Volcanology and Stratigraphy of the Hessig Ranch Area of Secret Springs Volcano, Oregon

Judy Wilson

Department of Geology, University of New Orleans, 2000 Lakefront, New Orleans, LA 70148

Faculty Sponsor: Kathleen Johnson, University of New Orleans

INTRODUCTION

The Hessig Ranch Area, east of the Klamath River gorge on the Oregon-California border, offers a unique opportunity to study a little known older "Western Cascades" type extrusive regime. This area of the Western Cascades has been active for over 35 million years as a convergent continental plate margin environment. Given the large time span of continuing volcanic activity many younger vents erupted on the eroded remains of older volcanoes. For example, older lavas and pyroclastic flows unconformably underlie the lavas of adjacent Secret Springs Mountain in this area. Mapping these various units, determining the stratigraphy, and developing a hypothesis of eruptive patterns based on field observations, thin section studies, and geochemical data, were the goals of the project.

FIELD OBSERVATIONS

The field area (Figure 1) consists of ridges oriented northwest-southeast and relatively flat plateaus at an elevation of approximately 1000 feet above the river valley, and a moderately sloping highland area which terminates eastward Secret Springs crater rim. The deeply eroded drainage systems also trend northwest-southeast, as do the apparent faults in this area.

The oldest unit in this area is a badly weathered basalt (bb) occurring in elongate ridges close to the Klamath River. The basalt in the ridge north of Shovel Creek dips from sixty to twenty-five degrees northeast, an anomaly given the prevalent dip of this basalt of fifteen degrees east seen throughout the rest of the field area. The unit generally appears massive in outcrop, and sometimes displays spheroidal weathering. In thin section the lava is glomeroporphyritic (plagioclase + olivine) with a fine-grained intersertal matrix of plagioclase, olivine, and clinopyroxene.

Atop these basalts is a pyroclastic section (pts) of approximately 100 feet in thickness. This unit is characterized by pumice and lithic fragments in a layered sequence; with cross-bedding, small thrust and normal faulting, uneven erosional resistance, and "block sags" suggesting a pyroclastic origin. The symmetrically graded layers show a complex depositional process in the varying size and arrangements of the lithic fragments, which range from an extremely fine-grained ash to occasional layers of lithics up to two inches in diameter. Most mafic particles are angular while the pumice is generally of rounded appearance. In the upper ten feet of this unit are larger, apparently monolithologic, clasts from one to one and a half foot in diameter. The pumice at this location displays various colors and compositions. These clasts are entirely matrix supported, and well-spaced throughout this mixing zone, although the spacing decreases upward until the clasts are in continuos contact with each other with no supporting matrix.

Immediately above this section is a wide-spread agglomerate breccia (tb) that has a known north-south lateral extent of over three miles and a vertical thickness of up to three hundred feet. This is the dominant cliff-forming unit in the area and also the largest single unit. Individual clasts are supported by a grey, grainy matrix in weathered outcrops. In the upper zones the matrix has weathered away leaving clasts only. Many parts of the breccia unit are thin one to five feet thick basaltic lavas. The resistant rim and capping units (rb) are also composed of various basalt flows. In thin section these basalts are similar to the lower basalts (bb), but with slightly smaller phenocrysts.

A mid-level epiclastic unit (ts) overlies the basalt-breccia complex. It is composed of tuffaceous sandstone which has been extensively altered by hydrothermal activity. Cross-bedding on a fine scale occurs, with alteration zones of oxides accenting the flow patterns. The particles are generally sand-sized grains of felsic composition interspersed with mafic minerals of slightly larger size. The upper areas of this unit are less sorted and layered.

