

THE PETROLOGY AND GEOCHEMISTRY OF QUATERNARY AND TERTIARY VOLCANICS FROM THE MOUNT MCLOUGHLIN REGION OF THE CASCADE MOUNTAINS, OREGON

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INTRODUCTION

The Cascade Range is a volcanic mountain chain that extends from British Columbia to northern California. Volcanic activity associated with this area is believed to be the result of the subduction of oceanic lithosphere beneath the continental crust of North America, and has been occurring in different forms during the late Cenozoic. This study focuses on some of the petrology of the many smaller Miocene to Holocene volcanic units that create most of the High Cascades and is part of a larger E-W geochemical transect across the Cascades.

STUDY AREA AND FIELD OBSERVATIONS

My field area consists of 8 square miles located on either side of Oregon Highway 140, approximately 60 miles east of Medford, Oregon. It is situated to the southeast of Mt. McLoughlin and directly east of Brown Mt. It is bounded on the east by Lake of the Woods (figure 1). Topographically, the dominant feature is a non-continuous ridge running approximately north-south west of the lake, continuing to the north of Highway 140. The area was mapped by foot traverses from known locations and with triangulation with Mt. McLoughlin and Brown Mt. Frequently the topographical features mimicked the lithology in the area, however there were many exceptions.

Based on samples examined in the field, the area was divided into nine distinct rock units based on mineralogy and texture. These units were further described based on petrography and whole-rock geochemistry. The Units were placed in stratigraphic order based on contact relationships and relative weathering observed in the field. However, due to lack of exposed contacts and alluvial cover, some age relationships were impossible to determine. Potassium-Argon dating (Mertzman 1991, 1992) provided an absolute framework for the stratigraphy and linked the major units in the area (figure 1).

LITHOLOGIES

The oldest two units in my area are the Dry Creek basaltic andesite and South Billie Creek basaltic trachyandesite. Their outcrop pattern is very similar and consists of 0.2 to 1.5 m spheroidally weathered boulders on the surface. South Billie Creek can be distinguished from Dry Creek by its fine orthopyroxene corona around olivine. They are distinctive chemically from the other units in my area by their high phosphorus content (0.5%), and plot similarly to samples of Rye Prime and Rye Spring material (Mertzman 1991, Nauert 1992). Rye Prime material has been dated to 6.43 ± 0.10 Ma and it is likely that Dry Creek and S. Billie Creek are of approximately the same age.

Esther Applegate andesite is a two-pyroxene andesite unit that comprises the southern portion of the study area. The unit crops out in many forms ranging from relatively fresh platy flows to weathered blocks and boulders from 0.1 to 1.5 m in diameter. Southern samples typically have higher proportions of olivine than the northern samples, suggesting the unit could be further subdivided, possibly into andesite and basaltic andesite members. However, a much more detailed mapping of the unit and more samples would be necessary to subdivide it more precisely. Contact relationships of Esther Applegate as a whole indicate that it is older than Brown Mt., a conclusion supported by the K-Ar date of 3.25 ± 0.05 Ma from south of the study area.

Billie Creek, affectionately known as Mt. Fred, is the most distinctive unit in the area and only slightly younger than Esther Applegate. Large plagioclase phenocrysts (1-3 mm in length) and abundant clinopyroxene phenocrysts, commonly in glomeroporphyritic clumps, characterize this unit. It crops out as 0.5 -1.5 m diameter spheroidally weathered boulders. K-Ar dates place it at 3.14 ± 0.04 Ma.

Rye Spur basaltic andesite, which sits stratigraphically above South Billie Creek, is a light to medium gray 2-pyroxene basaltic andesite. It has characteristic mineralogy of large (1-3 mm) clinopyroxene grains. It crops out as spheroidally weathered boulders (0.5-3 m) and no flow geomorphology is visible in my area. The source of the material is believed to be to the north from Rye Spur. Although it lies directly east of Billie Creek basaltic andesite, no age relationships in the field could be determined due to the poor exposure. K-Ar results date Rye Spur basaltic andesite to 1.58 ± 0.03 .

The Pierce Point I and Pierce Point II basalts occur together and appear to have originated from the small cone in the northeastern corner of the study area. Chemically the units are very similar, but in hand sample and thin-section PPI shows a distinct texture of 2 to 4 mm diameter glomeroporphs of olivine, clinopyroxene and plagioclase. PPII can also be distinguished from PPI by its highly iddingsitized olivines. At the cinder cone, PPII is well exposed due to excavation and 0.2 to 1 m thick feeder dikes are evident in the spatter and cinder material. Directly northeast of the excavation, PPI crops out in massive boulders 2 to 4 m in diameter. Field relationships on

the western portion of the area show PPI on top of PPII, indicating that it was extruded second. K-Ar dates from this outcrop place PPI at 1.48 ± 0.04 Ma (Mertzman 1991).

