Cascade Volcanics on the Southern Flanks of Brown Mountain, Southern Oregon.

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Purpose:

The aim of this project is to comprehend better the processes responsible for the extrusion of volcanics in the Southern Cascade Range. The field work by ten students covered 70 square miles over the course of three weeks.

Geologic Setting:

The High Cascades are a subduction-related volcanic arc extending from Mt. Garibaldi in British Columbia to Mt. Shasta in Northern California. Subduction of the Juan de Fuca Plate to the west combined with extensional Basin and Range tectonics to the east seems to cause the exceptional diversity found within Cascade volcanics (Hart and Carlson, 1988). Variation in chemical composition is thought to be caused by variation in the rate and angle of the subducting lithosphere over time (Mertzman, 1993).

Methods:

The seven square mile area studied in this project is to the south and southwest of Brown Mountain. Blocky Brown Mt. Andesite flows comprise the northern boundary of the area while Cox Butte summit marks the southwest corner. The eastern edge of the area is the boundary between the Rogue River and Winema National Forests. Five flow units were identified in the field. A sixth, Daley Creek Basaltic Andesite, was identified by geochemical analysis.

A total of 23 samples collected were prepared for thin section analysis. Major and trace element determinations using X-ray fluorescence were performed upon 17 of these samples at the University of Massachusetts (Amherst) and at Franklin and Marshall College. Six samples were also analyzed by instrumental neutron activation analysis (INAA).

Petrography:

The six unit descriptions are listed from oldest to youngest as determined by K-Ar data and field relationships.

Daley Creek Basaltic Andesite

This unit is a fine to medium grained holocrystalline rocks distinguished from Little Butte Creek Andesite by fewer glomeroporphyritic clumps within an aphanitic groundmass. Thin sections display flow banding defined by groundmass coloration. Plagioclase (An 40-50) (20-25%) of 1-3 mm tabular grains is resorbed. Olivine (Fo 85) (6-8%, 0.25-0.5 mm grains) is occasionally found in small clumps with plagioclase. Clinopyroxene (2-3%) (1-4 mm) grains are often found in clumps with other clinopyroxenes. Orthopyroxene (1-2%) (1mm) is sparse and discrete.

Little Butte Creek Andesite

This unit is 3.4± 0.08 Ma (Mertzman, personal communication, 1994). It is a fine to medium grained holocrystalline unit characterized by extensive glomeroporphyritic clumping of all minerals. Plagioclase (An 30) (25-30%) laths of 1-4 mm (with few equant grains) dominate the unit megascopically. Olivine (Fo 85) (4-5%, 1-3 mm at varying stages of iddingsitization), orthopyroxene (4-5%) (1 mm phenocrysts), and clinopyroxene (3-4%, 0.5-1 mm phenocrysts) are found within the plagioclase-dominated clumps. Samples collected range from vesicular to platy to massive.

Esther Applegate Two-Pyroxene Andesite

This unit flowed into the area from the east at 3.25± 0.05 Ma (Mertzman, personal communication, 1994). It is a fine to medium grained holocrystalline unit characteristically defined by equigranular phenocrysts and limited glomeroporphyritic clumping. Plagioclase (An 45) (35-40%) displays two populations - small 1 mm tabular grains and occasional equant zoned grains (2-3 mm) at a 20:1 ratio. Orthopyroxene (En 85) (7-

9%, 0.5-1 mm) exists in discrete grains or in clumps with plagioclase, clinopyroxene (6-8%, 0.5-1 mm), and olivine (1-3%, 1 mm, at various stages of iddingsitization). Orthopyroxene tends to dominate glomeroporphyritic clumping. Trace epidote was noted in one thin section.

Cinder Pit Basalt

This unit is dated at 2.77± 0.05 Ma and 2.92± 0.07 Ma (Mertzman, personal communication, 1994). Predominantly platy in outcrop, this fine to medium grained holocrystalline unit is characterized by large olivine phenocrysts (Fo 85) (8-10%, 1-5 mm elongate grains). Plagioclase (35-45%) comprises a flow-oriented groundmass together with fine grains of olivine and clinopyroxene.