a factor. At some time between 6.2 Ma and 3.4 - 3.8 Ma crustal contamination ceased to be a major factor in lavas erupted in this region. This time interval corresponds to that of the change from extremely calc-alkaline magmatism to increasingly tholeiitic magmatism. Based on this relationship it is concluded that between 6.2 Ma and 3.4 - 3.8 Ma a change occurred allowing magma to reach the surface more easily. This change may have been caused by the onset of extension related to the formation of the Blanco Fracture Zone at 4.9 Ma (Embley et al., 1984). As subduction of the Gorda Block ceased, lateral movement on the Blanco Fracture Zone increased as did the resulting extension in Southern Oregon and Northern California. The resultant fracture system grew, allowing progressively more mafic magmas to reach the surface. This trend of increasingly mafic magmatism occurred between 3.4 - 3.8 and 1.9 Ma, a time period that corresponds to the northward migration of the andesite belt in southern Oregon between 5 and 1 Ma (Guffanti and Weaver, 1988).

Conclusions:

From at least 14 Ma to ≈5 Ma the Southern Oregon study area was characterized by calc-alkaline magmatism. At approximately 5 Ma the Blanco Fracture Zone began forming. Opening fractures allowed increasingly mafic lavas to reach the surface. As fracturing due to the Blanco Fracture Zone became more regionally extensive, andesitic magmatism migrated north. This process took place over a period of 4 Ma. The changeover to tholeiitic magmatism in the map area occurred between 3.4 and 3.2 Ma and lavas continued to become increasingly tholeiitic until 1.9 +/- .4 Ma when eruption ceased. To further validate this hypothesis, petrologic data from the entire tectonic region in question should be analyzed.

References:

Embley, R. W.; Kulm, L. ; Abbott, D.H., 1984, Kinematic and structural development of the Blanco transform zone: Eos, Transactions, American Geophysical Union, v. 65, p. 1110-1111.

Goldfinger, C.; Kulm, L. D.; Yeats, R. S.; McNeill, L.; Hummon, C., 1997, Oblique strike-slip faulting of the central Cascadia submarine forearc: Journal of Geophysical Research, B, Solid Earth and Planets, v. 102, p. 8217-8243.

Guffanti, M.; Weaver, C. S., 1988, Distribution of late Cenezoic volcanic vents in the Cascade Range: volcanic arc segmentation and regional tectonic considerations: Journal of Geophysical Research, v. 93, p. 6513-6529.

Hooper, P.R.,1988, Crystal fractionation and recharge (RFC) in the American Bar flows of the Imnaha Basalt, Columbia River Basalt Group: Journal of Petrology, v. 29, p. 1097-1118.

Le Bas, M.S.; Le Maitre, R.W.; Streckeisen, A.; Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, p. 745-750.

Mertzman, S.A., 1997, Personal communication of K-Ar age dates.

Pease, R. W., 1969, Normal faulting and lateral shear in northeastern California: Geological Society of America Bulletin, v. 80, p. 715-720.

Rickwood, P.C., Boundary lines within petrologic diagrams which use oxides of major and minor elements, Lithos, v. 22, p. 247-263.

Spence, W., 1987, Implications of the slowing of subduction at Cascadia: Eos, Transactions, American Geophysical Union, v. 68, p. 1467-1468.

Wilson, M., 1989, Igneous Petrogenesis: London, Unwin Hyman Ltd, 208-209 p.

Winick, J., 1998, *in* Mendelson, Carl V., and Mankiewicz, Carol, compilers, Eleventh Keck Research Sympoium in Geology Proceedings.

