Southern Oregon Cascade volcanism along the Klamath River Canyon

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Introduction and location of study area

The formation of the Cascade Range in Oregon, Washington and California has been attributed primarily to the subduction of the Juan de Fuca plate under the North American, with some influence from the Basin and Range province (Guffanti and Weaver 1988). The Cascades can be divided into the Western Cascades, the earlier episode of volcanism, and the High Cascades, the more recent episode (Taylor 1990). This abstract focuses on an eight square mile area in the southern Oregon High Cascades, which includes sections from the Hamaker, Chicken Hills, and Mule Hill quadrangles. This area is dominated by a mile of canyon wall along the Klamath River and two peaks of the Chicken Hills in the eastern portion of the area. Lower elevations of Hamaker Mountain occur at the far eastern edge of this area.

Overview of units and common themes

This area has been mapped into eight units, seven of volcanic origin and the other Quaternary alluvium. These volcanic rock units ranged from basalt to basaltic andesite according to a Le Maitre Diagram, (Na_2O+K_2O vs. SiO_2) (LeBas 1986). The basalts are sub-alkaline, tholeiitic basalts for the most part with a few samples straddling the border between calc-alkaline and tholeiitic. There are several characteristics that are pervasive throughout the volcanic rocks of this area regardless of unit boundaries. First, there are four primary minerals present: olivine, plagioclase, clinopyroxene and opaques. Olivine and plagioclase occur as the only phenocrysts; clinopyroxene is present almost exclusively as a groundmass constituent. Throughout these units, with the exclusion of one, there are two opaque phases; one is a chromite phase occurring poikilitically in the olivine phenocrysts. The other opaque phase is titanomagnetite, which comprises 5-15% of the modal mineralogy as either a microphenocryst phase or a member of the groundmass.

Hand Sample and Petrographic Analysis of Specific Units

Four units volumetrically dominate this area. They are:

Klamath Canyon Olivine-Phyric Basalt-Tvbo. (6.0±0.2 Ma) (All K/Ar dates from Mertzman 1996) This unit covers the largest amount of the study area; it is present on the eastern canyon wall, the western canyon wall and blankets the area west of the canyon (Figure 1). Rocks collected in this area were grouped together as one unit in the field because of the absence of plagioclase phenocrysts and the consistent presence of 3-6% olivine phenocrysts up to 8 mm in size. The only major variation was the color of the groundmass which varies from dark and cryptocrystalline to light gray and almost granular. Petrographically, however, this unit is anything but consistent; the modal amount of phenocrysts and textures span a large range. In general these rocks have olivine phenocrysts with plagioclase and clinopyroxene crystals relegated to the groundmass or as microphenocrysts. The modal mineralogy ranges from 5-20% for olivine, 20-70% for plagioclase and 1-20% for clinopyroxene. The textures include the entire range from intersertal to ophitic and include both felty and trachytic alignments of the plagioclase laths. One vent, a cinder cone, is exposed in the eastern canyon wall, 500 feet down from the canyon rim. This vent was identified by abundant, poorly sorted, inclined layers of pyroclastics, which measure 30 to 50 meters thick.

Keno Diktytaxitic Basalt-Tvbk. (2.0±0.3 Ma) This aphyric, light gray unit lies three-quarters of the way up the east and west canyon walls. Although this rock does not contribute a large volume of lava to the study area, it is still interesting because it 1) provides cross canyon correlation which suggests that the canyon was not present at the time of depostion and 2) deviates from the general area signature seen in the other units. This unit has no phenocrysts; it is comprised of 50% plagioclase, 15-25% olivine and 10-20% clinopyroxene. There are few chrome spinel crystals present in the olivine and the opaques constitute a relatively small amount of the samples, only 2-4%. It has a subophitic, diktytaxitic texture.

