A Petrographic and Geochemical Study of a section of the High Cascades in southern Oregon, near Fish Lake

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Tectonic models of subduction-related magmatism are typically evoked to account for the persistent volcanism in the Cascade Range of the Pacific Northwest. While studies have generally confirmed this model, the proximity of the extensional regime of the Basin and Range province makes the Cascades a tectonically interesting area. The purpose of this study is to utilize petrographic and geochemical analyses to constrain a petrogenetic model for volcanism in the area. It is also hoped that this project will provide a foundation for subsequent studies in the area.

The Keck project in the Cascades, taken as a whole, mapped and sampled nearly 70 square miles south of Mt. McLoughlin, a major composite volcano of the Cascade Range. The area of study considered in this paper includes seven square miles south of Mt. McLoughlin which partially surround Fish Lake; this area will hereafter be referred to as the Fish Lake area. In the field, units were distinguished and informally named according to dominant phenocryst assemblages and general outcrop patterns.

The youngest unit is a blocky flow that extends into the Fish Lake area from Mt. McLoughlin. The unit is a dark gray, highly vesicular, olivine-phyric basaltic-andesite, dated at less than 100 Ka (Mertzman, personal communication). Blocky flows from Brown Mountain, a smaller volcano to the southeast of Mt. McLoughlin, also date at less than 100 Ka (Mertzman, personal communication), but the relative ages between these two units is ambiguous. Several Brown Mountain flows are apparent , although significant differences between the possible subunits have not ben verified by subsequent petrographic and chemical studies. The Brown Mountain unit is characterized by light gray, virtually aphyric, orthopyroxene andesites. Practically surrounded by Brown Mountain flows is a topographically elevated section, hereafter referred to as "Kipuka Hill". Samples date at 3.56±.06 Ma (Mertzman, personal communication), suggesting that this island-like feature was formed when younger Brown Mountain flows filled in the pre-existing valleys around the ridge. Outcrop in this area usually occurs as rubble, and samples are somewhat heterogeneous. Generally, the Kipuka Hill unit is characterized by two-pyroxene basaltic-andesites and andesites. There are two plagioclase-phyric units, distinguishable only after petrographic and/or chemical examination. The two units differ slightly in olivine content, and although both units are olivine-bearing, two-pyroxene, plagioclase-phyric andesites, one unit contains considerably less SiO_2. The more basaltic of the units has been dated at 3.97±.08 Ma (Mertzman, personal communication). No source has yet been identified for either the Kipuka Hill unit or the plagioclase-phyric units. The oldest unit of the Fish Lake area can be traced to a shield volcano north of Fish Lake called Rye Spring.

Samples from the Rye Spring unit, dated at 6.06±.10 Ma (Mertzman, personal communication), are relatively homogeneous, dark gray two-pyroxene olivine basalts. Much of the outcrop in this area occurs as rubble, although occassional flow fronts do occur.

Petrographic analysis of 29 representative samples reveals common phenocryst assemblages dominated by plagioclase. Olivine, orthopyroxene, and clinopyroxene are also phenocryst phases in most samples ± magnetite and apatite. Common petrographic characteristics include a diktytaxitic texture in vesicular samples, porphyritic and glomeroporphyritic textures, resorbed olivine crystals rimmed by orthopyroxene, and two distinct populations of plagioclase -- one tabular and euhedral and the other equant and oscillatory-zoned. The latter observations suggest disequilibrium conditions in the magma chamber. These conditions may have been a result of thermal and bulk chemical disturbances caused by the injection of new magma batches into the pre-existing magma body. The chemical compostions of plagioclase and olivine phenocrysts, as well as phenocrysts within glomeroporphyritic clumps, will be analyzed by energy dispersive spectroscopic techniques in order to determine the validity of this hypothesis. Coexisting oxides will also be analyzed in order to determine the partial pressure of oxygen within the system.

Chemical analyses of 19 representative samples place Fish Lake volcanics in the subalkaline, calc-alkaline magma series (see Figures 1 and 2), supporting the assumption that these volcanics are subduction-related. SiO_2 ranges from 52 to 62%; TiO_2 from 0.5 to 1%; Al_2O_3 from 17 to 19%; FeO* from 5 to 8%; MgO from 3 to 6%; CaO from 5 to 8%; alkalis from 4 to 6%; P_2O_5 from 0.2 to 0.6%. Samples plot as normal basalts and andesites according to LeBas and others (1986) and as medium-K basalts and andesites according to Gill (1981). Rye Spring samples, along with one sample from Kipuka Hill, plot anomalously as "tholeiitic" in Figure 3. Further research is necessary to explain this trend. Analysis from rare earth element concentrations in six samples show LREE enrichment and no europium anomaly (see Figure 4), as is typical for calc-alkaline volcanics.