Secret Springs Mtn.
Quadrangle
Scale 1:24,000

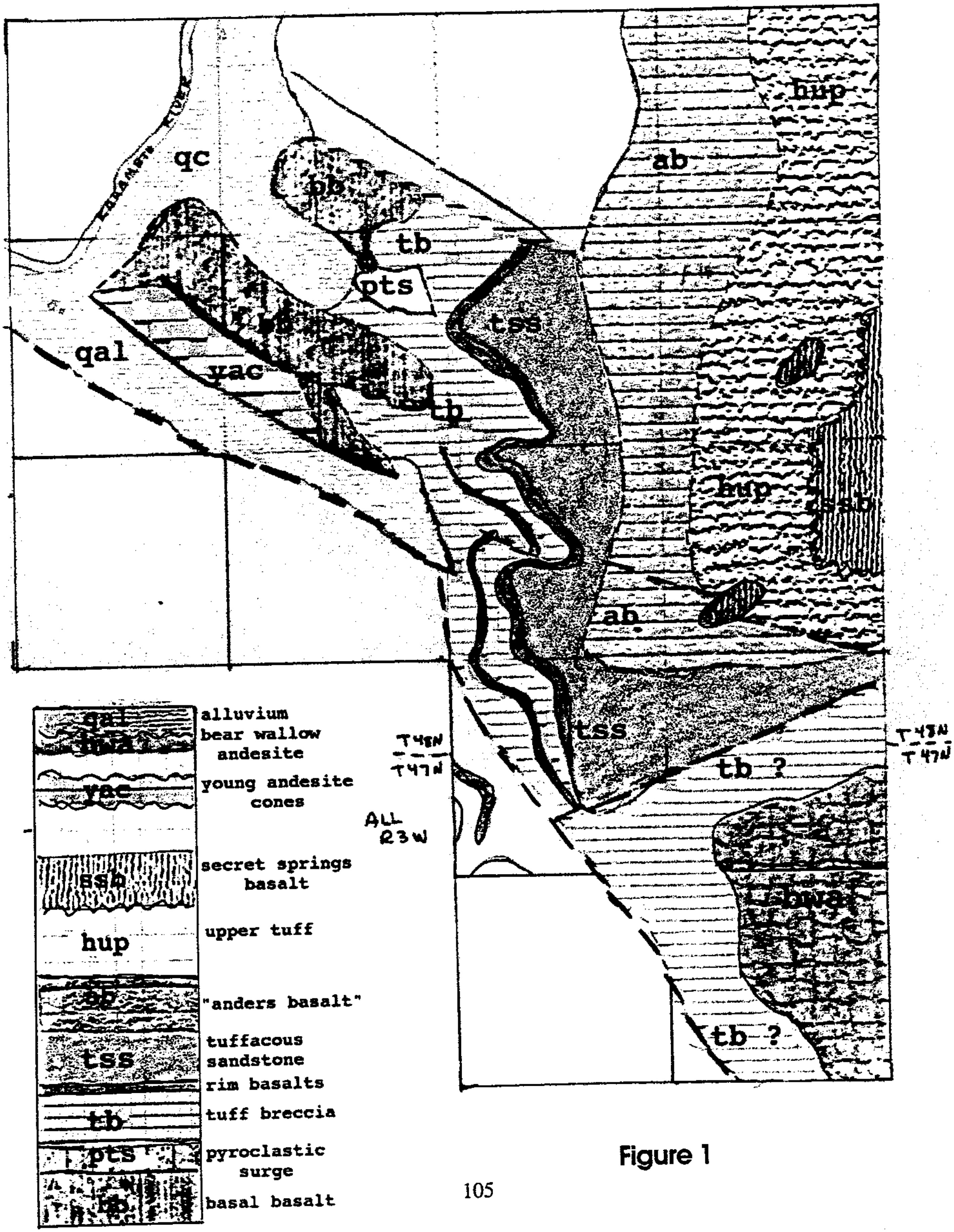

Figure 1

Lying conformably above the epiclastic unit is a basaltic-andesite lava unit (ab)of one to three hundred feet of depth. This unit dips to the east approximately ten to fifteen degrees, concordant with the units below it and thins to the south. After thin section analysis it seems apparent that there are several distinct units here, some decidedly richer in plagioclase (an andesite) than the others (basaltic-andesites).

A third pyroclastic unit (hup) occurs next, and is comparable to the middle unit in it's reworked and layer appearance with the exception of larger white tuffaceous zones and larger pumice clasts (up to melon size). This unit varies in thickness from fifty to several hundred feet thick.

