PETROLOGY AND GEOCHEMISTRY OF MIOCENE-HOLOCENE VOLCANICS IN THE HIGH CASCADES OF SOUTHERN OREGON

Introduction:

The Cascades Mountain Range is a north-south trending range, extending from Mt. Garibaldi in southern British Columbia down to Mt. Lassen in northern California. In the past seven million years, this arc has been subject to the volcanic period known as the High Cascades Volcanic Episode. This episode, due to the subduction of the Juan de Fuca plate under the North American plate to the west and the extension of the Basin and Range province to the east, extruded lavas ranging in composition from rhyolite/dacite to basalt (Guffanti and Weaver, 1988). In the summer of 1994, ten students continued the Oregon Cascades Keck project designed to study the lithologies of the High Cascades. Each student chose his/her own seven square mile area in an area to the south of Mt. McLoughlin to map and sample, in order to add to the knowledge of the geological quadrangle already in progress. The area was located in the far western reaches of this quadrangle, in Township 37 South and Range 4 East. (See Figure 1)

Methods:

Through analysis of hand specimens and field relationships, each student left the field with a proposed stratigraphic column and knowledge of their local lithologies. To supplement this knowledge during the school year, students traveled to Franklin and Marshall College in Lancaster, Pennsylvania to perform the geochemical techniques of Inductively Coupled Plasma Mass Spectrometry and X-Ray Fluorescence on 30 samples to determine their major, trace and rare earth elemental compositions. In addition, each of these 30 samples was examined in thin section to determine modal abundances and textures.

Stratigraphic Column/Petrography:

The rocks in the study area were typically in the range of basalt--basaltic andesite--andesite, but there were a few more alkalic samples in the trachy-basalt and basaltic trachy-andesite range of the Lebas classification diagram (1986). Eight different lithologies were encountered in this area, and they are described below in reverse chronological order, from youngest to oldest.

Brown Mountain Andesite is the youngest unit in the study area, dated at ~ 50,000 years (Mertzman, personal communication). It consists of blocky flows of fine-grained, aphanitic lavas located in the most northern part of the section. This is a two pyroxene andesite with microphenocrysts of plagioclase, orthopyroxene and clinopyroxene, and ranging vesicularity, depending on location within flow regime. The source of Brown Mountain Andesite is the Brown Mountain volcano, located several miles northeast of the area. These eruptions flowed over the pre-existing Little Butte Creek Basaltic Andesite unit directly to the south.

Robinson Butte Basalt is dated at 400,000 years, and located in the most northwestern corner of the area (Mertzman, unpublished data). It displays glomeroporphyritic clusters of plagioclase, clinopyroxene, and olivine, as well as ranging vesicularity, depending on location within the flow. Outcrops of this unit are scarce in the area, but do exist as partially weathered slabs and boulders. (Due to the low-Si basaltic nature of this unit, it tends to weather more quickly than its higher Si counterparts. The source of Robinson Butte Basalt is the Robinson Butte located directly northwest of the area. To the south and east, these flows contact with (and presumably partially overlay) the South Fork Canal Andesite unit, which is stratigraphically older.

Cox Butte Basaltic Andesite is located in the southeastern corner of the section, having erupted from a source of the same name. This unit displays phenocrystic olivine, a sugary texture, and plagioclase groundmass in both its quarry rocks, and samples from slab-like outcroppings. This lava is dated at ~ 2.96 Ma, and maintains a distinct lobate flow structure which allows us to infer that it is stratigraphically younger than bordering South Fork Canal Andesite to the north and Daley Creek Basaltic Andesite to the west (Mertzman, unpublished data).

South Fork Canal Andesite displays unusually long, hornblende-like clinopyroxene phenocrysts up to 6 mm in length and large, zoned, equant plagioclase phenocrysts up to 1 cm in length. This unit is found in the center of the study area, and provides some of the only outcrops. These are predominantly blocky, broken, slab-like masses which can be found intermittently along the entire length of the South Fork Canal. The source of these rocks is unknown, as is the age, however, judging by their geographic location with respect to the other lithologies, it may be inferred that this lava flowed from the south. Unfortunately, this unit is not found in any other student study areas.

