A Petrographic and Geochemical Analysis of the Burton Butte Microshield and Surrounding Volcanic Units, Jackson and Klamath Counties, Southern Oregon. Implications of Back Arc Involvement during Petrogenesis

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Introduction

During the Eocene, the Farallon plate began to dive under a westward moving North American craton. The resulting volcanic arc has been active continuously since then producing lavas which range in composition from basalt to rhyolite. The current system in Oregon includes the High Cascades volcanic arc and a natural back-arc extensional regime, the south-eastern Oregon portion of the Basin and Range. Volcanism in the back-arc and bordering the High Cascades province has produced an interesting mix of magma sources, including the Newberry complex, which have surfaced through vents, dikes and other fissures.

The purpose of this Keck project was to study an east/west transect of the High Cascades province and determine if mixing of back-arc magma and subduction zone magma occurs within the High Cascades itself, or is confined to an area along the border between the two provinces. During the summer of 1994, ten students from nine different schools mapped volcanic units in the Rogue River National Forest of Southern Oregon. In this project, seven square miles of the High Cascades were mapped, and later analysed for chemical variation and petrography at Colorado College.

Stratigraphy

The region mapped in my portion of this project included eight different volcanic units ranging in age from .82 ma to 5.77 ma. Four of these units were basalts, one was basaltic andesite, and three were andesites. Each of these units was described in the field and named according to location, mineral assemblage and texture (fig. 1).

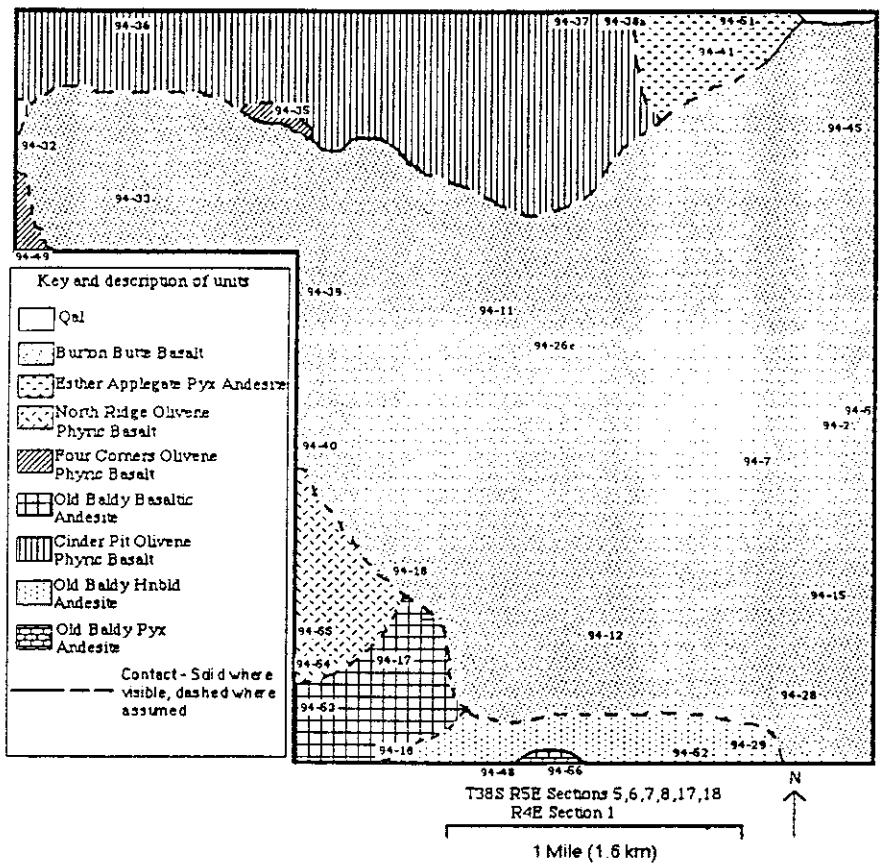

Figure 1: Geologic map of study area.

The oldest unit is the Old Baldy Two Pyroxene Andesite. In outcrop, this unit resembles the younger Esther Applegate andesite. It has little flow morphology, an abundance of float, and is typically difficult to trace. Thin section analysis of this unit shows that it is nearly 74% plagioclase (An_{60}). Orthopyroxene is the dominant mafic phenocryst, but clinopyroxene does exist in small amounts.

