basaltic andesite related flows. This trend can be seen when K2O vs. SiO2 is plotted (Fig. 5).

Conclusions

The units in my field area are the products of at least two different magma sources. By comparing the geochemical data with the age relations, one can see discontinuities where younger units plot in between older units. These discontinuities are evident in the Harker diagrams plotting FeO*, P_2O_5, TiO_2 vs. SiO_2 (Fig. 2-4). Two excellent examples are the Old McLoughlin flow (2.42±.15 my) exhibiting higher values than the Mosquito Andesite (6.01±.30 my) and equally discontinuous is the Hornblende Quarry Unit (5.62±.09 my) corresponding to the plot of the Flank Eruption and Associates (.66±.02 my) and McLoughlin Summit Data (150,000 yrs max.).

Petrological and geochemical data suggest a strong relationship between the Old Mt. McLoughlin flows-Flank Eruption flows- and McLoughlin Summit flows. The decreasing trends in major and trace element data make a crystal fractionation model from a common source possible.

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There exist great discrepancies between the petrology, geochemisty and ages of the Rye Spring, Mosquito Andesite and Hornblende Quarry flows. Rye Spring and Mosquito Andesite may be related but I am unable tell at this time. The Hornblende Quarry is anomalous. I found no hydrous minerals in any of my other samples. This fact alone makes the Hornblende Quarry unit distinct and therefore it would seem to come from a magma source unrelated to any of the others previously mentioned.