The uppermost unit in the area, the olivine-phyric Secret Springs basalt (ssb), forms an angular unconformity of about fifteen to twenty degrees with the underlying formations through all areas where it is found. This section has large olivine phenocrysts which are generally very weathered, at times only showing a relic crystal shape. The matrix has a large glass component, along with olivine, plagioclase, and pyroxene.

Two other distinct units occur in the area; one to the immediate north of Shovel Creek (yac) near its confluence with the Klamath River; and the other on the plateau south of Panther Canyon, near Bear Wallow (bwa). Both of these units are much younger (7.9 and 4.9 Ma. respectively) than any to the north. In thin section these andesites are very similar, plagioclase dominating the phenocryst content, with a trachytic texture in some samples. In the plateau area some medium sized olivine crystals are found as opposed to the aphanitic texture of the Shovel Creek samples. There was a columnar section of andesite in the Shovel Creek unit also. This was also seen to a greater extent across the creek in an area locally known as Devil's Postpile. Samples collected in that area by R. Hazlett were closer in mineralogy to the lower Shovel Creek unit than they were to the plateau area directly across from them, but all these units showed more similarity than to the northern units. An age date determination for the "Postpile" sample would be a next step to understanding these much younger units.

MAJOR ELEMENT GEOCHEMISTRY

Two different trends are evident from the geochemical XRF data done at Tulane by myself, and later by S. Mertzman at Franklin and Marshall. Calc-alkaline basalt to basaltic-andesite occur in the older areas, and andesites make up the younger and more southern units (Figure 2). Most of the samples were of medium-K composition, with the exception of the clasts found in the "avalanche" zone and in the upper zone of the pyroclastic surge unit (Figure 3). These were high-K in content, indicating a different source magma . All samples have an orogenic imprint, as would be expected, and show a strong trend towards increasing crustal assimilation according to the Di-Ol-Plag ternary.

DISCUSSION AND CONCLUSIONS

The weathered basalt units have an estimated age greater than 21.2 million years, and these seem to be the oldest units in this area. The ash, pumice, and breccia stratigraphically above these basalts is likely to be of pyroclastic surge origin; given the cross-bedded and layered appearance of the fine-grained pumice, the uneven weathering patterns, the subtle thrust and normal faulting seen, the block sags, and other evidence (Fisher and Schmincke, 1984). This unit, along with the massive breccia unit above it, suggest a Plinian eruptive phase, considering the amount of pumiceous material found in this deposit. A clast imbedded in the pumice has been dated at 19.6 million years, correlation this unit with the "greywall" unit of Ander's to the immediate north.

The unit above the surge, with all the clasts in contact with one another may be the result of an avalanche caused by the collapse of the conduit walls or vent area. This might have been the result of a quickly-emptied magma chamber and was probably not caused by a landslide.

This eruptive event triggered a debris flow, or giant lahar, which covered much of the study area and beyond. The water generated a fluid mix of volcanic material and the rubble scoured from it's path. Several basalt flows are interspersed throughout the debris flow, possibly denoting fresh magma injections during the longer eruption. This entire pyroclastic event may have taken place in a matter of hours, or at the most, days. We see clasts deeply imbedded in the pumice-and-ash surge flow, and the continuous clast unit grades into the debris flow unit with no evidence of an air-fall ash accumulation (Cas and Wright 1998).

The units above this extensive section, the "Anders" basalt, the upper pyroclastic section dated 17.6 MYA, and the Secret Spring unit, dated at 14.5 MYA ,which lays with an angular unconformity above the extensively reworked pyroclastics, are continuos throughout the area studied south of the river.

The least understood areas are the Shovel Creek "cones" which appear superimposed on lavas that are approximately 10 million years older. These cones are in a linear array, with the cone nearest the river the highest topographically. It appears that the structures are fault related, especially in light of the age discrepancy. They may be linked to the unit south of the creek as a cross-creek unit appears exactly where the cones stop north of the creek. Continued research would be required to fully understand the volcanological history of the Secret Springs area.

REFERENCES CITED

Cas R.A.F. and Wright J.V. 1988, Volcanic Successions, Modern and Ancient: London, Chapman and Hall 528 p.