Cox Butte Basaltic Andesite

This unit is 2.96± 0.06 Ma (Mertman, personal communication, 1994). Though K-Ar dating places this unit below the Cinder Pit Basalt in the stratigraphic column, field relationships appear to disagree. The margin of error within the dating method allows for this possibility. It is a fine to medium grained holocrystalline porphyritic unit. Plagioclase (An 40) (20-30%, 0.5-1mm laths) is variable, as shown by broken grains and larger (3mm) equant grains. Olivine (Fo 85) (8-10%, 1-2mm with few 3-4 mm elongate grains) shows minimal weathering. Clinopyroxene (1-2%, 1 mm) is discernible only by twinning features. Orthopyroxene (1%) is found only in clumps surrounding olivine.

Brown Mt. Andesite

This unit is approximately 50,000 years old (Mertzman, personal communication, 1994). A fine grained holocrystalline rock, the unit displays discrete phenocrysts of plagioclase (An 47) (20%, heavily zoned laths of <1 mm) and orthopyroxene (3-4%, often clumping as small laths (1 mm) in an X formation). Collected from a young, blocky flow, the samples are nearly unweathered.

Geochemistry:

Seventeen samples plotted on a TAS diagram indicated six rock units ranging from 50% SiO_2 to 59.7% SiO_2 (Cinder Pit Basalt and Brown Mt. Andesite, respectively): one basalt, two basaltic andesites, and three andesites (figure 1). Two units Little Butte Creek Andesite and Cox Butte Basaltic Andesite (both characterized by high olivine phenocryst content), showed higher SiO_2 levels than predicted from hand specimens in the field and were reclassified on the basis of their geochemistry.

Na_2O+K_2O as well as K_2O correlate positively with SiO_2, forming a smooth, medium-K calc-alkaline series. P_2O_5 varies inversely with SiO_2, supporting a calc-alkaline trend (Gill,1981). TiO_2 decreases with higher SiO_2 levels. Cinder Pit Basalt and Cox Butte Basaltic Andesite show the highest concentrations of CaO and MgO as well as the lowest concentrations of Na_2O+K_2O.

A rock vs. MORB Pearce plot shows enrichment of Large-ion lithophile (LIL) elements and depletion of elements of mantle affinity, a trend that is typical of subduction-related arc volcanism (figure 2). These magmas are clearly not primitive. The lower SiO_2 units (Cinder Pit Basalt and Cox Butte Basaltic Andesite) show Rb depletion not found in other units. Cinder Pit Basalt is highly enriched in Ce. Little Butte Creek and Esther Applegate Andesites are nearly identical, diverging only slightly at Rb.

Plots of Rare Earth Elements (vs. chondrites) show moderate fractionation characteristic of a calc-alkaline series (Figure 3). The slight negative Eu anomaly of Cinder Pit Basalt suggests removal of plagioclase during fractional crystallization (Rollinson,1993). The abundance of plagioclase in Little Butte Creek Andesite is supprted by a modest positive Eu anomaly.

Discussion:

Major element data indicate a medium-K calc-alkaline magma series. Trace element data show contamination by or assimilation of continental crust in the course of magma history - LIL enrichment coupled with depletion of Ni. The low SiO_2 - high MgO units (Cinder Pit Basalt and Cox Butte Basaltic Andesite) exhibit a depletion of Rb not found in the older, more andesitic units. Trace element data similarities show a possible relation between Esther Applegate Two-Pyroxene Andesite and Little Butte Creek Andesite.

The six units studied are products of the subduction related volcanism of the descending Juan de Fuca plate. No unit seems related to Basin and Range extensional volcanism characterized by primitive tholeiitic basalts. This fits within the history of the region. Basalts with SiO_2 of 50% or lower did not appear until 3 Ma (Mertzman, 1993). With the exception of Brown Mt. Andesite, the youngest units of the area are only slightly younger than 3 Ma. The more basaltic compositions of the Cinder Pit Basalt and Cox Butte Basaltic Andesite may represent an early movement towards a tholeiitic magma.