Little Butte Creek Basaltic Andesite is a weathered, poorly outcropping unit in the northeastern part of the section, shared with Peter Taylor (see 1995 Keck Abstract). K/Ar dating techniques place it at ~ 3.40 Ma. (Mertzman, unpublished data). This unit closely resembles Daley Creek Basaltic Andesite, but often contains larger plagioclase phenocrysts. These plagioclase phenocrysts display two different habits, one of laths, and the other of equant faces. This unit also contains small phenocrysts of olivine, clinopyroxene, and orthopyroxene. Like the South Fork Canal Andesite, the source of this unit is unknown, and presumably buried by Brown Mountain flows to the northeast.

Daley Creek Basaltic Andesite, as was mentioned above, closely resembles the Little Butte Creek Basaltic Andesite. This unit also has an unknown source, and is dated at ~ 3.40 Ma. (Mertzman, unpublished data). Phenocrysts of plagioclase, clinopyroxene, and olivine are common, with occasional orthopyroxene. The resemblance between Daley Creek Basaltic Andesite and Daley Creek Basaltic Andesite is so striking, that they may actually be different parts of the same unit. The variation between the two may be attributed to their differing distances from the source, as well as differing cooling times (Mertzman, personal communication).

Little Butte Creek Basalt is made up of a series of flows, slightly chemically distinguishable, most likely from a common source (now buried). It is dated at ~ 6.14 Ma. This unit forms large cliffs of approximately 20 feet in height which have been formed by the Little Butte Creek slicing through the landscape. It is fine-grained, with olivine phenocrysts making up 10-15% of the rock. In hand sample, this unit closely resembles Butte Creek Basalt, studied by Baum in 1991.

Western Cascades Volcanics are, by far, the oldest units in the study area, and can be found underlying almost every unit. Where absent, they may be inferred to be present because they are the decaying volcanics left from the Western Cascades volcanic episode of ~ 20 Ma (Mertzman, unpublished data). Friable and highly weathered, they are exposed along the man-made South Fork Canal, underlying and in direct contact with the South Fork Canal Andesite.

Discussion:

Using the geochemical data determined at Franklin and Marshall College, I have concluded that there are a total of 8 lithologies in the area. The Lebas classification diagram shows that the majority of these fall in the basaltic andesite range, however, there are a few exceptions. Little Butte Creek Basalt plots as the only Trachy-basalt, while the Little Butte Creek Basaltic Andesite plots over a range between basaltic andesite and andesite. Robinson Butte Basalt plots as the only true basalt, whereas Cox Butte Basalt falls in the basaltic andesite range.

Data were plotted on Harker diagrams, as well as on oxide/element vs. MgO, and on spider diagrams. Many trends were illustrated using these methods. From the positive correlation between Na_2O + K_2O and Zr vs. SiO_2, there is evidence that the suite of rocks in the study area may have been part of a fractionating magma chamber. The positive correlation between Ni and Co vs. MgO suggest that olivine fractionation occurred. The negative correlation in Al_2O_3 vs. MgO, as well as the lack of variation within the Sr vs. CaO diagram suggest that there is no plagioclase fractionation taking place (Wilson, 1989). (See Figure 2) However, to contradict this information, we see that the ages of the lithologies are much too spread out to represent the evolution of just one source magma. Hence, the genesis of the study area rock types may or may not be related to one another.

Finally, there are a few anomalies within the sample set. The samples representing Little Butte Creek Basalt plot high on Harker and MgO diagrams relative to every other lithology in the area. Of particular interest, these basalt samples are of the same group of high P_2O_5 rocks found by Baum in 1991. In addition to high quantities of P_2O_5, these samples also show high amounts of Na_2O, K_2O, Th, Rb, and Be. Possible future research could include an investigation into how this magma became so enriched in the aforementioned components.

Acknowledgments:

I would like to thank Stan Mertzman and Steve Weaver for their endless patience and assistance in the field. In addition, I am grateful to the Keck Foundation for supporting my senior research.

References:

Baum, J., 1992. Miocene to Holocene Volcanism of Robinson Butte and Vicinity, Southern Oregon Cascades. Keck Research Symposium in Geology, Abstracts Volume, 1992 Meeting at Washington & Lee University, v.5.