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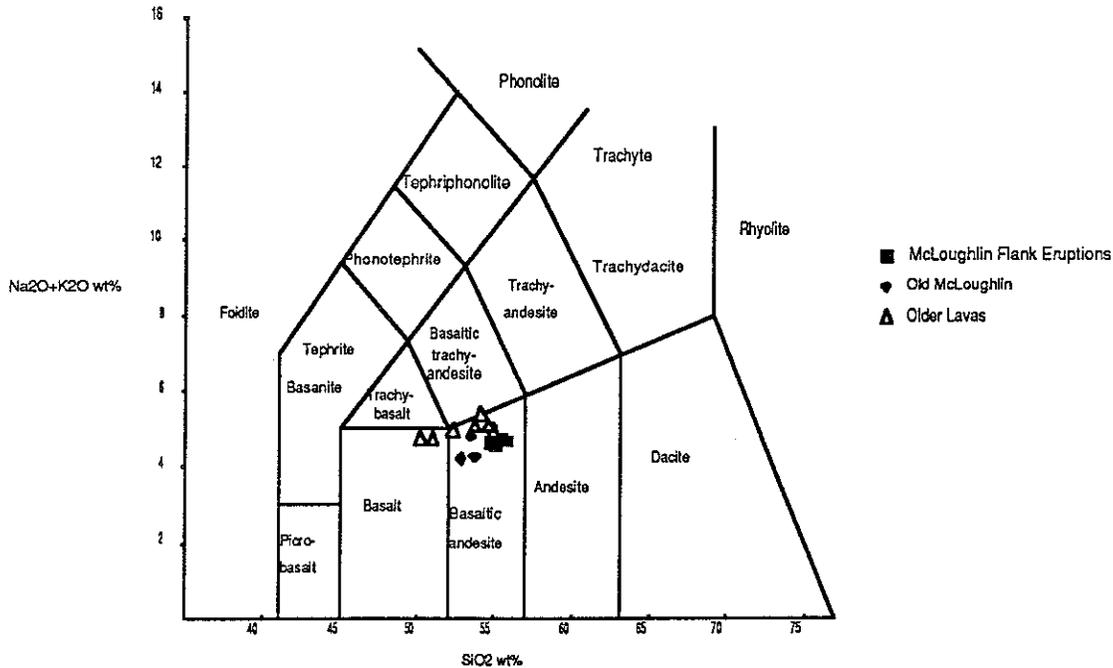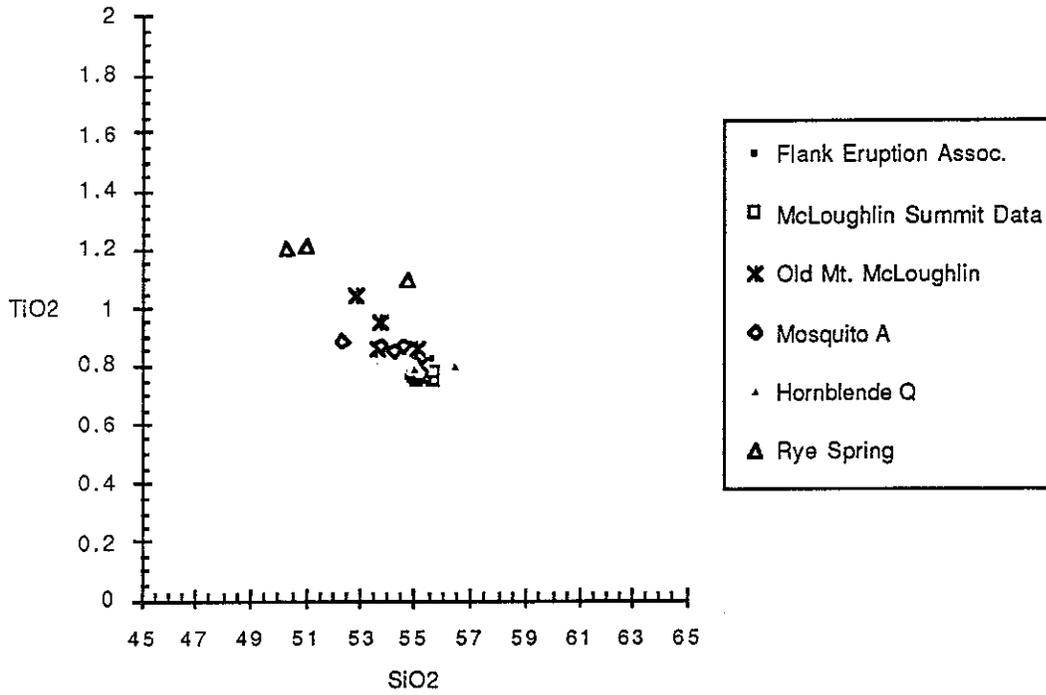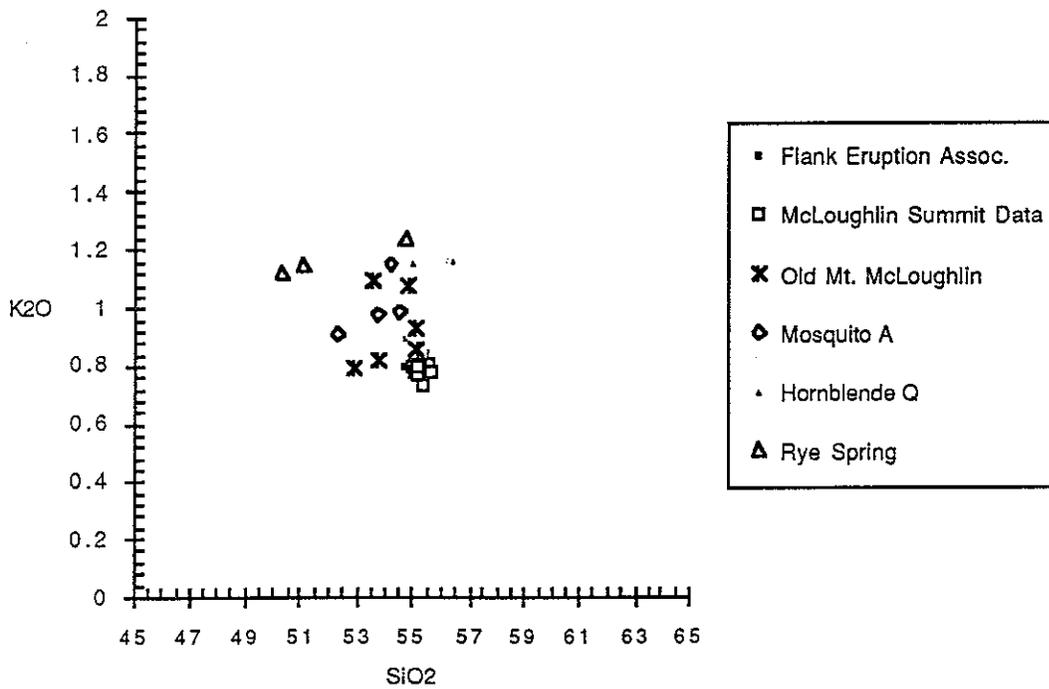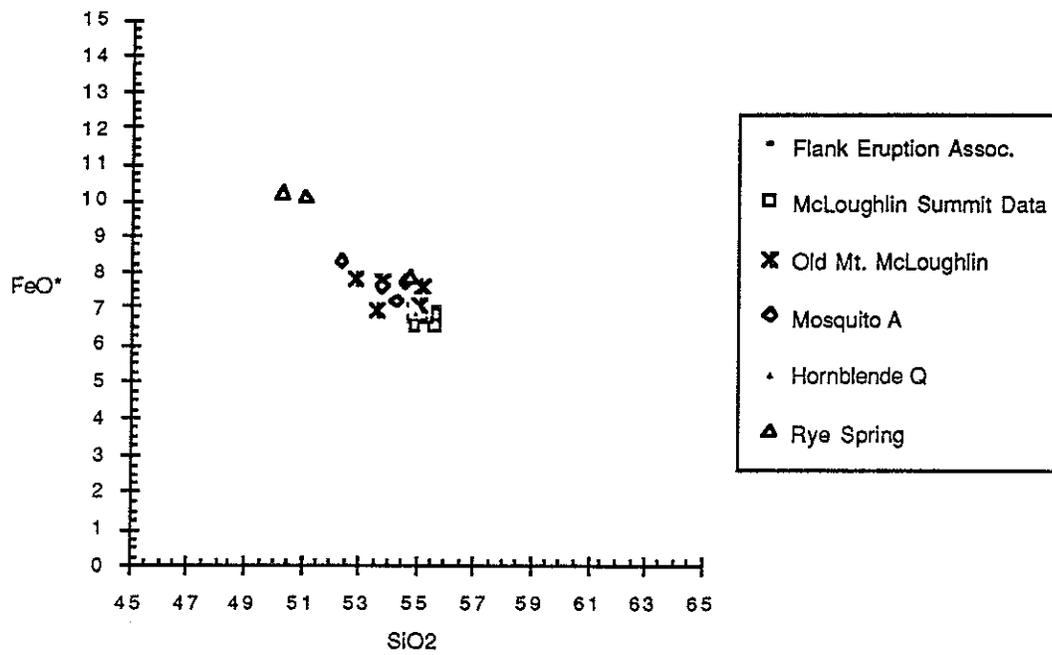
Figure 1. Total alkalies vs. silica diagram of Mt. McLoughlin western flank flows. Data collected by Wayne R. Wright, Summer 1991