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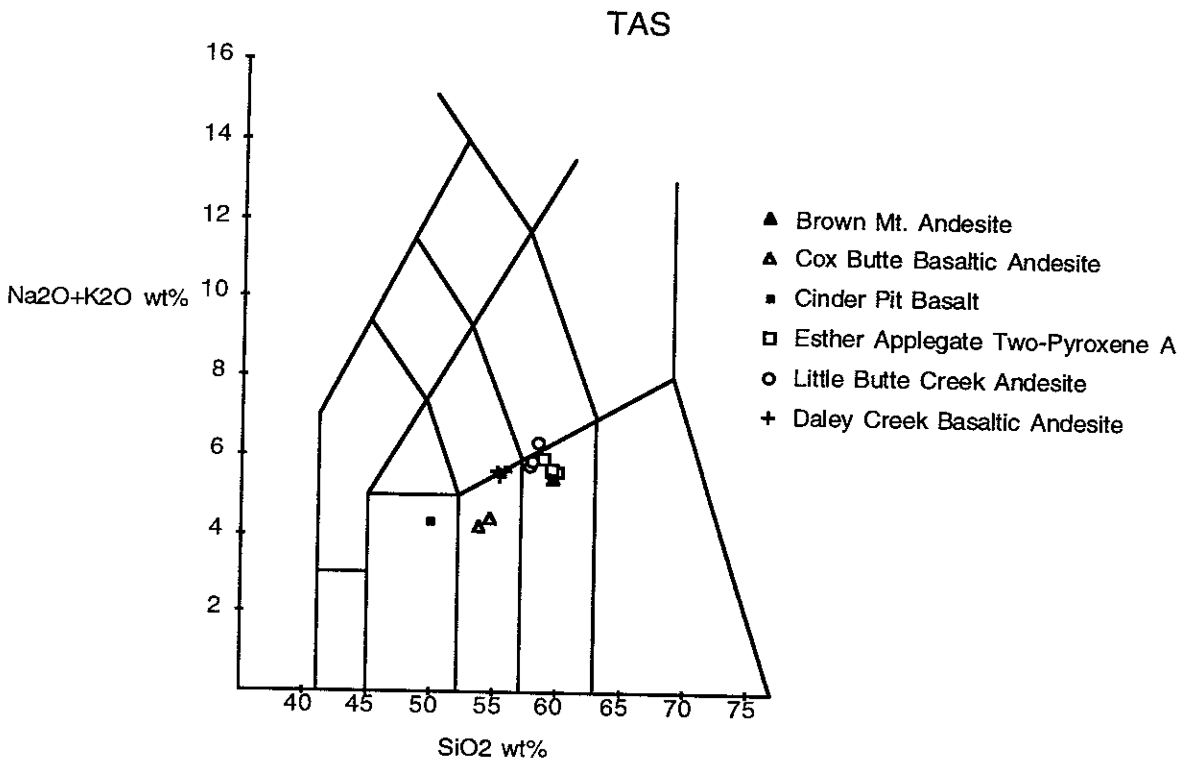

Figure 1: Total Alkali vs. Silica classification after Le Bas, et. al., 1986.

