Petrology and Geochemistry of the Pelican Butte Area, Southern Oregon

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Introduction

The Cascade mountain range consists of a linear chain of composite volcanoes extending from British Columbia to northern California. The volcanic rocks of the Cascades range in age from Miocene to Holocene. They are believed to result from subduction of the oceanic Juan de Fuca plate, beneath the continental North American plate. The area studied is located in the southeastern Oregon Cascades, near Fish Lake, Oregon. Little formal mapping of this area has been done. The purpose of the project was to describe the volcanic units in a seven square mile map area in terms of field relations, petrology, petrography and geochemistry.

Field Description

The field area was located on the southwestern flank of Pelican Butte, a small eruptive center northeast of Mt. McLoughlin. The summit of Pelican Butte has been dated at 0.54 Ma ± 0.05 Ma using K-Ar techniques (Mertzman, unpublished data). Three weeks were spent mapping and sampling the seven square miles. Five units were initially identified based on mineral assemblages and field relationships. An additional unit has since been distinguished (figure 1). The rocks range in composition from basalts to andesites (LeBas et. al. 1986, figure 2). Outcrops are generally blocky flows, some of which are associated with pyroclastic material. The overall mineralogy consists of plagioclase feldspar, olivine, ±clinopyroxene, ±orthopyroxene. Eighteen representative samples were selected for chemical analysis using Inductively Coupled Argon Plasma Spectrometry and X-Ray Fluorescence. Thirty thin sections were analysed.

Unit Lithologies, Petrography, and Geochemistry

The oldest unit identified, Lost Creek basalt, crops out as a small kipuka in the northwest area of the map (figure 1). Each outcrop of Lost Creek basalt is associated with pyroclastic material, some of which has been well exposed at Lost Creek Cinder Pit. Flows of Lost Creek basalt are rare, spheroidally weathered and usually not extensive (no more than 80 feet in length). They lack a vesicular flow top, evidencing their advanced age. This unit is distinct from the surrounding Black Bear basalt in terms of petrography, yet chemically these units are very similar. The plagioclase content ranges from 70-80%. Olivine makes up between 8-10% of the mineralogy and is typically altered to iddingsite. Plagioclase occurs as glomeroporphyritic clumps, about 2mm in diameter, often associated with the olivine. Clinopyroxene is present in the groundmass as microphenocrysts, accounting for 2-4% of the mineralogy. Opaques, generally iron-titanium oxides make up 2-3% of the rock. Minor apatite accounts for between 1-2% of the mineralogy.

Chemically, Lost Creek basalt is related to Black Bear basalt, the younger unit which flows around it. The silica content is generally close to 50%, Al_2O_3 is 17-17.4% and MgO ranges from 6.3 to 7.2%. The two units plot as a tight cluster on Harker diagrams for all major and most trace elements.

Black Bear basalt, crops out in the northeastern area of the map (figure 1). It was initially thought to extend over an area of approximately five square miles (mainly to the west, in Ben Surples' area). Subsequent geochemical analysis has defined these units as two possibly related flows: Long Creek basaltic andesite, which has been dated at 1.02 Ma ± 0.09 Ma (Mertzman unpublished data), and Black Bear basalt. Although Long Creek basaltic andesite does not crop out in the map area, an inferred contact has been established based primarily on topographic controls. It is possible that the flows of Black Bear basalt, Knob Top basalt, and Long Creek basaltic andesite are fault-controlled. The series of steep north-south trending slopes which exist in the western area of the map support the hypothesis of some degree of structural control, as do the flow morphologies of Long Creek basaltic andesite and Black Bear basalt (both occur in a linear north-south trending sequence). Pending K-Ar dates for Black Bear basalt, it will be considered younger than Long Creek basaltic andesite based on topography and morphology.