Chicken Hills' Rim Basalt-Tvbr. (1.1±0.2 Ma) This unit is a light gray basalt, located on the east side of the study area extending from the canyon rim to the lower elevations of Hamaker Mountain on the eastern most border. It has between 12 and 15% phenocrysts of olivine and plagioclase that sometimes occur in glomerporphyritic clumps. These phenocrysts are set in a groundmass of plagioclase, olivine and clinopyroxene which illustrate intergranular, intersertal, and subophitic textures. The intersertal and intergranular textures occur on and near the vents of the Chicken Hills, while the subophitic texture occurs in rocks farther away from the vents. Also present are the typical 5-10% microphenocrysts of titanomagnetite and 1% of chrome spinel in the olivine. The source or vents of this unit and the following unit are considered to be the three Chicken Hill peaks, which are aligned on a North West-South East trend. These peaks are scoria cones on the order of 3/4 of a mile across and 500 ft of relief.

Chicken Hills' Plagioclase Porphyry Basalt-Tvbsp. (1.1±0.3 Ma) This unit was affectionately called "super plag" by the study group this summer as it is dominated by plagioclase phenocrysts. The phenocryst population consists of 5% olivine crystals and 50-60% plagioclase crystals. These crystals are typically 3-4 millimeters in size. There is some clinopyroxene (10-15%) present, but it is relegated to the groundmass, forming a subophitic to ophitic texture. This unit is located on the peak of the central Chicken Hill and the western, northern and southern slopes of this peak. It is conspicuously absent from the eastern slope.

Geochemistry

Thirty-one samples were analyzed using the X-ray fluorescence spectrometer at Franklin and Marshall College to determine both the major and trace element compositions. Six samples were irradiated for INAA analysis and two were radiometrically dated.

Discussion of Geochemistry and Origins

Klamath Canyon Olivine Phyric Basalt. The samples from this unit plot as a lozenge shape on variation diagrams. Individual samples consistently plot in similar segments of the trend i.e. at one of the ends or in the middle. Any subdivisions of this unit based on petrography were not supported by geochemical data; those units that looked petrographically similar did not plot together consistently on variation diagrams. At first a fractional crystallization model was used to tie the samples together, inferring that the lozenge shaped plot represents the liquid line of descent. The mineral assemblage in this unit limits a fractionation model to one or any combination of four minerals: olivine, plagioclase, titanomagnetite, and clinopyroxene.

On a CaO vs. MgO plot, the Ca increases as the Mg decreases (Figure 2). This suggests two possible fractionation histories: 1) olivine fractionating with a Ca bearing phase or 2) the fractionation of a phase that takes in both Ca and Mg. The two calcium bearing minerals present with which olivine could fractionate are plagioclase and clinopyroxene. An Sr vs. MgO plot shows that as Mg decreases, Sr increases (Figure 3). This relationship suggests olivine did not fractionate with plagioclase; if it had, the Sr, a compatible element in plagioclase, would decrease as Mg decreases. (Wilson 1989) The petrography does not support an olivine-clinopyroxene fractionation. Clinopyroxene is a near solidus phase typically confined to the groundmass. When it does form microphenocrysts they are wrapped around plagioclase laths in a subophitic to ophitic texture. Given this petrography it is hard to imagine the clinopyroxene being able to fractionate without taking large amounts of plagioclase with it. A CaO vs. Al_2O_3 diagram indicates that plagioclase was not fractionating; thus, cpx cannot be fractionating either with olivine or alone. The titanomagnetite also did not fractionate. This is shown in a SiO_2 vs. Fe_2O_3T plot.

Since fractionation plays a minor role in the evolution of this unit, two other hypotheses were considered: 1) that this unit is actually several separate units, and 2) the members of this unit are related by partial melting. Although this unit has varying petrographic characteristics, spider diagrams of representative members from this unit show the same rare earth element signature (Figure 4). This signature is especially coincident in the heavy rare earth elements. Thus, the rocks in this unit are related by an imprint of a similar source; the small amounts of scatter among the light rare earth elements could have been caused by small amounts of crustal contamination or fractionation. The theory that provides the most satisfactory explanation of the olivine-phyric unit is a partial melting model, in which all members of this unit were formed by partial melting of similar source rock; thus, each batch of magma was provided with nearly the same rare earth signature. The variation in petrography is not caused by changes in source rock characteristics, but rather by individual cooling histories.