Guffanti, M. and Weaver, C.S., 1988. Distribution of Late Cenozoic Volcanic Vents in the Cascades Range: Volcanic Arc Segmentation and Regional Tectonic Considerations. J. Geophys. Res., v.93, p.6513-6529.

Lebas, M.J., Le Maitre, R.W., Streckeneisen, A., and Zanettin, B., 1986. A Chemical Classification of Volcanic Rocks Based on the Total Alkali-Silica Diagram: J. Petrol., v.27, p.745-750.

Mertzman, S.A., personal communication, 1994.

Mertzman, S.A., unpublished K-Ar data, 1991, 1992, and 1994.

Taylor, P., 1995. [title unknown]. Keck Research Symposium in Geology, Abstracts Volume, 1995 Meeting at Pomona College, v.8.

Wilson, M., 1989. Igneous Petrogenesis, London, Unwin Hyman, 466p.

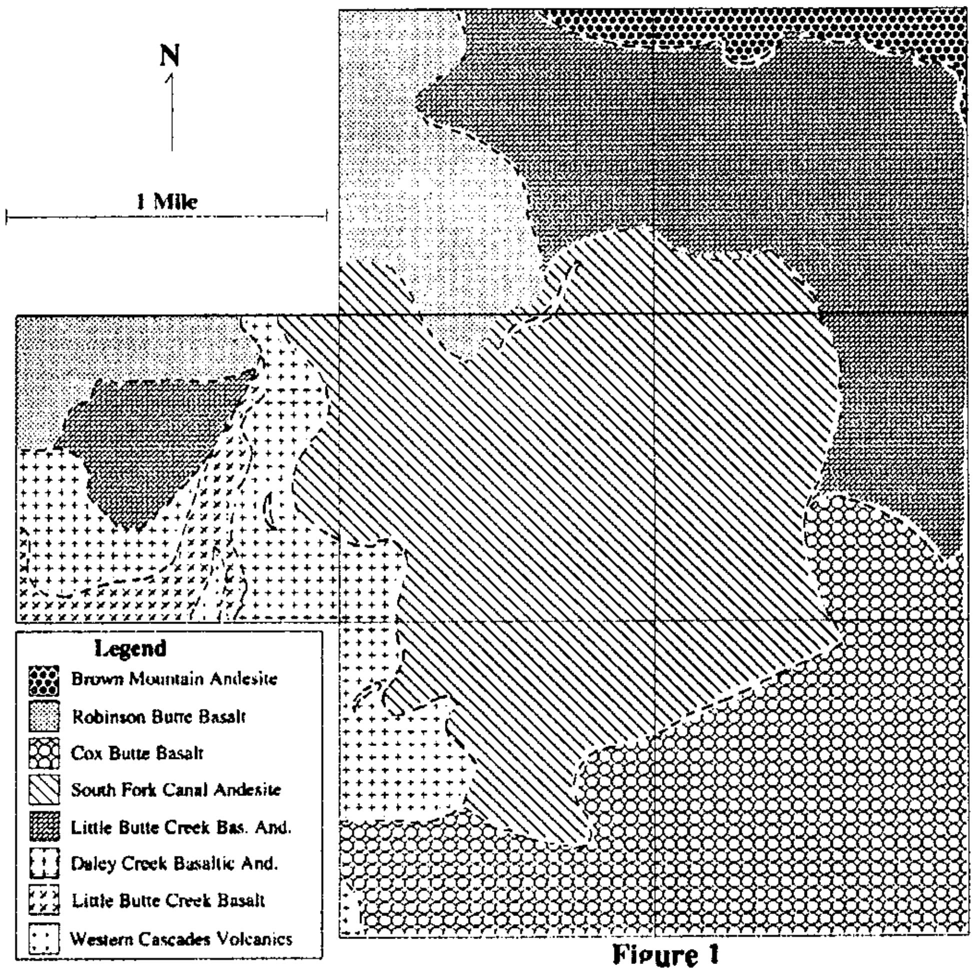

Figure 1: Contact map of the study area at T37S, R04S, near Fish Lake, Oregon.

