PLIO-PLEISTOCENE CASCADE VOLCANISM IN SOUTHERN OREGON

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Late Tertiary Volcanism in the Mt. McLoughlin-Upper Klamath Lake Region of the Southern Oregonian Cascades

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INTRODUCTION

The second Keck Geology Consortium research project in the southern Oregonian Cascades focused on the region southeast of Mt. McLoughlin volcano during July and August of 1992, extending to the western shore of Upper Klamath Lake. The research group consisted of eleven rising senior geology majors representing eight of the Keck consortium colleges and three faculty supervisors. During the time of the project, the group received four faculty visitors including Shelby Boardman (Carleton), Lori Bettison-Varga (The College of Wooster), John Brady (Smith College) and Samuel Kozak (Washington & Lee University). Each of these visitors was of much assistance in helping the students formulate their research plans and to get them off on the right heading.

GEOLOGIC SETTING

The Cascade volcanic province is often divided into two parts on the basis of age and style of volcanism. Calc-alkaline volcanic rocks of the Western Cascades erupted from Late Eocene to Miocene time in a broad band across much of western Oregon and Washington. The arc narrowed markedly during Pliocene and Pleistocene time to form the majestic High Cascade volcanoes of today. The Cascade arc of today is approximately on average 80 km wide and stretches from Lassen Peak in northern California to Mt. Garibaldi in British Columbia (Figure 1).

The Cascade subduction zone is somewhat peculiar compared to other convergent plate margins. No deep focus earthquakes (>100 km) have been detected with the present Juan de Fuca plate subduction even though seismic tomography has detected and imaged a subducting slab at depths greater than 100 km (Rasmussen and Humphreys, 1988).

With the Juan De Fuca divergent boundary being quite close to the subduction zone, the plate being subducted is relatively warm and thin. This situation may be a root cause for the lack of intermediate and deep seismicity. It may also effect the angle at which the Juan de Fuca plate is being subducted as well as the rate at which it is occurring. Presently subduction is on the order of 4 cm/year at an angle of approximately N50^{o} E to the Pacific Northwest continental margin. This oblique subduction results in a regional stress field in which the greatest principal stress (horizontal compression) is oriented nearly north-south while the least principal stress (horizontal extension) is aligned nearby east-west (Smith, 1982). The Upper Klamath graben, the eastern boundary of the 1992 field area, may be a direct result of this stress field orientation.

OVERVIEW OF RESULTS

Eleven students mapped and sampled nearly 80 mi^2 in the Oregonian Cascades. The area of interest during the summer of 1992 is due east of that focused on during the summer of 1991. The volcanic rocks mapped during the 1992 field season have all turned out to be < 4 million years old as determined through K-Ar whole rock radiometric dating. The most siliceous lavas yet mapped in the region were found by Rob Bruant in the Muddy Springs portion of his area. These two-pyroxene dacite lavas have SiO2 contents between 65 and 67 percent and are 2.47 ± 0.04 million years old. Of the twenty-five K-Ar ages available for 1992 samples, this dacite age is the oldest. It is interesting to note that the 1991 field party mapped a sizable number of volcanic units which were extruded between 3 and 6 million years ago. Clearly there is a substantial variation in age of extrusion as you cross the volcanic arc from west to east. This trend is clearly delineated in Figure 2 and is likely related to changes in the angle of subduction as a function of geologic time.

Data from age-dated samples only, representing many of the stratigraphic units, depict a relatively weak trend of increasing SiO2 west to east across the arc (see Figure 3). Examining various incompatible element concentrations as a function of geographic position across the arc suggests little in the way of systematic variation.