Chicken Hills Rim Basalt and Plagioclase Porphyry Basalt. These units seem to be related by olivine fractionation. This is supported by diagrams such as a Ca vs. Mg plot, which shows a trend from Rim Basalt to Plagioclase Porphyry Basalt, along which Mg decreases as Ca increases (Figure 2). This is also supported by the steepness of the trend connecting these units on an Ni vs. Mg plot (Figure 5). Because the distribution coefficient of Ni in olivine is 10-15, an olivine fractionation trend would produce a steeply inclined line on this diagram. Plagioclase enrichment of the Plagioclase Porphyry Basalt is also supported by the Sr spike of this unit in comparison to the Rim Basalt on a spider plot (Figure 6). The Keno diktytaxitic basalt, in many cases, appears to plot as part of this olivine fractionation trend. However, certain diagrams, such as the Ca vs. Mg plot, and the very different REE signatures show this unit is not related to the Chicken Hills.

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

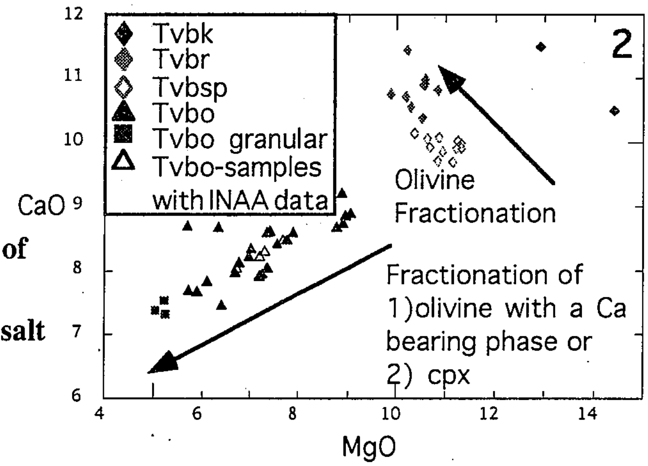
Figure 2. CaO vs. MgO

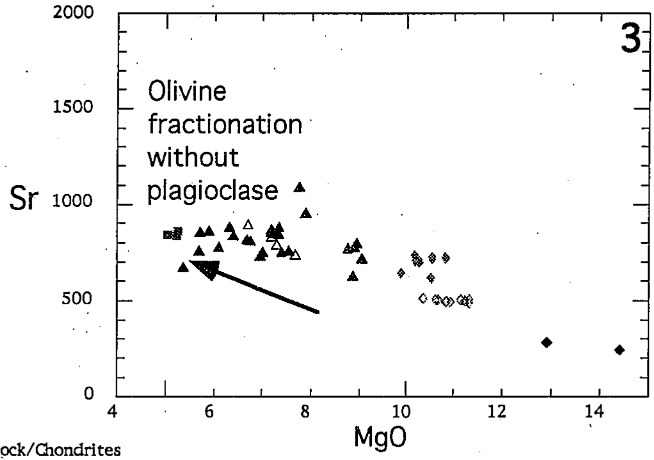
Figure 3. MgO vs. Sr

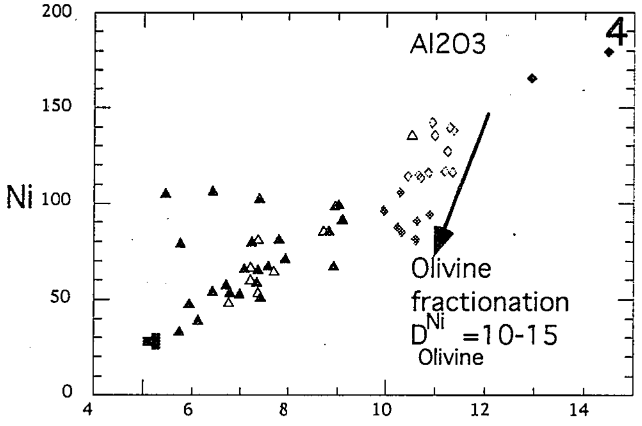
Figure 4. Ni vs. MgO

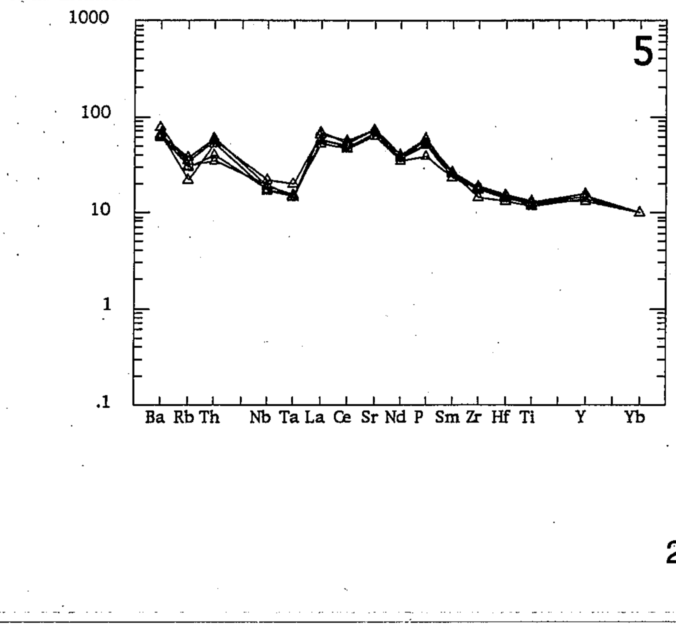
Figure 5. REE plot of representative sample of Klamath canyon Olivine-Phyric Basalt

