GEOLOGY, PETROLOGY, AND GEOCHEMISTRY OF A SECTION OF THE HIGH CASCADES ON THE SOUTHERN BOUNDARY OF THE WINEMA NATIONAL FOREST, OREGON

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Introduction

The 1994 Keck Geologic Consortium project in the Southern Oregon Cascades was conducted in an area south of the Mt. McLoughlin composite volcano. This study involves a 7 square mile area located 12.5 miles south-southwest of the volcano on the southern boundary of the Winema National Forest. Field mapping was followed by petrographic and geochemical analysis of 9 distinct volcanic units ranging from basalt to andesite. Age dating using K/Ar techniques was also employed for some units in the area. The purpose of this study is to investigate the reasons for the lithological, textural and geochemical variations seen in the units while putting the area within the framework of subduction and extenstion related volcanism.

Geologic Setting

Subduction of the Farallon/Juan de Fuca Plates beneath the North American Plate is thought to have been occurring since the early Cenozoic and has resulted in the creation of the north-south trending Cascade Range (Atwater, 1970). These mountains, consisting primarily of basaltic andesite to andesite composite volcanoes surrounded by basaltic shield volcanoes, have been divided into two sub-provinces based on type of volcanic activity. The Western Cascades, an earlier and more extensive episode of magmatism (Late Eocene to Miocene) produced diverse extrusives over a large area and is capped by the volcanoes of the High Cascades (Miocene to Holocene), a later occurrence characterized by isolated monogenetic andesite stratovolcanoes and some mafic extrusives in a relatively narrow arc (Taylor, 1990). This study will focus on the later event and possible influence of extensional, back-arc type volcanism common on the northwestern Great Basin of Eastern Oregon (Hart et al., 1984).

Unit Descriptions

The field area shown in figure 1 is characterized by lavas from local vents, two vents lie within the mapping area while four lava sources lie in a 3 mile radius of the mapped sections. Twenty samples were analyzed for major and trace elements using X-ray fluorescence and inductively coupled plasma techniques at Franklin and Marshall College. Chemical composition of the respective units indicates that there is a calc-alkaline series of basalts through basaltic andesites to andesites in addition to several high alumina olivine tholeiite basalts (Burton Butte and the Burton Butte Kipuka). Beyond these geochemical similarities, hand and petrographic descriptions indicate that plagioclase is ubiquitous in the groundmass and a common phenocryst phase. The basalts generally have olivine phenocrysts, the basaltic andesites pyroxenes, and the andesites pyroxenes and/or hornblende. The following description of the nine mappable units in the area will be from oldest to youngest with some grouping of lithologically and age equivilant rocks.

The oldest unit found in the field area, Johnson Creek Olivine Phyric Basalt, is found infrequently in outcrops and always stratigraphically below or surrounded by younger units. The rock is a nearly aphyric olivine basalt. Based on silica content, however, this unit is actually a basaltic andesite.

Two andesites, both originating within the field area were mapped (figure 1). The Old Baldy Pyroxene Andesite and Old Baldy Hornblende Andesite display varied mafic assemblages and plagioclase content. The older unit, Old Baldy Pyroxene Andesite is characterized by phenocrysts of clinopyroxene and orthopyroxene in a fine grained plagioclase groundmass. In contrast, the younger, Old Baldy Hornblende Andesite, dated at 5.77 ± 0.09 Ma (Mertzman, unpublished 1994), contains large, infrequent hornblende phenocrysts displaying dehydration effects associated with a rapid decrease in water pressure with eruption. In addition to distinctive hornblende crystals, this unit in the field displays platy flow jointing and appeared well weathered. In thin section plagioclase phenocrysts appear as euhedral to anhedral forms, can be zoned, and make up the dominant portion of the groundmass usually as microlites in a pilotaxitic flow texture.

The 6054 Peak Basalt has a source to the northwest and forms a lobate kipuka as well as a dike flow in the southwestern corner of the field area. Hand samples display olivine phenocrysts at 1 to 2 mm and very few, anhedral plagioclase phenocrysts.