Fisher R.V. and Schmincke H. 1984, Pyroclastic Rocks: Berlin, Springer-Verlag, 472 p.

Guffanti,M. and Weaver, C.S., 1988, Distribution of late Cenozoic volcanic vents in the Cascade Range: Journal of Geophysical Research, v.95, B12, p. 6513-6529

Tatsumi, Y. and Eggins, S. 1995, Subduction Zone Magmatism : Cambridge, Blackwell Science, 212 p.

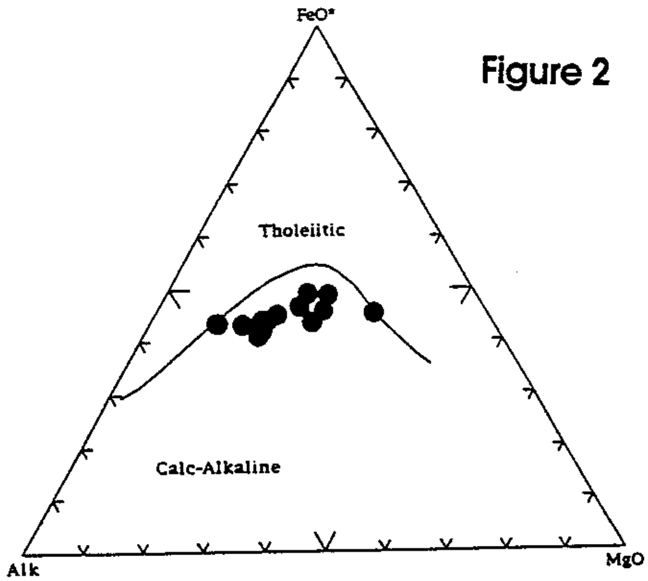

Figure 2

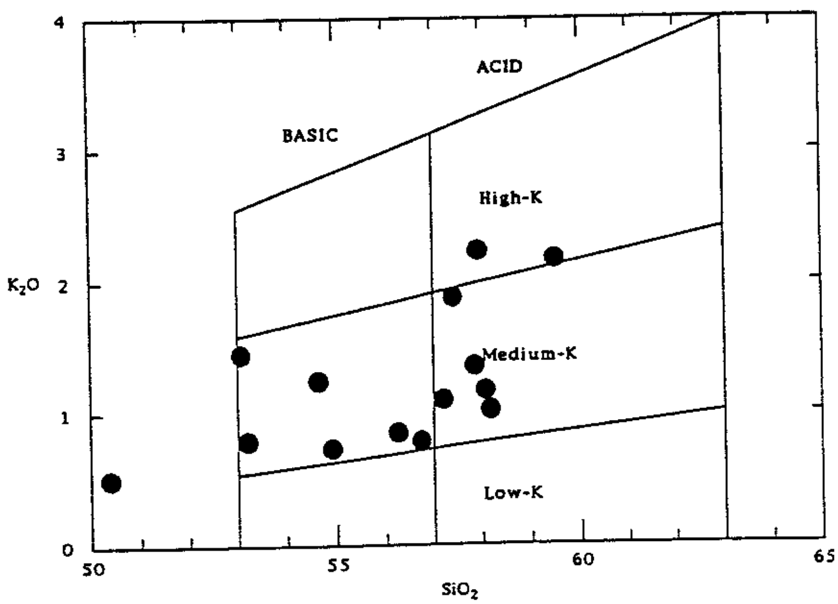

Figure 3

Geochemistry and Petrology of Neogene Volcanics of the Southern High Cascades near Keno, Oregon

Jeffrey A. Winick
Department of Geosciences, Franklin & Marshall College, P.O. Box 3003, Lancaster, PA 17604-3003
Faculty Sponsor: Stanley A. Mertzman, Franklin & Marshall College