The Old Baldy Hornblende Andesite consists of one lobate flow extending from the south. This unit displays relatively good outcrop compared to the pyroxene andesite. Old Baldy Hornblende Andesite is characterized by large (>.5 cm) hornblende phenocrysts found in some hand samples. In thin section, the hornblende phenocrysts were resorbed and replaced by plagioclase, pyroxene and ilmeno-magnetite crystals The unit as a whole consisted of 87% plagioclase (An_{45}). Both clinopyroxene and orthopyroxene phenocrysts accounted for only 6% of the rock, while ilmeno-magnetite was an abundant phase (7%). In this mapping area, only one flow lobe of hornblende andesite existed. K/Ar dates of the unit came out to 5.77 ±.09 ma (Mertzman, personal communication)

The only basaltic andesite in the mapping area is Old Baldy Basaltic Andesite. Like many other units, flow morphology was difficult to observe because of limited exposure in this mapping area. However, the distinctiveness of the unit, as well as the freshness of the rock allow for excellent sample collecting. In both hand sample and thin section, plagioclase (An_{60}), olivine, and clinopyroxene phenocrysts were easily identifiable. The olivine phenocrysts displayed reaction rims of clinopyroxene. The unit was highly vessicular indicating a high volatile content during eruption. The age of the basaltic andesite unit is 2.78 ±.06 Ma (Mertzman, personal communication).

On the northern border of the mapping area, massive flows of Cinder Pit Olivine Phyric Basalt (OPB) can be found and traced directly to the source. The source, an excavated cinder pit, has excellent exposures of pyroclastics, primarily ash and well-preserved bombs. The main flows appear to extend to the west and south. These flows include both vesicular and massive parts, as well as extensive vertical jointing towards the center of some flows. Cinder Pit primarily consists of 49% plagioclase (An_{45}), and 47% olivine. Many of the olivine phenocrysts are replaced by iddingsite K/Ar dating of this unit is calculated to be 2.77 ±.05 ma (Mertzman, personal communication)

The next youngest unit and the oldest basalt is the Four Corners Olivine Phyric Basalt. This unit has a platy jointed massive interior, and vesicular outer crust. Its flows can easily be mapped, but it does not crop out extensively in my area. It consists almost entirely of olivine phenocrysts in a microcrystalline groundmass. Small plagioclase (An_{40}) phenocrysts can sometimes be found. K/Ar analysis indicates this unit is 2.63 ±.08 Ma.

The North Ridge Olivine Phyric Basalt is limited in exposure but is relatively unaltered. This unit has both flow and vent facies. One outcrop contains massive boulders of an aa basalt flow. An abundance of brecciated pyroclastics were found along the crest of the north\south trending ridge. Its young age is demonstrated by the preservation of both flow and vent rocks. Mineral assemblages are 70% plagioclase (An_{50}), 24% olivine, and 5% ilmeno-magnitite. Orthopyroxene could be seen in thin section, but it was undetectable in hand sample.

The next unit is the Esther Applegate Pyroxene Andesite, which is found in the northeast corner of the map (fig. 1). This unit has been heavily weathered and crops out poorly. Hand sample and thin section analysis reveals this unit is 80% plagioclase (An_{60}). Both orthopyroxene and clinopyroxene each make up 5% of the rock, while the remaining 10% is ilmeno-magnetite. An age of 1.79 ±.04 Ma. was measured by K/Ar (Mertzman, personal communication).

Burton Butte Basalt is the youngest and most extensive unit in the mapping area. The lava is derived from the Burton Butte micro shield vent, which stands as the highest point in the seven square mile mapping area. Dated at .82 ±.08 Ma., it is one of the youngest volcanic units that was mapped by this Keck Project (Mertzman, personal communication). Close to the summit, aa flows are very well preserved . Downslope, the flows are much more lobate and weathered. Spheroidal weathering is common along the lower slopes of Burton Butte. Thin section analysis shows an intergranular texture comprised of 66% plagioclase (An_{60}), 31% iddingsitized olivine, and 2% ilmeno-magnetite. Trace amounts of pyroxene were also detected. The Burton Butte unit shows a distinct diktytaxitic texture, along with glomeroporphyritic clumping of the olivine, plagioclase, and in some cases, clinopyroxene.

Geochemistry

Chemical analyses of 28 representative samples were determined using XRF trace and major, ICP, LOI and Iron Titration at Franklin and Marshall College. An AFM diagram of the units shows most of them are calc-alkaline with the exception of the Burton Butte basalt (Fig. 2), which clearly plotted as tholeiitic. Most of the andesites in the study area show medium K contents. Spider diagrams show that large ion lithophiles (LIL) are enriched, while the high field strength elements (Zr, Ti, Yb) are equal to, or somewhat depleated compared to NMORB. Zr turns out to be a key trace element in determining the tectonic association of the basalts. The Burton Butte unit has considerably less Zr than its neighboring basalts as shown on the Zr vs. TiO2 diagram (Fig. 3).