Figure 6. REE plot of Chicken Hills' Rim Basalt andPlagioclase Porphyry









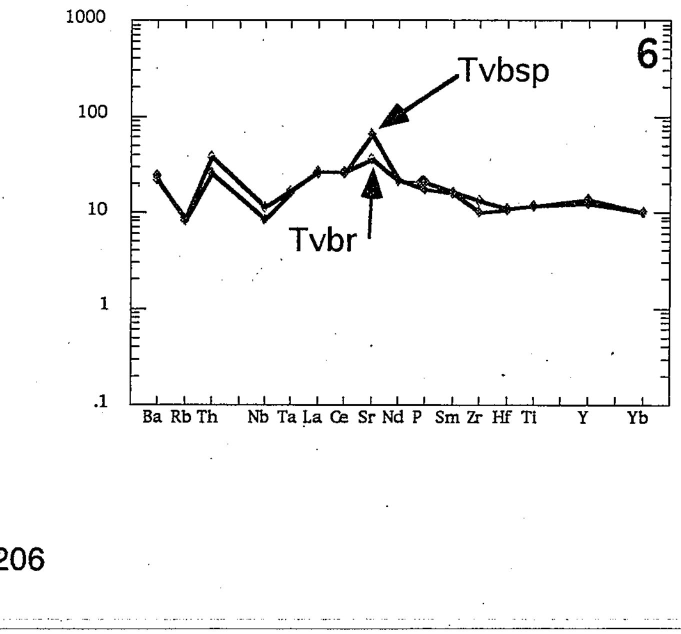
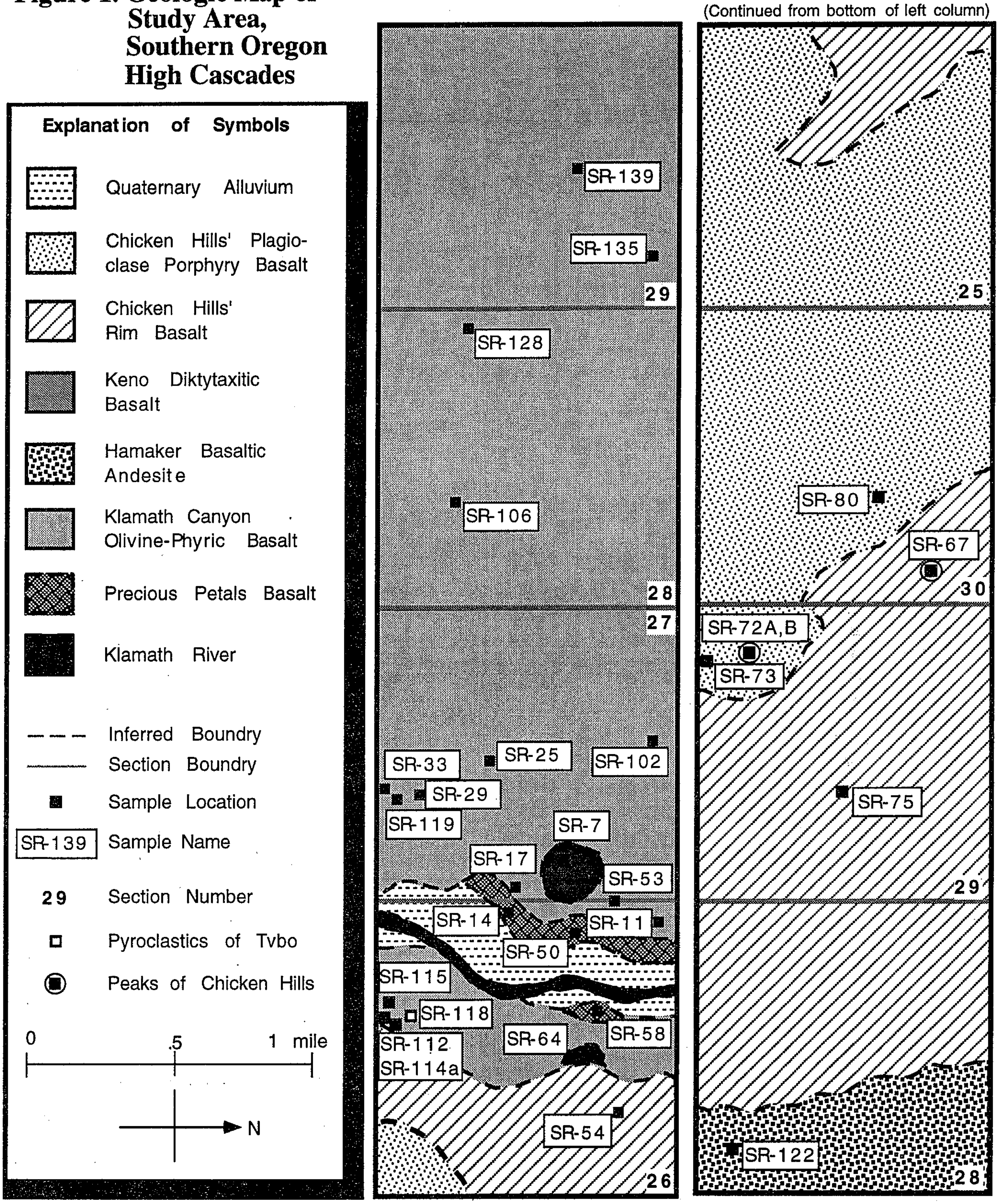


Figure 1. Geologic Map of Study Area, Southern Oregon High Cascades



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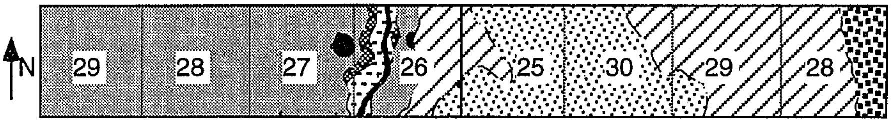

Due to page restrictions, the study area map could not be shown as one unit. This reduced version is to aid in understanding how the two sections above fit together as one map.