Flows of Black Bear basalt tend to form resistant ridges or large blocky flows of spheroidally weathered material. Textural differences among different flows of Black Bear basalt are apparent in thin section, yet the overall mineralogy varies little and the chemistry is consistent throughout the extent of this unit. In general, plagioclase makes up between 65-70% of the rock. Olivine, often highly iddingstitized, accounts for about 10% of the phenocrysts, and clinopyroxene for approximately 15-20%. There may also be occasional orthopyroxene present in the groundmass (1-2%). The oxide minerals are less abundant than in Lost Creek basalt, comprising less than 2% of the total mineralogy.

The variation among samples of this unit is shown primarily in the clinopyroxene occurrence. The lower flows of Black Bear basalt have fewer megascopic (1-2mm) phenocrysts in general and the clinopyroxene is present primarily in the groundmass phase. The percentage of clinopyroxene is more variable in the lower units, ranging from 10-20%. Again, orthopyroxene is present as microphenocrysts only. The upper flows of Black Bear basalt display a difference in texture compared to that of the lower flows. While both units contain glomeroporphyritic clumps of plagioclase, oivine and clinopyroxene, the clinopyroxene of the upper flows exhibits subophitic textures. The implications of such textures are that the upper unit is a later flow of the same material, which occurred after some crystal settling had taken place.

Knob Top basalt may also be related to Black Bear basalt, but is distinct enough in mineralogy and geochemistry to be considered a separate unit. Knob Top basalt crops out as three large blocky flows in the northwestern area of the map (figure 1). The flows of Knob Top basalt are spheroidally weathered in most areas. The knob (from which the unit gets its name) consists of 50% pyroclastic material and is the probable source for this unit. Mineralogically, Knob Top basalt consists of 75-80% plagioclase, 8-10% olivine, about 5% clinopyroxene, with approximately 2% oxides. The plagioclase and olivine occur almost exclusively as large (2mm+) glomeroporphyritic clumps. The clinopyroxene occurs as rare phenocrysts, not associated with the glomeroporphyritic clumps or, more frequently, as groundmass microphenocrysts.

Chemically, Knob Top basalt differs from the other two basaltic units. On Harker diagrams, Knob Top basalt plots high for both K_2O and Sr. Although the silica content of Knob Top basalt is almost the same as that of the other basalts, its Sr content (730-750 ppm) is closer to that of the andesitic units in the map area. Knob Top basalt also has a much higher percent CaO than Black Bear basalt or Lost Creek Basalt do.

Pelican Butte two-pyroxene basaltic andesite extends laterally along the southwestern flank of Pelican Butte (figure 1). Outcrops of Pelican Butte two-pyroxene basaltic andesite are always spheroidally weathered and rarely larger than about 90 feet in length. The majority of outcrops are about 50-60 feet in length and form ridges about 20-30 feet wide. One blocky flow was found, but all the other outcrops form distinctive small platy ridges. This unit is frequently vesicular and the vesicles are often lined with zeolites. The source for this unit is either Pelican Butte, or one of its parasitic features, neither of which have been studied in detail. The mineralogy of Pelican Butte two-pyroxene basaltic andesite shows some variation across its extent, but generally is as follows. Plagioclase comprises 75-80%, clinopyroxene accounts for 8-10% and orthopyroxene makes up between 8-10%. Olivine is present in all samples, but the percentages vary from less than 2% to close to 5%, although most samples contain close to 3%. Olivine is always partially or completely altered to iddingsite and often is associated with hematite. The texture of this unit consists of pilotaxitic plagioclase. The clinopyroxene and orthopyroxene grains are also randomly oriented and are not physically associated with one another.

The geochemical data for Pelican Butte two-pyroxene basaltic andesite presents an interesting problem. All but one of the data points plot with the other andesites and basaltic andesites. One sample however, exhibits high Ni (74.8 ppm) and high Cr (115 ppm) when plotted against SiO_2. The same sample has a much higher Sr/CaO ratio than the other units as well. Petrographically, this sample does not exhibit any characteristics not shared with other samples of Pelican Butte two-pyroxene basaltic andesite. As no immediate explanation exists for these discrepancies, the only obvious conclusion is that this sample represents an inhomogeniety within the unit.