Discussion

The calc-alkaline nature of most of the units, except Burton Butte, agrees with the subduction zone model applied to the Cascades. Units, such as Old Baldy basaltic andesite and North Ridge Olivine Phyric Basalt show

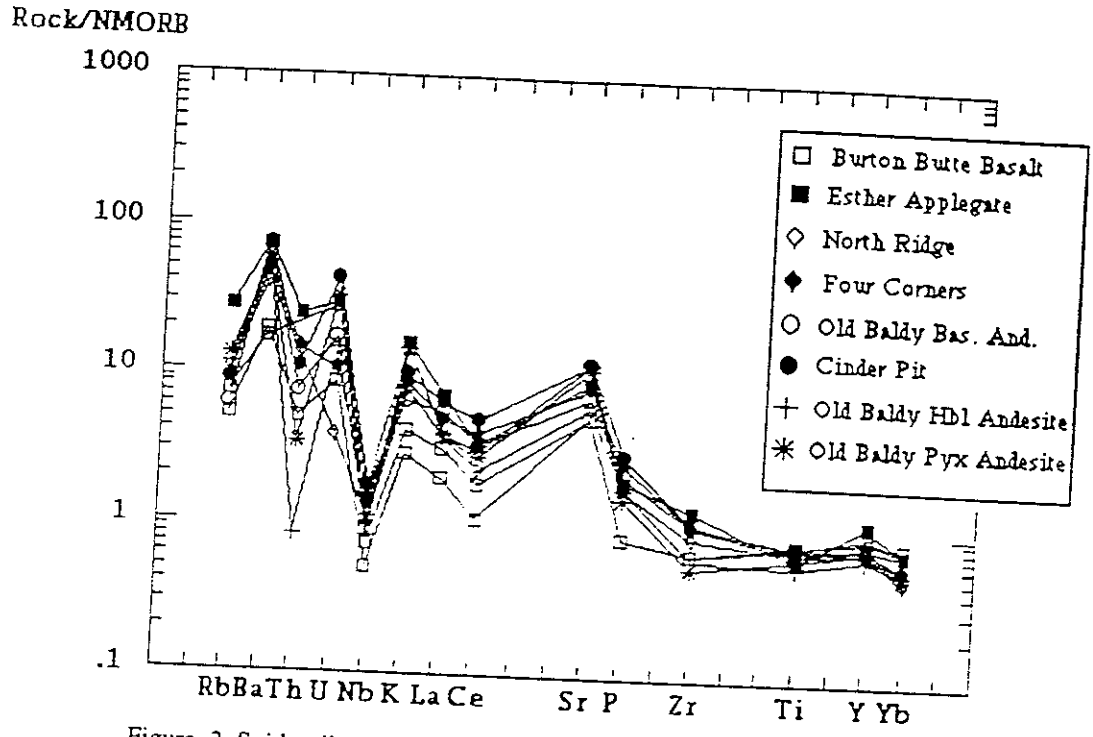

Figure. 2: Spider diagram of all units vs. NMORB (Sun and MacDonald, 1989).