Basaltic andesites from sources both within the area and from locations to the east were mapped. These units commonly display phenocrysts of plagioclase, pyroxenes and sometimes minor olivine. The oldest of these units, Kent Peak Basaltic Andesite, dated at 2.81 ± 0.06 Ma (Mertzman, unpublished 1994), is seen as flows in the southeastern corner of the field area. Outcrops display platy flow jointing and consist of a light to medium grey groundmass. Located just east of the study area, Old Baldy Mountain produced basaltic andesites that flowed to the south and east. These 2.78 ± 0.06 Ma (Mertzman, unpublished 1994) flows display prominent vesiculation and flow jointing, while the unit made up a large feeder dike along the crest of Old Baldy Ridge. The Old Baldy Basaltic Andesite has distinctive glomeroporphyritic clumps of olivine and plagioclase that distinguished this unit in the field. The youngest units of this type in the area, the Surveyor Peak Basaltic Andesite, age dated at 1.88 ± 0.05 Ma (Mertzman, unpublished 1994), erupted from a small vent to the east, and were mapped as well defined flows in a curving arc trending southwest-northeast.

The youngest units within the field area are tholeiitic basalts associated with Burton Butte. The Burton Butte Kipuka Basalt located 1.5 miles south-southeast of Burton Butte is characterized by pyroclastic deposits, a high degree of vesiculation and lava flows a short distance to the south. Thought to be an earlier eruptive event for Burton Butte lavas, the vent structure itself and the flow from it are nearly surrounded by later Burton Butte lavas and calc-alkaline units. Petrographically and geochemically similar, these tholeiites display phenocrysts of plagioclase and olivine usually less than 1.5 mm with infrequent glomeroporphyritic clumps. Texturally the rocks differ somewhat, with the Burton Butte lavas having a dictytaxitic texture not found in the subsidiary vent basalts.

Discussion

Harker variation diagrams were used to indicate trends among the units (Figure 2). With increasing SiO_2 concentrations, MgO, FeO, TiO_2, and CaO amounts decrease while Al_2O_3 and Na_2O increase. The tholeiitic basalts from Burton Butte and the subsidary vent appear isolated on these diagrams while consistent trends seem apparent for the calc-alkaline series. Trace element analysis is displayed in figure 3. This spider diagram, from Thompson (1982), is a chondrite normalized diagram of the calc-alkaline units and displays troughs at Th, Nb and slightly at Ce.

The calc-allkaline suite is best explained by a cogenetic series of magmas that evolved from a more primitive parent in one or more shallow magma chambers. The linear trends readily apparent in figure 2 for the calc-alkaline units is consistent with fractionation of olivine, pyroxenes, amphiboles and plagioclase (Grove, 1986). The geochemical trends are supported by petrographic analysis, which indicate decreasing amounts of olivine and pyroxenes from the basalts to the andesites in the suite. Troughs at Th, Nb and slightly at Ce in figure 3 indicate possible contamination by crustal materials, and is not seen in the tholeiites from Burton Butte (Wilson, 1989). The trends apparent in figure 2 and the trace element consistencies in figure 3 portray a cogenetic nature among the calc-alkaline basalts, basaltic andesites and andesites mapped. The tholeiites of Burton Butte and the subsidary kipuka, obviously do not match the trends exhibited by the calc-alkaline units and do not have characteristics common to calc-alkaline type volcanics. The isolation, age difference and peculiar lithologies exhibited by the tholeiites indicates possible extension related, Basin and Range or back-arc basin volcanism where the high alumina olivine tholeiites are derived from upper-mantle sources that have undergone significant depletion (Hart et al, 1984). Here, high alumina olivine tholeiites are extruded due to oblique horizontal compressive forces at the active margine, creating extension in the back-arc area. The proximity of the mapping area to the Klamath Basin, the northern most extent of Basin and Range extension, supports this hypothesis.