Trace element analysis reveals one strikingly anomalous sample. The same Kipuka Hill sample which plots as tholeiitic in Figure 3 has an abundance of over 1400 ppm strontium whereas the other samples range between 500 and 800 ppm strontium. This sample also has a La/Yb ratio of approximately 25 whereas the La/Yb ratio of other samples range between 5 and 15. These anomalous abundances suggest the possibility that at least two concurrent magmatic sources were involved in the petrogenesis of these volcanics. Magma mixing, then, would be a distinct possibility.

Petrographic evidence and major and trace element analyses seem to corroborate a petrogenetic model including significant amounts of mama mixing. Further work is necessary in order to verify this hypothesis, and to eventually develop a cohesive tectonic model which accounts for these processes.

References

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LeBas, M.J., LeMaitre, R.W., Streckeisen, A., and Zanettin, B., 1986. A chemical classification of volcanic rocks based on the total alkali-silica diagram. Journal of Petrology, v.27, part 3, p. 745-750.

Figure 1.

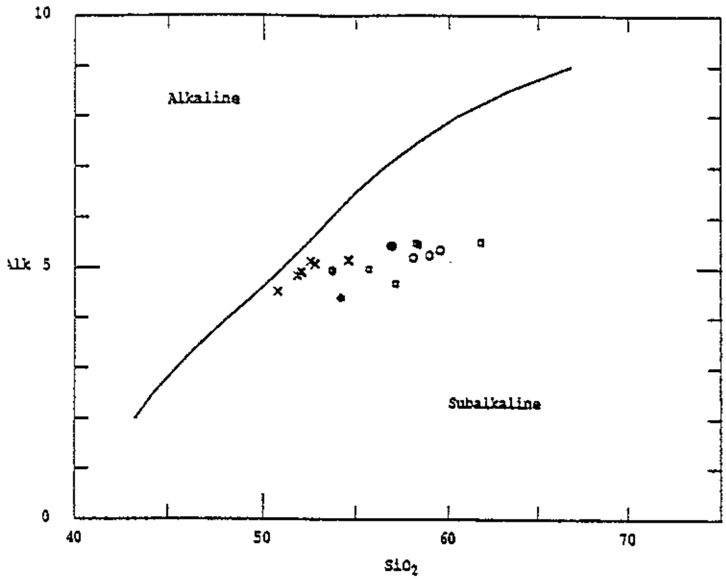


Figure 2.

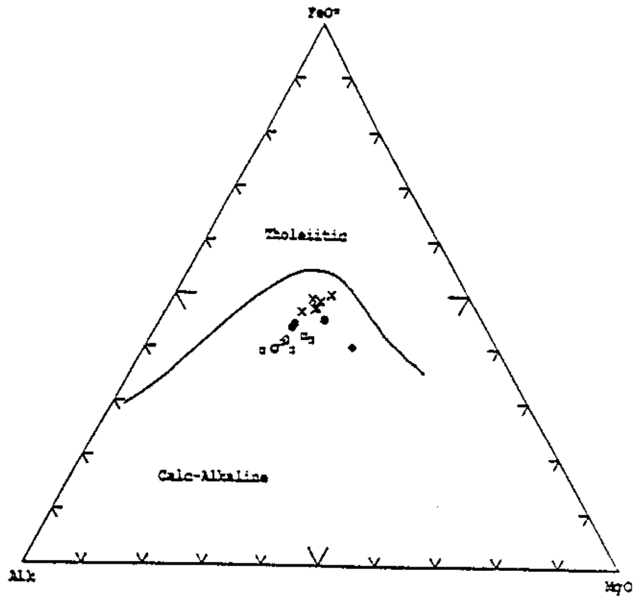


Figure 3.