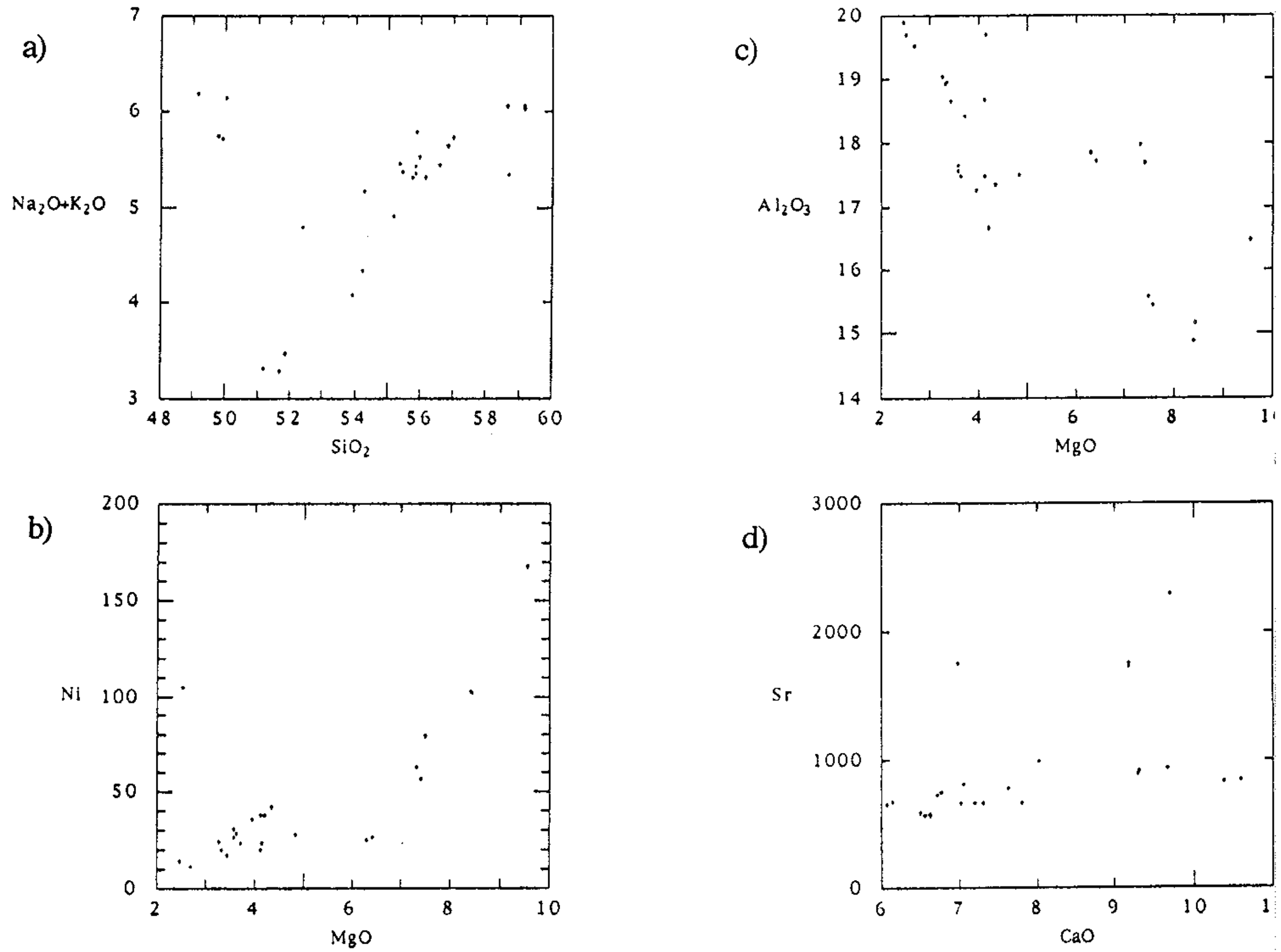

Figure 2: a) Plot of $Na_2O + K_2O$ vs. SiO_2 b) Plot of Ni vs. MgO
c) Plot of Al_2O_3 vs. MgO d) Plot of Sr vs. CaO