The youngest unit identified, Four-Mile two-pyroxene andesite has been dated at 0.21 Ma $\pm$ 0.18 Ma (Mertzman unpublished data) and is the youngest dated unit in the project area. It extends across the central and eastern area of the map (figure 1). It appears to have its source at the hilltop of elevation 5444'. Outcrop of Four-Mile two-pyroxene andesite is abundant, vesicular, and fresh. Rarely are outcrops of this unit vegetated. Outcrops tend to be blocky flows, although occasional platy ridges have been described. Typically the mineralogy consists of 75-80% plagioclase, 8-10% orthopyroxene, 5-7% clinopyroxene and occasional olivine, 2-3%. The plagioclase is pilotaxitic and the olivine is usually altered to hematite and iddingsite. Clinopyroxene occurs both as phenocrysts and as groundmass microphenocrysts. Orthopyroxene occurs primarily as phenocrysts.

Chemically, Four-Mile two-pyroxene andesite plots with the other andesitic compositions. The one inconsistency is the somewhat higher percent K_2O in the sample from the hilltop of elevation 5444'. Again, the petrography of this sample is consistent with that of the whole unit. This inhomogeneity may be due to volitile escape from the vent area.

Discussion

In order to investigate genetic relationships between basaltic and andesitic compositions, certain incompatible elements were plotted on a cartesian coordinate system. On such a plot, ratios of incompatible elements remain constant among units whose source is the same. The La/Ba plot shows two distinct groups (andesites and basalts) which represent two distinct magmatic sources (figure 3a). Within each group, the La/Ba ratio is within error for all units. The ratios of light REE's, Ce_N/La_N, however, are within error for all compositions (figure 3b). This may suggest a similar mantle source for both basalts and andesites. The increase in Ba in the andesitic compositions may indicate crustal contamination of the mantle source (Hickey et.al., 1986). The trends within compositional groups (especially within the andesites) probably result from crystal fractionation but no fractionation evidence exists between compositional groups. Future investigation of fractionation within the two groups is necessary in order to establish a coherent genetic model.

References Cited

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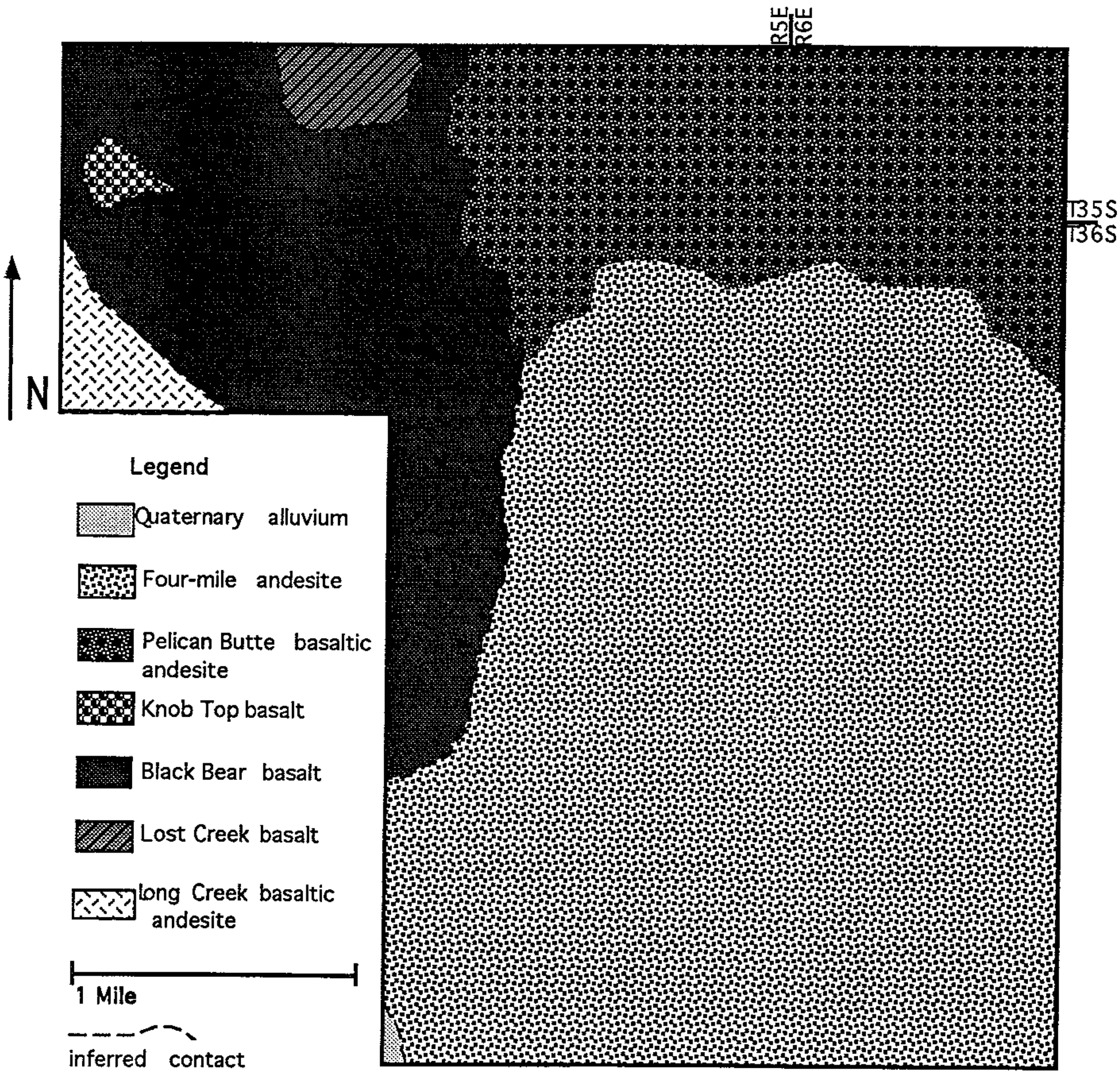