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Figure 1. Geologic map and sample locations of study area

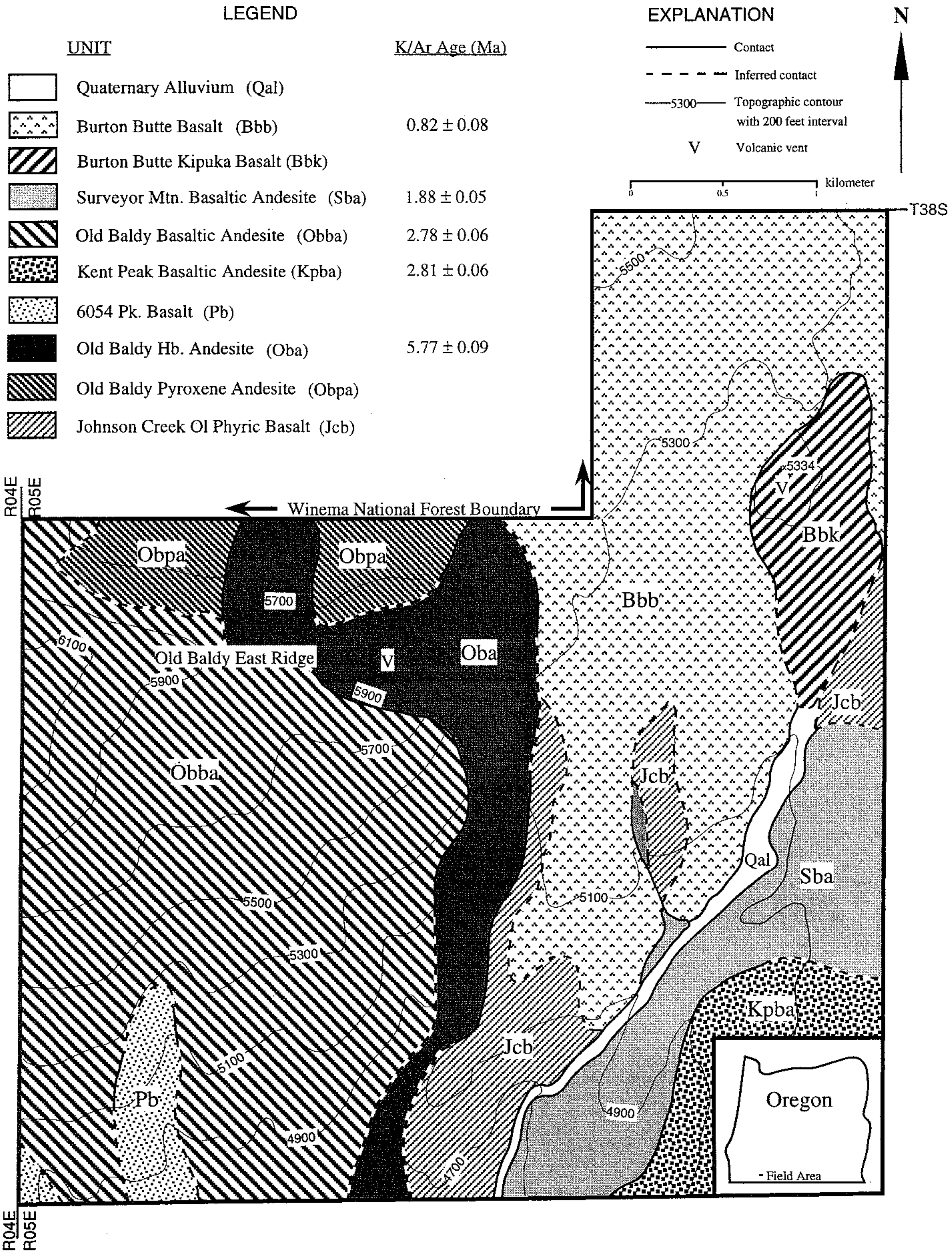

Figure 2. Harker diagrams, unit symbols are as follows: Burton Butte Basalt (+), Burton Butte Kipuka Basalt (▲), Surveyor Mtn. Basaltic Andesite (○), Old Baldy Basaltic Andesite (△), 6054 Pk. Basalt (●), Old Baldy Hb. Andesite (■), Old Baldy Pyroxene Andesite (◇), Johnson Creek Ol Phyric Basalt (◆)