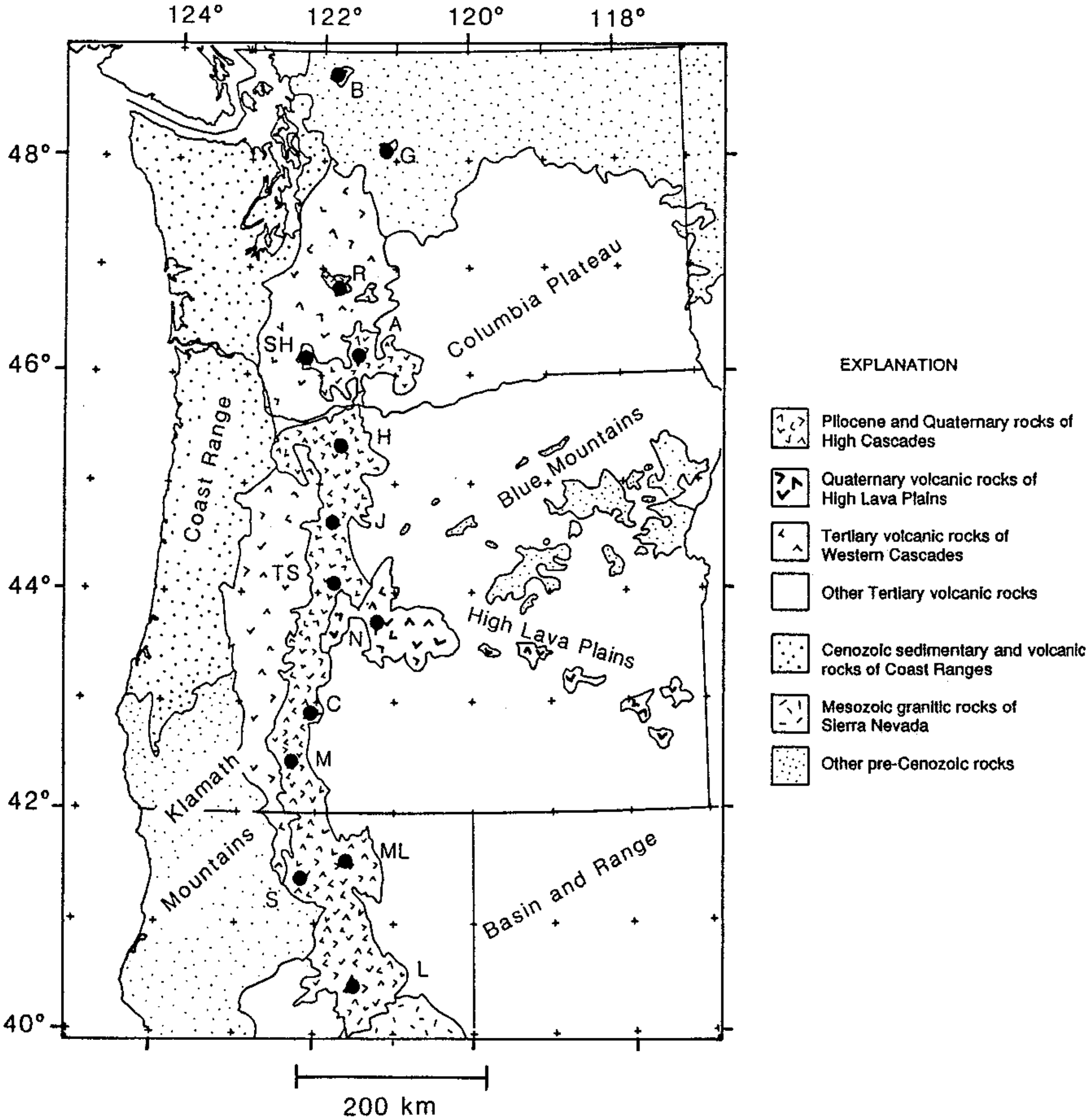

Figure 1. Generalized geologic map of the Cascade volcanic province and surrounding areas of the Pacific Northwest within the United States. Modified from Blakely and Jachens (1990). Letters refer to major volcanoes; in particular, C - Crater Lake, M - Mt. McLoughlin, S - Mt. Shasta, ML - Medicine Lake.

Given slightly in excess of four dozen samples for which K/Ar ages have been determined, some clarifying statements are in order with regard to those made in last year's Symposium volume concerning compositional variation as a function of geologic time. Those statements were made based on two dozen samples from only the western half of the volcanic arc. With decreasing age several features are noticeable:

1) Ba, Be, and K2O decrease as a function of decreasing age (See Figure 4 as an example),

2) basalts whose SiO2 contents are $\leq$ 50% make their first appearance approximately 3 Ma years ago, and

3) Fe2O3 (Total), MgO, CaO, TiO2, A12O3, Na2O, P2O5, Rb, Sr, Y, Zr, La, Ce, Co, Sc, La/Yb, and Na2O/K2O show no particular trend as a function of age.

If these trends persist as more absolute ages become available, then it is likely they reflect long term changes in the mineralogy of the source region or perhaps an increasing degree of partial melting. The common thread which links the items listed in (1) is their incompatible behavior in mafic igneous systems. There is much work to be done in southern Oregon wherein petrology, geochemistry, and plate tectonic movement are integrated to provide a comprehensive picture of the generation of the volcanic rocks.