Figure 1. Geologic map of field area, Lake of the Woods North Quadrangle Oregon--Klamath Co. In explanation units are in stratigraphic order.

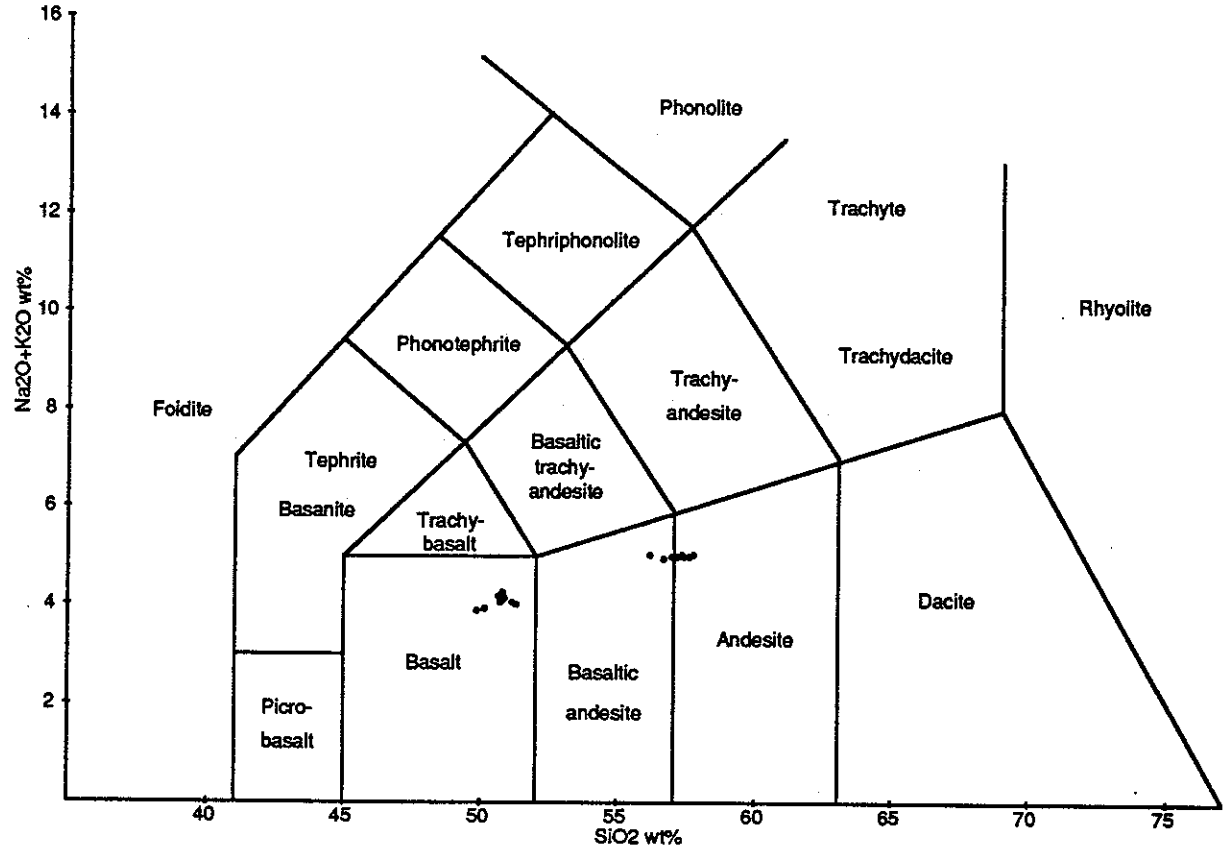