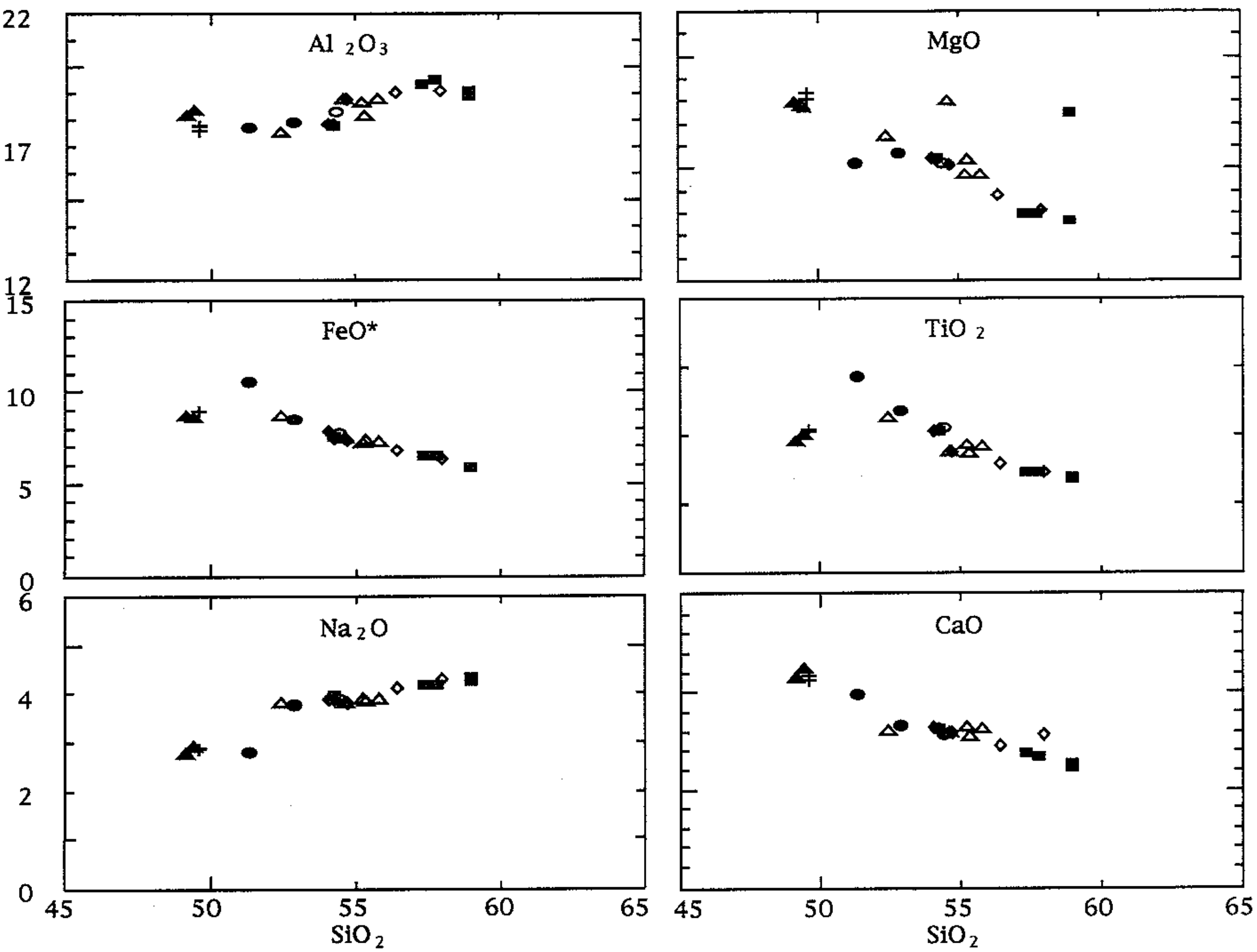

Figure 3. Spider diagram of calc-alkaline units, key to units above (After Thompson, 1982)