The Rainbow Bay andesite is a small and poorly exposed unit of 0.5-1 m spheroidally weathered boulders east of Lake of the Woods. It is a two-pyroxene andesite and appears to have originated from Greylock Mt. or Whiteface Peak on the east side of Lake of the Woods. No age constraints could be placed on this unit as it does not come into contact with any dated units; weathering, however, indicates it is significantly older than Brown Mt.

Brown Mountain andesite, is clearly the youngest unit in the area and consists of many fresh blocky flows. It is characteristically dark black to brown in color and is usually aphyric. At the periphery of Brown Mt., material exhibiting slightly more weathering and often a thin covering of soil suggests several ages of flows. The summit material shows evidence of glaciation suggesting the youngest flows predate Pleistocene glaciation. The most recent volcanic activity is approximately 20 to 30 Ka old.

PETROGRAPHY

Twenty eight samples were examined in thin-section and contained similar mineralogies of olivine, clinopyroxene, orthopyroxene and plagioclase, with Fe-Ti oxides and Cr-spinel as minor phases. All of the units are highly porphyritic, with the exception of Brown Mt., which is aphyric, and are dominated by plagioclase (60-80%) in both the groundmass and phenocrysts. Plagioclase as a phenocryst exhibits various and complex patterns of zoning, which often vary within a sample. Alteration of cores is common, but in some cases is restricted to certain zones. In the basaltic units, olivine is the dominant mafic phenocryst comprising 6 to 9 % by volume. It is generally euhedral to subhedral and commonly contains micro inclusions of chrome-spinel. Olivine is also present in the basaltic andesites (1-4%) and andesites (<1-3%), but is often corroded and subhedral to anhedral in shape. Clinopyroxene is present as a phenocryst phase in all of the samples and is often found in glomeroporphyritic clumps with plagioclase and olivine. The groundmass is universally holocrystalline and many samples exhibit a trachytic texture. Iron-titanium oxides are also present in the groundmass of all of the samples and occasionally occurs as micro-phenocrysts in the Esther Applegate unit.

GEOCHEMISTRY

Thirteen samples were analyzed for major and trace elements using XRF and ICP techniques at Carleton and Beloit Colleges respectively. The samples were selected to represent each of the rock units mapped in the field. In choosing samples for chemistry, preference was given to fresh samples and samples collected from interior, massive portions of flows. The samples were classified chemically using a Total Alkali Silica diagram (LeBas, et al. 1986) with an alkalic-subalkalic dividing line (Miyashiro 1978), and plot into the four groups of Basalt, Basaltic trachyandesite, Basaltic andesite and Andesite (figure 2). Based on AFM diagram the units show a fairly typical calcalkaline trend toward increasing alkali with no iron enrichment (Wilson 1989).

More refined geochemical trends can be seen in examining Harker plots of oxides versus SiO_2 . Variation in K_2O (figure 3a) reveals an overall positive trend which can be further divided into high, intermediate and low ranges. Samples from Dry Creek (21) and South Billie Creek (45) show the highest proportion of K_2O . Samples from Esther Applegate unit (42 and 36) have a more intermediate value, while the rest of the units plot along a lower K_2O trend. Within these subdivisions and between pairs of units additional trends are apparent. Mg (figure 3b), Fe, Cr, Co, and Ni all show negative correlation with SiO_2 , while the incompatible elements of Zr (figure 3c), Ba, La, and Ce show a corresponding increase.

DISCUSSION

Examination of the geochemical trends in light of the petrography and stratigraphy indicates that some of my units may be genetically related. The clearest relationship exists between Billie Creek and Rye Spur where data suggest the derivation of Rye Spur by crystal fractionation of olivine and pyroxene. Similar conclusions could be drawn based on trends within the Esther Applegate samples, and between Dry Creek and South Billie Creek units; however, the small sample size makes this a more tentative conclusion.

Although crystal fractionation appears to have been a dominant process in the area, it is clear that it alone cannot explain the evolution of all the volcanic activity. Additional complex interactions must be occurring in the mantle and shallow magma chambers to produce the variation seen in the volcanism.