Figure 2. Chemical Classification after LeBas et. al., 1986

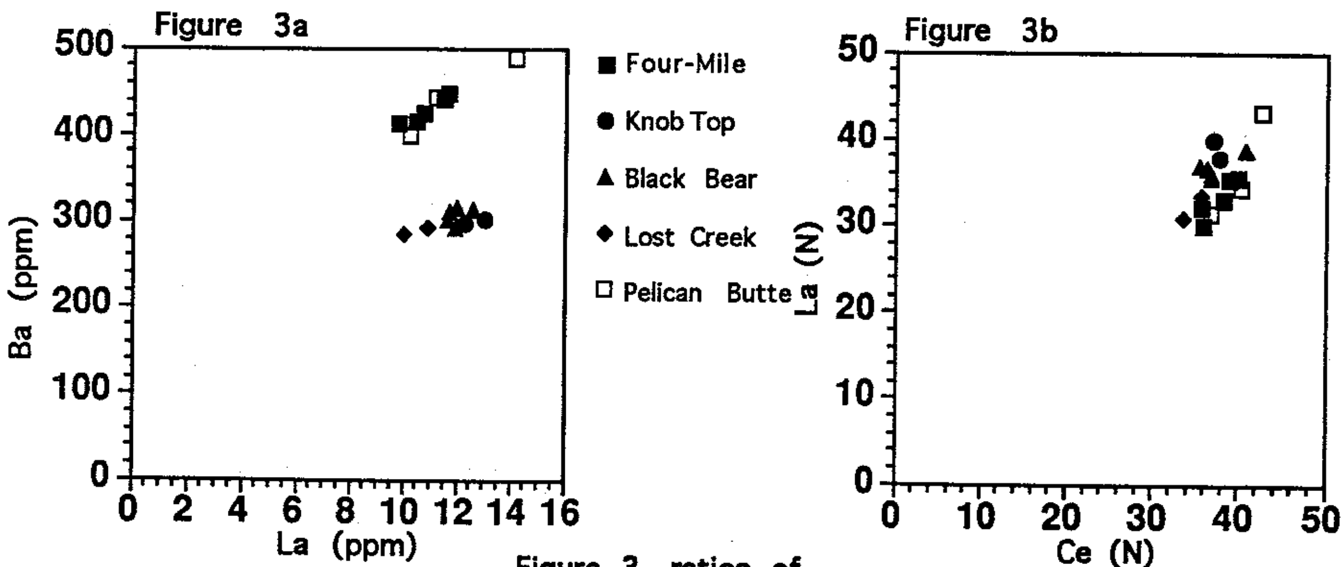

Figure 3. ratios of incompatible elements