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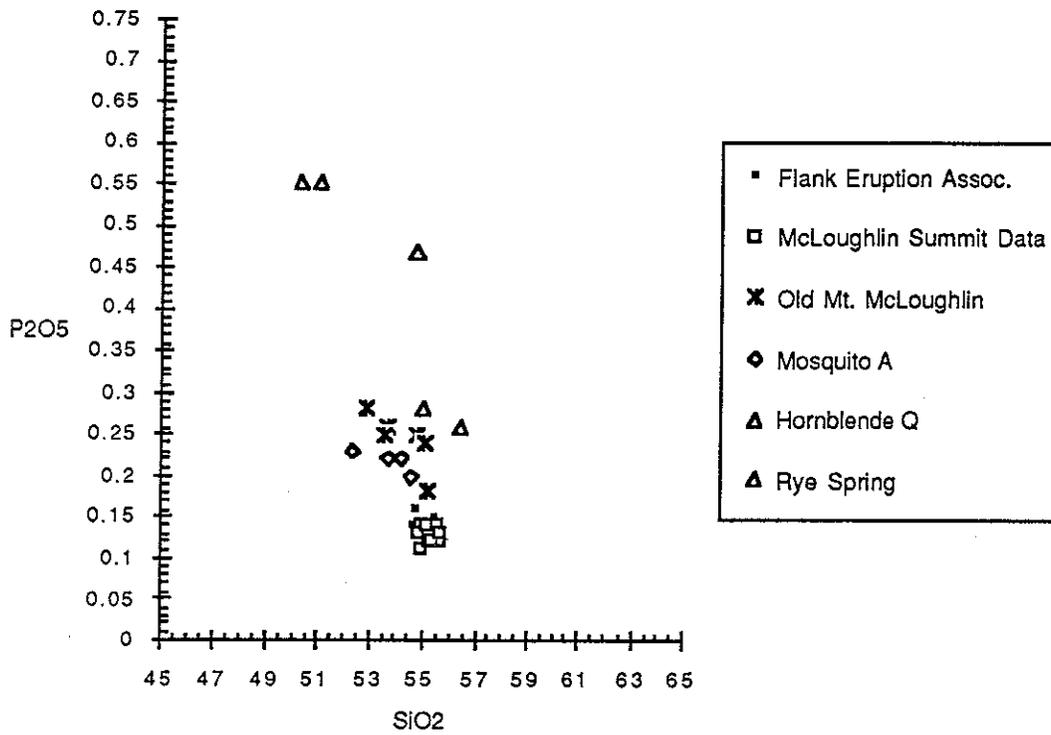(Figure 4) All Units: Harker Diagram of TiO_2 vs. SiO_2

(Figure 5) All Units: Harker Diagram of K_2O vs. SiO_2

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(Figure 2) All Units: Harker Diagram of FeO* vs. SiO_2

(Figure 3) All Units: Harker Diagram of P_2O_5 vs. SiO_2

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