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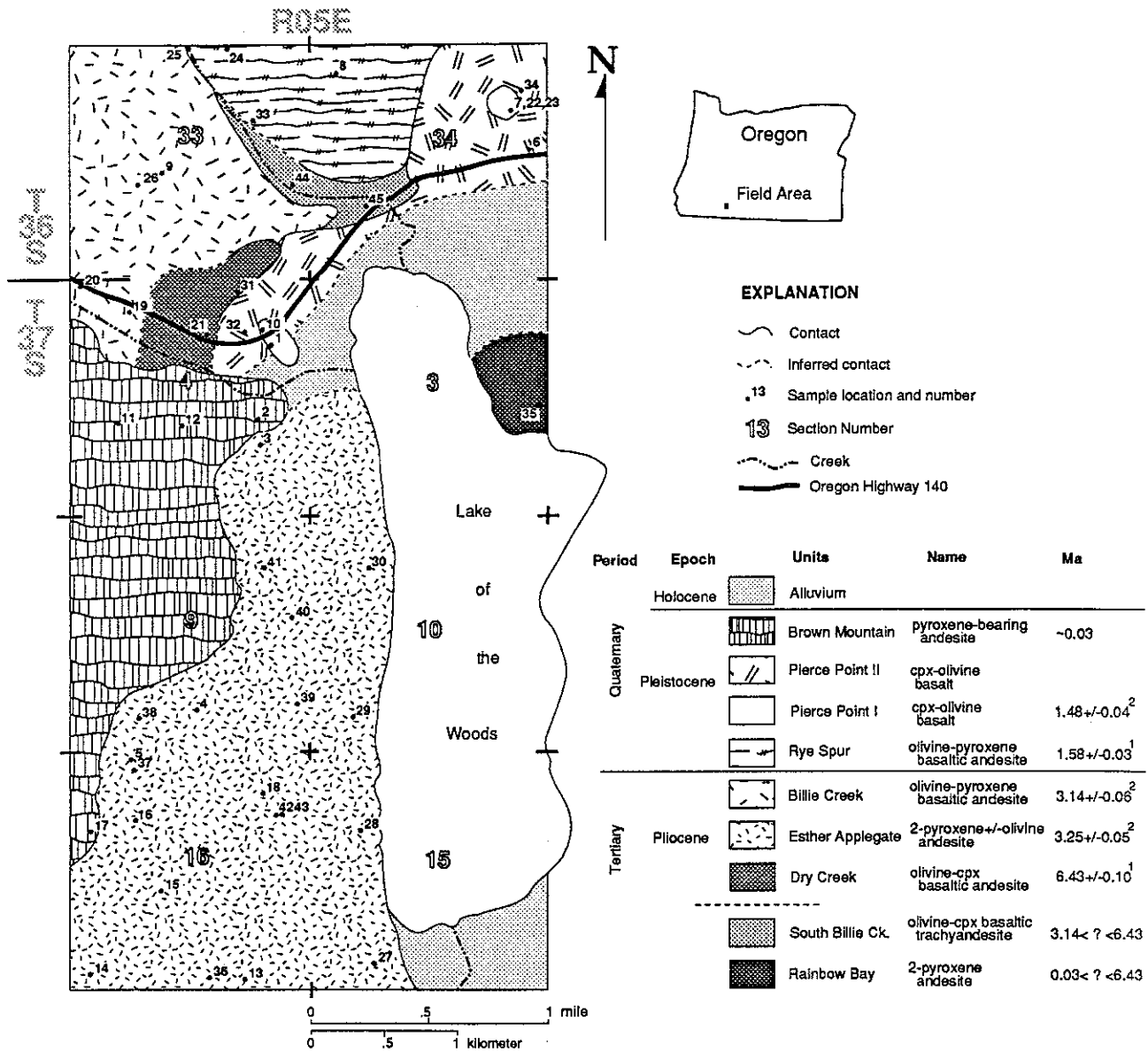


Figure 1. Geologic map of study area with sample locations. In explanation units are in stratigraphic order and dates, except for Brown Mountain, are based on K-Ar dating (¹=Mertzman 1991; ²=Mertzman 1992).

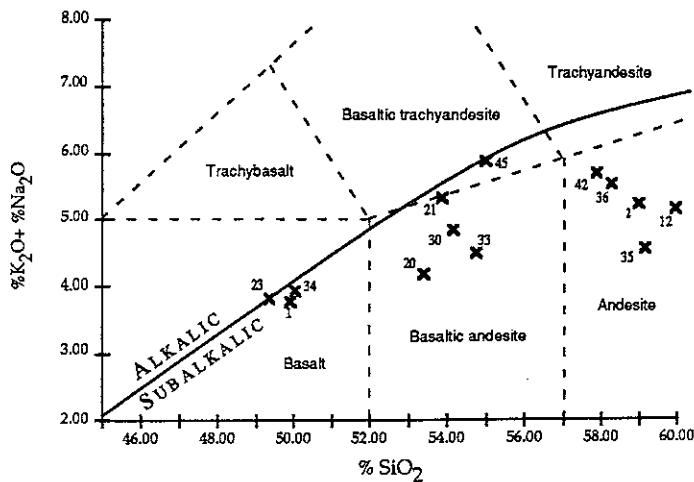


Figure 2. Classification of samples based on Total Alkali Silica diagram (After LeBas, et al. 1986) with Alkalic-Subalkalic dividing line (Miyashiro 1974). Sample numbers correspond to those on map.