INTRODUCTION

The Cenozoic evolution of the Cascades been marked by a northwestern migration of volcanism coincident with subduction of the East Pacific rise spreading center under the North American Plate beginning approximately 30 Ma. In more recent times (Late Miocene to Holocene), active calc-alkaline volcanism of the Cascades has been focused in the High Cascades which extends from Lassen Peak in California to Mount Meager in British Columbia. This young volcanic arc is primarily a result of oblique subduction of the Juan de Fuca, Gorda, and Explorer plates under the North American plate. Structurally, the region is characterized by numerous NW-SE trending normal faults due to the recent impingement of Basin and Range extension on the High Cascades (Blakely et al., 1997). Because of its proximity to Basin and Range extension and volcanism, it is possible that two different mantle source regimes are involved in the latest magmatism which has sporadically occurred in this region. This study focuses on a suite of subalkaline Cascade rocks collected immediately north of the California-Oregon border. Geochemical and petrographic analysis of these rocks may yield a clearer picture of the complicated magmatic processes ongoing in this region.

FIELD AND ANALYTICAL METHODS

The study section consists of a ten square mile area (from north to south on the Mule Hill Quadrangle: R5E, T40S, Sections 2, 11, 14, 23, 26, 35; and R5E, T41S, Sections 2, 11, 14) located just north of the Klamath River. Lithologic units, as well as individual flows within units, were delineated in the field based on hand sample mineralogies and textures. Relative ages were difficult to interpret due to poor exposure of contacts between many of the units.

A suite of 38 rocks representative of the various lithologic units was chosen for geochemical and petrographic thin section analysis. Various procedures including rock crushing, X-ray fluorescence analysis, loss on ignition, and iron titration were performed at Franklin & Marshall College.

PETROGRAPHY AND STRATIGRAPHY

A 1000-point count of each thin section was performed to provide an accurate measure of the modal abundance of phenocryst and groundmass phases. On the basis of field relationships, petrography, and geochemistry of the 38 rock specimens, eight distinct lithologic units ranging in composition from basalt to basaltic trachy-andesite have been defined:

Andesite Kipuka (A) (15.0 +/- 0.4 Ma) (All K/Ar dates from Mertzman, 1998): This unit is the oldest in the study section and is found only in the southern portion as a topographic high point. In hand sample, the rock is a flow laminated, medium-gray, aphanitic andesite, with a very fine-grained groundmass. In thin section, trachytic plagioclase laths dominate the rock. Clinopyroxene is the dominant ferromagnesian phenocryst phase, and both clinopyroxene and orthopyroxene exist as intergranular phases. An abundance of fine grained (<.01 mm) apatite needles is characteristic of this rock. The modal mineralogy ranges from 60-65% plagioclase, 10-15% clinopyroxene, 10% orthopyroxene, and 5-11% opqaque oxides. Using the Le Bas and others, 1986 classification, reveals this rock to be a basaltic trachy-andesite, quite anomalous in the context of the surrounding lavas.

Northern Equigranular HAOT (Neh) (3.66 +/- 0.24 Ma): This unit consists of a NW-SE trending flow front situated about one mile south of Oregon State Rt. 66. In hand sample, the unit appears as a light-gray, diktytaxitic, high alumina olivine tholeiite (HAOT) basalt. In thin section, the subophitic texture of this unit is revealed. Olivine is the dominant ferromagnesian phenocryst phase containing numerous poikolitically enclosed euhedral picotites. The unit is comprised of 48-50% plagioclase, 20-23% clinopyroxene, 15-20% olivine, 4-5% vesicles, and 3-4% opaque oxides.

66 Basaltic Andesite (66Pba) (3.4 +/- 0.1 Ma): This unit is located directly south of Oregon State Rt. 66, and in outcrop exhibits flow jointing and spheroidal weathering. A hand sample reveals a medium grained, dark-gray, porphyritic basaltic andesite. In thin section, plagioclase occurs as both small laths in the groundmass and larger tabular phenocrysts. Small resorbed zones are present within the plagioclase phenocrysts giving them a "moth eaten" texture. Olivine, clinopyroxene, and plagioclase often occur in glomeroporphyritic