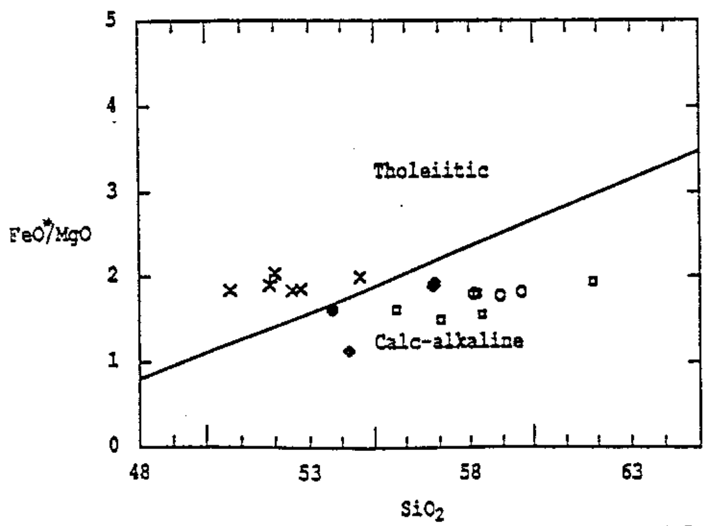
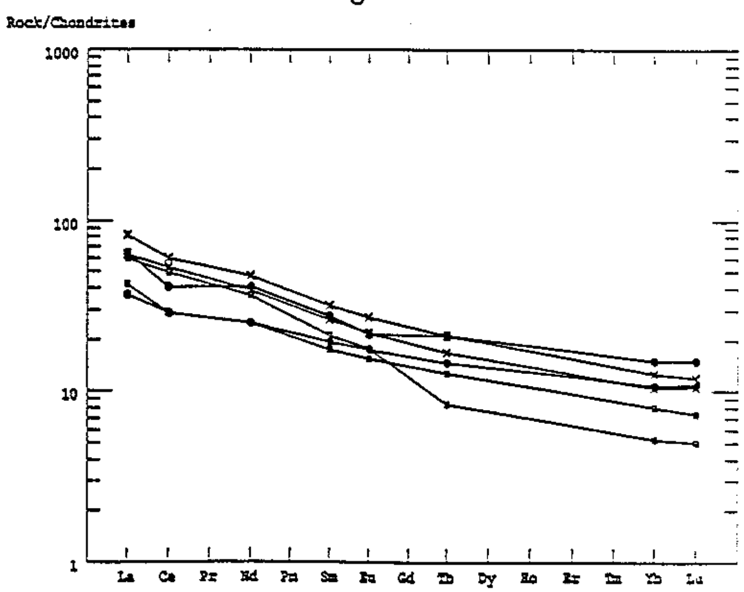


Figure 4.



A Petrological and Geochemical Study of the Rye Spur Area, Cascade Range, Southern Oregon

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The Cascade Mountain Range defines a linear trend of composite volcanoes that have been active from Miocene to the present. Calk-alkaline volcanics dominate this range at present, but changes in the subducting slab beneath the Cascades have also produced large outpourings of basalt interspersed with the volcanics. The Rye Spur area lies immediately to the southeast of Mt. McLoughlin, a volcano within the High Cascades province in southern Oregon. Less than twenty miles to the east of the area lies the Klamath Basin, a large water-filled graben that is thought to mark the beginning of the Basin and Range Province. This combination of compressional and extensional regimes may have yielded the variety of basalts and basaltic andesites (as defined by Le Bas et al., 1986) within the Rye Spur area

Rye Spur occupies the center of the six square mile field area and its andesitic lavas make up the most voluminous geological unit. Six other units are also present within the area: the southwest corner of the area is covered by Billie Creek andesite, the southeast corner by Pearce Point basalt, and the western edge by North Billie Creek andesite. The northern third of the field area contains the other three units, each of which have very limited extent (on the scale of hundreds of meters): the Rye Spur Quarry andesite, the high-alumina olivine tholeiites (HAOT), and a unit most easily identified by its sample number as Basalt 63. These latter units are surrounded partially or completely from colluvium predominately derived from Mt. McLoughlin. In the northeastern corner of the field area, this colluvium consists of fields of boulders of various lithologies that look very much like lava flows; at higher elevations the colluvium produced a hummocky terrain of laharic deposits that may have been modified by periglacial processes.

All of the units in the field area contain an anhydrous mineral assemblage dominated by plagioclase and include lesser amounts of olivine, clinopyroxene, orthopyroxene, magnetite/ilmenite, spinel and apatite. Rye Spur basaltic andesites have silica contents that range from 53 to 56 weight percent; the samples from the dome atop Rye Spur generally have a lower silica content and a higher percentage of mafic minerals than do the samples from lava flows. Textures are porphyritic to glomeroporphyritic; olivine is present only as a phenocryst phase whereas clinopyroxene and orthopyroxene are present as phenocrysts and are present in the groundmass. All phenocrysts range from 1 to 3 mm in length. Rye Spur lavas characteristically contain glomeroporphyritic clumps of plagioclase + pyroxene +/- olivine that are no more than 3 mm in diameter. The North Billie Creek andesites have similar mineralogy and texture to the Rye Spur samples and are distinguished primarily by the presence of glomeroporphyritic clumps of