# THE ORIGIN OF THE MAFIC ENCLAVES WITHIN THE WALLOWA BATHOLITH, OREGON

Andrew W. West
Department of Geology
Beloit College
Beloit, WI 53511

## INTRODUCTION

Mafic enclaves are ubiquitous throughout the Craig Mountain pluton of the Mesozoic Wallowa Batholith. The Wallowa Batholith is located within the Eagle Cap Wilderness Area of the Wallowa Mountains, northeastern Oregon. The mafic enclaves of the batholith were first described by Krauskopf (1943). Since then no specific studies have been done on the mafic enclaves. The density of the mafic enclaves is relatively the same throughout the batholith and they are not concentrated in certain areas.

It is believed that mafic enclaves can be the products of the mixing of magmas, differentiation by fractional crystallization of magma, incomplete melting of the source material (restite), or incorporation of the country rock (xenoliths) (Dodge and Kistler, 1990). Three different types of enclaves, based on petrography and geochemistry, were sampled from the field area. The most abundant type is medium-grained (finer than the host rock), contains 25%-45% mafic minerals (dominantly hornblende and some biotite), and has phenocrysts of plagioclase feldspar. Only one specimen of each of the other two types of enclaves were taken, so detailed work has not been done on them and they will not be mentioned. The purpose of this study is to determine the origin of these mafic enclaves using petrographic methods and both major and trace element data obtained with an inductively coupled argon plasma spectrometer (ICAP).

## FIELD AND PETROGRAPHIC DESCRIPTIONS

### Tonalites

The plutons of the Wallowa Batholith are classically zoned, being more granodioritic in the center and more tonalitic on the margins (Piwinskii and Wyllie, 1970). The host rocks of the mafic enclaves that were sampled plot as tonalites on the Streckeisen diagram (see figure 1). The host rock consists of mostly hornblende and biotite as the mafic minerals, and apatite, sphene, and zircon as the accessory minerals. In thin section the host rock has a strong poikilitic texture. Plagioclase crystals surround hornblende and hornblende crystals surround plagioclase. The composition of the plagioclase is between $An_{36}$ and $An_{40}$.The tonalites are uniformly medium grained. Very few structures, such as flow lineations, are found in the study area.