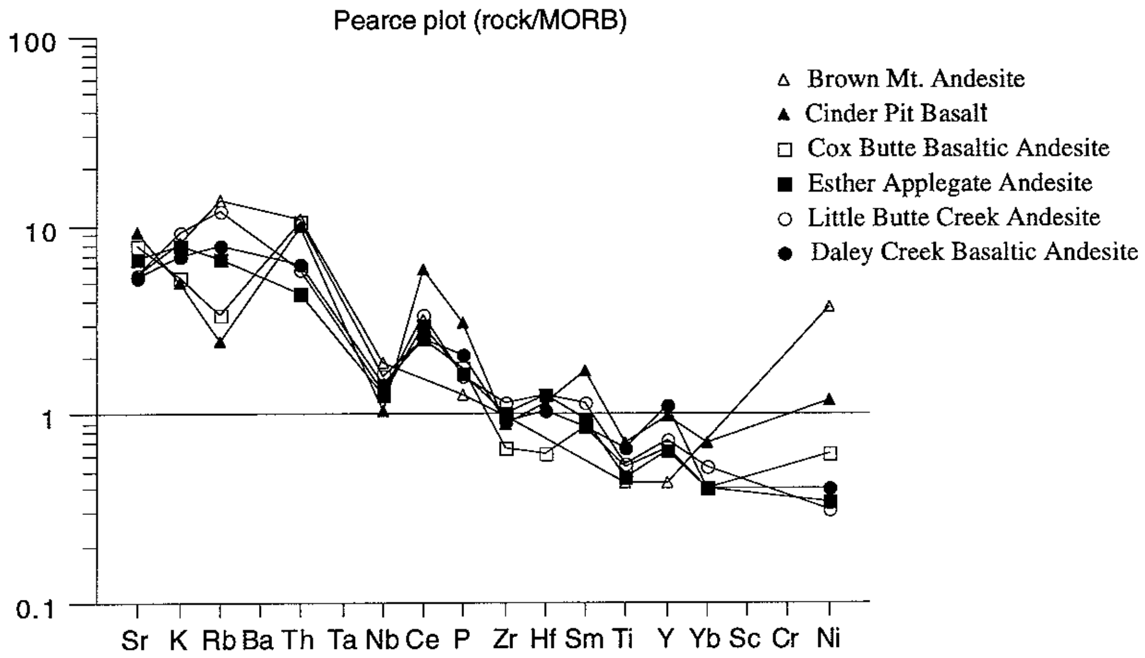

Figure 2: Trace element composition plot showing enrichment of LILs.

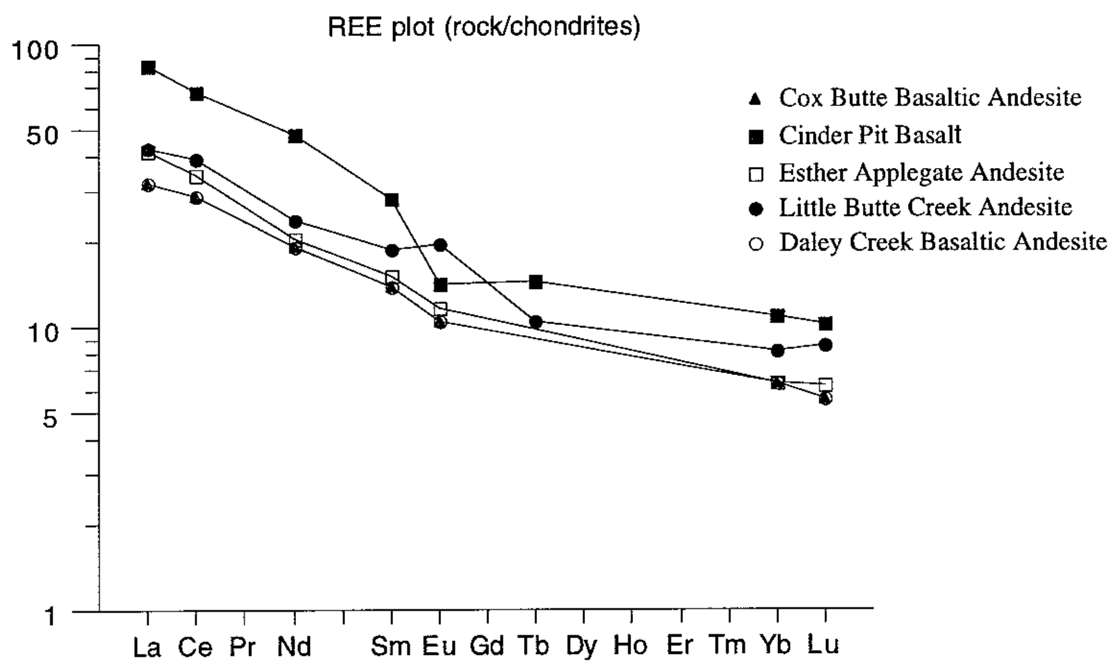

Figure 3: Chondrite-normalized REE plot shows moderate fractionation between LREE's and HREE's. Note opposing Eu anomalies of Cinder Pit Basalt and Little Butte Creek Basaltic Andesite.