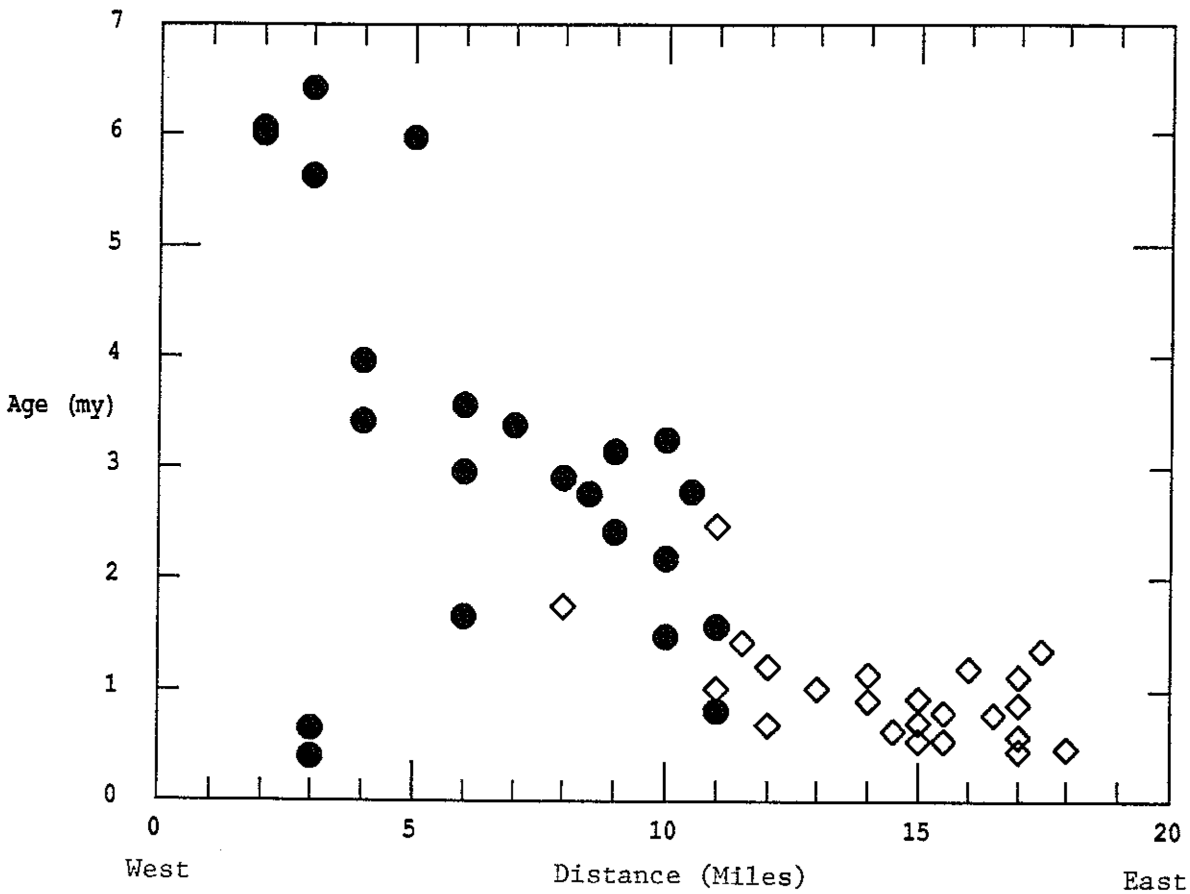

Figure 2. K-Ar age versus West to East distance across the arc. The arbitrarily selected zero point is the section boundary at the head of Grizzly Creek, two miles west of Robinson Butte. Solid symbols, 1991 field season; open symbols, 1992 field season.