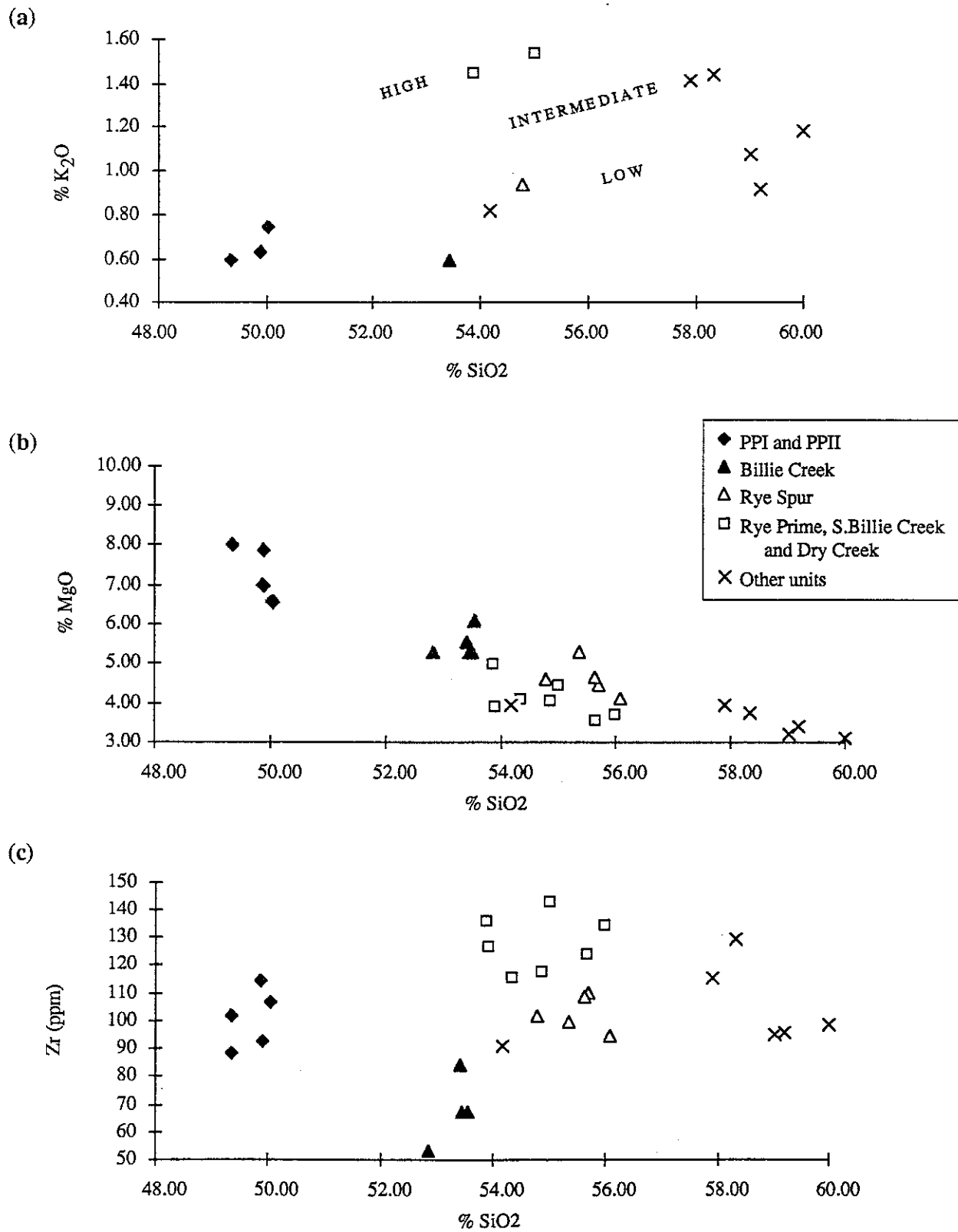


Figure 3. Harker plots illustrating K_2O (a), MgO (b), and Zr (c) variation between units. (Supplementary data in (a) and (b) from Gilmore 1992, Mertzman 1991, 1992, and Nauert 1992.)