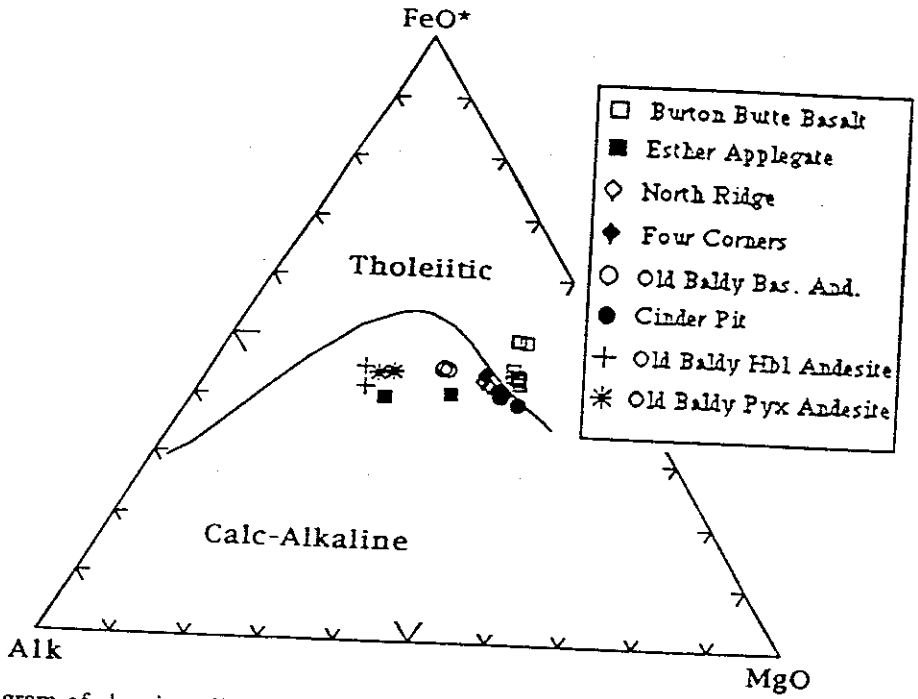

Figure 3: AFM diagram of showing all of the units falling in the Calc-Alkaline field with the exception of the Burton Butte HAOT (Irvine and Baragar, 1971)

some signs, petrologically and chemically, of tholeiitic trends. The North Ridge unit falls in between the Basin and Range and the Cascades fields on the Zr versus TiO2 diagram (Fig. 4). This may suggest mixing between the local Basin and Range magmas with High Cascades magma. The North Ridge Basalt is of similar age and lies very near to the Old Baldy Basaltic Andesite vent. This correlation could help explain why both of these units have been contaminated. As mentioned earlier, the Burton Butte unit is considerably depleted in Zr compared to the other basaltic units in the study area, and presumably underwent minimal, if any, crustal contamination. Though this is common in low-K high alumina olivine tholeiites, its presence in the High Cascades is peculiar. In the NMORB spider diagram, the enrichment of LIL's indicates crustal contamination. However, when taking the ratio of Zr/Nb, as suggested by McGretchin (1981), the basalts can be classified as type I (NMORB), or type II (EMORB). The Zr/Nb ratios of the basalts are approximately 30/1. This is suggestive of NMORB type source region, and confirms the lack of enrichment in some of the units. It also explains why Nb is anomalously low for the LIL's (McGretchin et al., 1981).

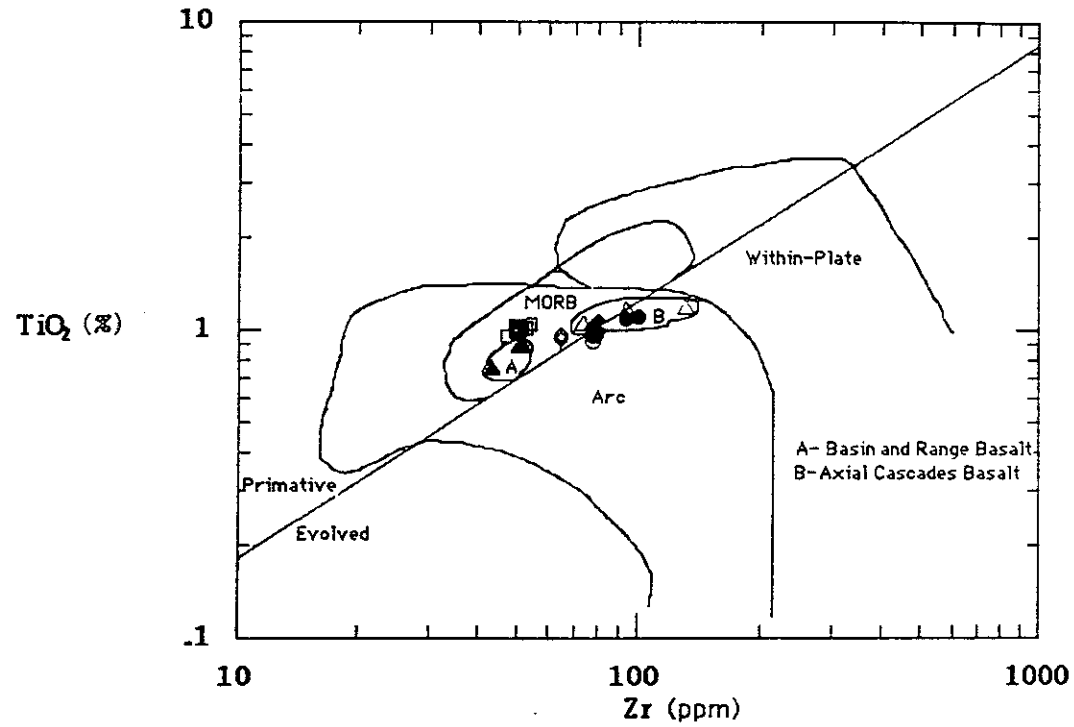

Figure 4: Zr (ppm) vs. %TiO2, showing Burton Butte corresponding to Basin and Range basalts, while all of the other basalts fall in the field of Axial Cascades basalts (Pharoah and Pearce, 1984).

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