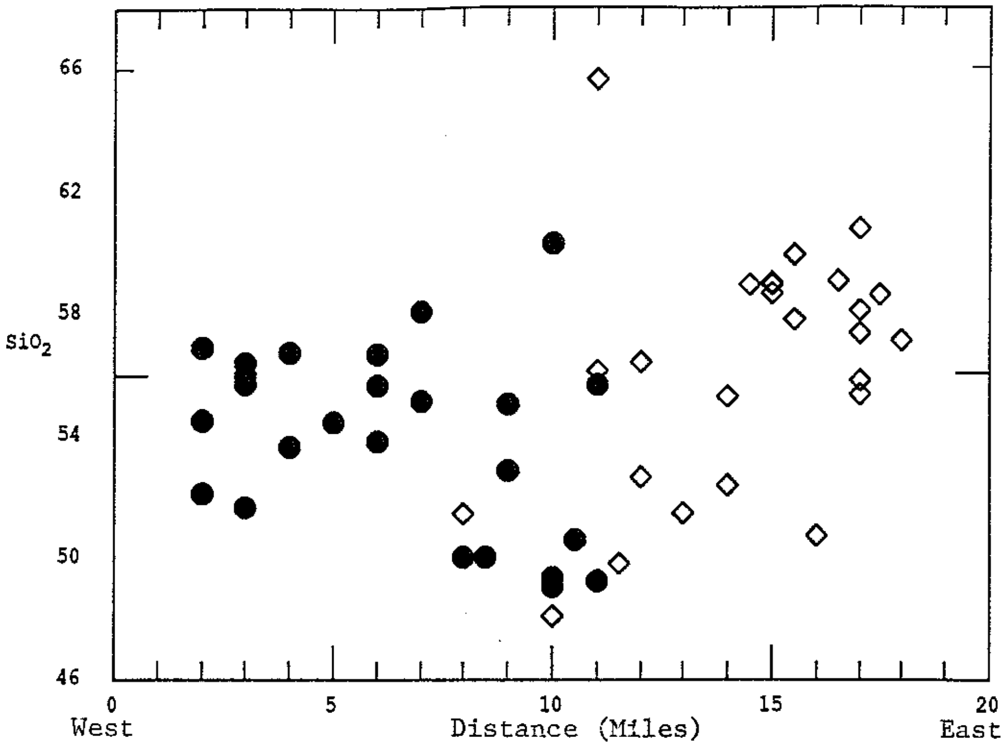

Figure 3. SiO2 versus West to East distance across the volcanic arc for K-Ar samples only. See text for explanation.

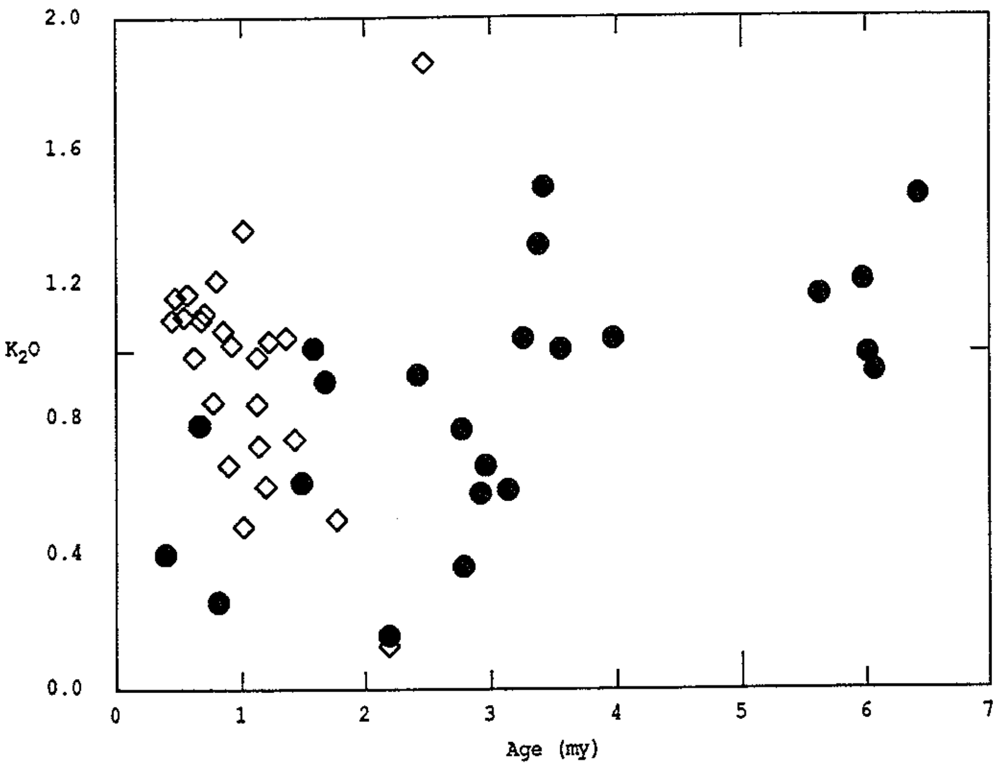

Figure 4. K2O versus K-Ar age. See text for explanation.

Lastly, of particular interest are two quite different olivine tholeiite basalts. One, a low K high alumina variety (K2O<0.3, Al2O3 >17%) erupted from a vent south of Fourmile Lake 2.19 m.y. ago and Burton Butte 0.82 m.y. ago. The second type is lower in alumina (15-17%) and richer in K2O, MgO, Ba, Sr, Ni, Cr, and Zr. Nearly a half-dozen vents for this olivine-phyric basalt have been located. These vents erupted between 2.8 to 2.9 m.y. ago and 1.0 m.y. ago. Both of these basalt compositions reflect generation in the upper mantle with little subsequent crystal fractionation. Their origins are likely related to Basin and Range extensional tectonism.

Acknowledgment

I would like to thank the twenty-one students who worked on this project over the past two years. Some of you are among the very best students I have had the pleasure of working with during my twenty-one years of teaching and doing research.

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