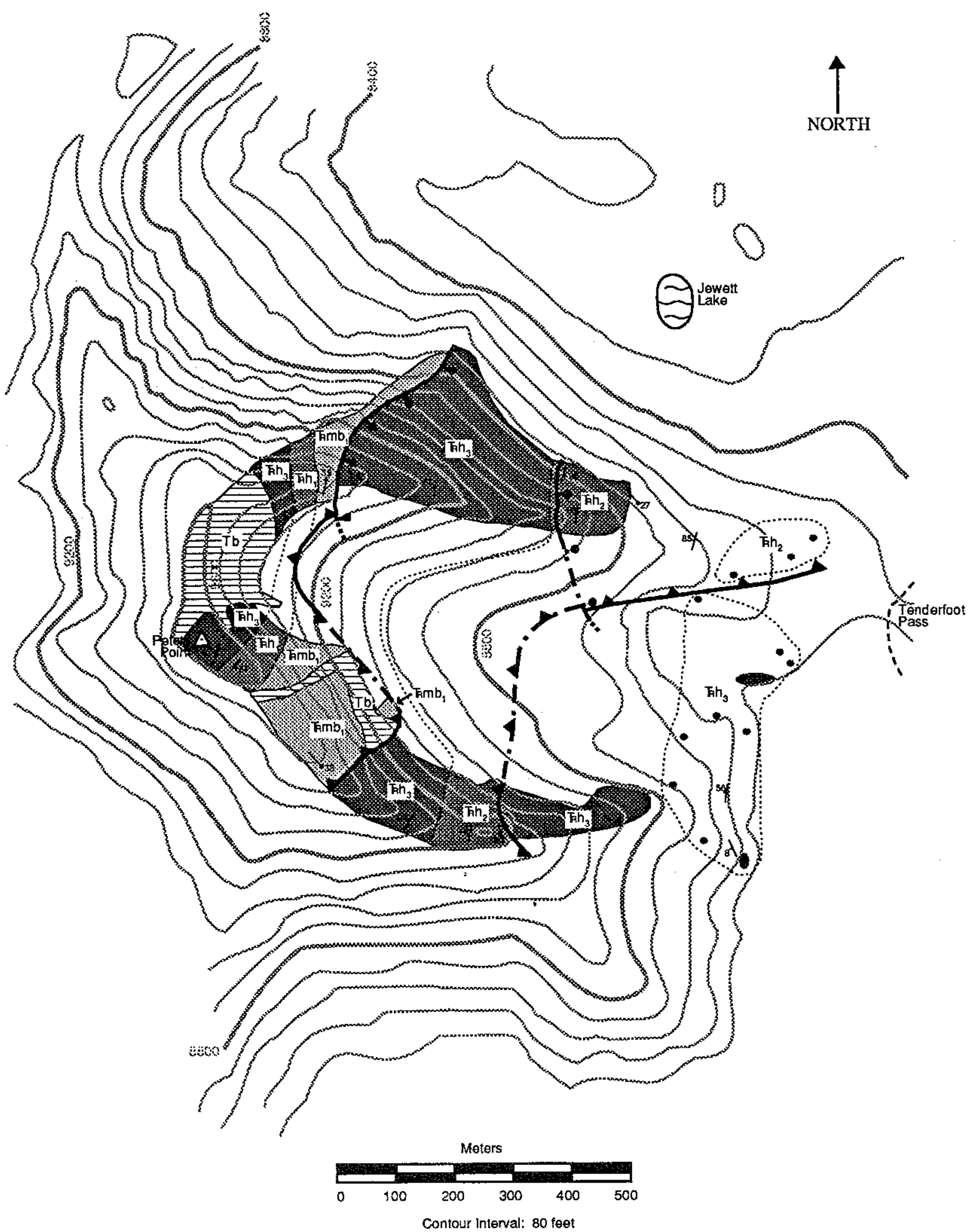
### Mafic enclaves

Mafic enclaves are relatively evenly distributed throughout the study area. In no outcrops do the enclaves seem to be in any preferred alignment. They range in size from 4 to 75 centimeters in diameter, and generally are either round or elliptical. The enclaves are always finer grained than the host tonalite. The contacts between the enclaves and host rocks are gradational and show no reaction or cooling zones.

In outcrop and hand specimen the enclaves are medium to medium fine grained and lack any sort of structure. The mineralogy consists of dominantly plagioclase, hornblende, and biotite. There are phenocrysts of plagioclase, and to a lesser extent, of biotite. Minor amounts of quartz and potassium feldspar can also be identified. The mafic enclaves display a large degree of homogeneity in both texture and mineral relationships within themselves.

Thin sections of seven of the mafic enclaves were studied. All the enclaves exhibit minerals with a very strong poikilitic texture. Plagioclase crystals are found within larger

**Figure 1: Map of field area showling lithologic contacts and major structural features**



hornblende crystals and hornblende, quartz, apatite, and smaller plagioclase crystals are found with plagioclase phenocrysts. This could be a result of simultaneous plagioclase and hornblende crystallization. Many of the phenocrysts of plagioclase are oscillatory zoned. Using the Michel-Levy method the composition of the plagioclase varies between $An_{34}$ and $An_{46}$ with most specimens having a composition on $An_{40}$ (andesine). Nearly all of the plagioclase exhibit albite twinning. All of the specimens plot within the diorite or quartz diorite fields on the Streckeisen diagram (see figure 1). The dominant mafic mineral in every enclave is hornblende which varies between 14 to 35 modal percent. Biotite is between 4 and 13 modal percent. The order of crystallization from first to last appears to be the opaque minerals, apatite, hornblende and plagioclase, biotite, quartz, and lastly potassium feldspar.

### Intermediate dikes

The intermediate dikes that crosscut the batholith are not very common. They were mapped in only a few localities of the field area. The dikes vary from .6 to 3 meters wide and do not show any preferred trend or plunge. The dikes are medium to fine grained, and are always finer grained then the host rock in contact. The contact between the dikes and host rock is sharp, but yet shows no reaction or chill zones. Small blebs (2-3cm in diameter) of the host rock are incorporated into the dikes. The dikes also become dismembered in places, with pieces of the dike breaking up into small angular enclaves. Some contacts of the host and dike rock exhibit schlieren texture, with "wisps" of the dike material flowing through the host rock. These observations suggest that the dikes are synplutonic. Phenocrysts of plagioclase, hornblende, and biotite are found in the groundmass of quartz and plagioclase.

Three thin sections of the intermediate dikes of different localities were studied and point counted. The dikes show the same poikilitic texture that the enclaves do. Hornblende and biotite crystals envelope plagioclase while plagioclase crystals contain hornblende. The phenocrysts of plagioclase are oscillatory zoned. The composition of the plagioclase ranged from $An_{32}$ to $An_{40}$. These dikes plot as tonalites or quartz diorites on the Streckeisen diagram (see figure 1).

## GEOCHEMISTRY

Data for the major elements and 13 trace elements of 16 rocks (5 host, 3 dikes, and 8 enclaves) was compiled using the ICAP at Beloit College. The results for silica content were inaccurate due to contamination from the silica torch of the ICAP. The values for silica were determined by calculating the difference between the values for the other elements including the LOI and 100 percent. Because there is some uncertainty in the silica values, elements are plotted against MgO as a differentiation index.

The plots of the major elements and the compatible trace elements versus MgO show well defined linear trends, suggesting that the host rocks, intermediate dikes, and the mafic enclaves are related. The plots of CaO and FeO* give good trends versus MgO (figures 2 and 3). Both CaO and FeO* decrease with decreasing MgO. Similar trends are evident for the trace elements Sc, V, Ni, and Co (Sc and Co shown in figures 4 and 5). These trends suggest fractional crystallization of ferro-magnesium and oxides minerals, such as amphibole, biotite, and magnetite. The linear trends of CaO versus MgO and CaO versus $Al_2O_3$ (figure 6) suggest plagioclase involvement as well.

## CONCLUSION

Petrographic and geochemical data support the idea that the mafic enclaves and the host rock crystallized from the same magma. Both the host rock and enclaves show very similar mineralogy, have the same distinct poikilitic texture, and the major and trace element data suggest plagioclase and hornblende fractionation. Thus the mafic enclaves could represent early accumulation of plagioclase and hornblende.

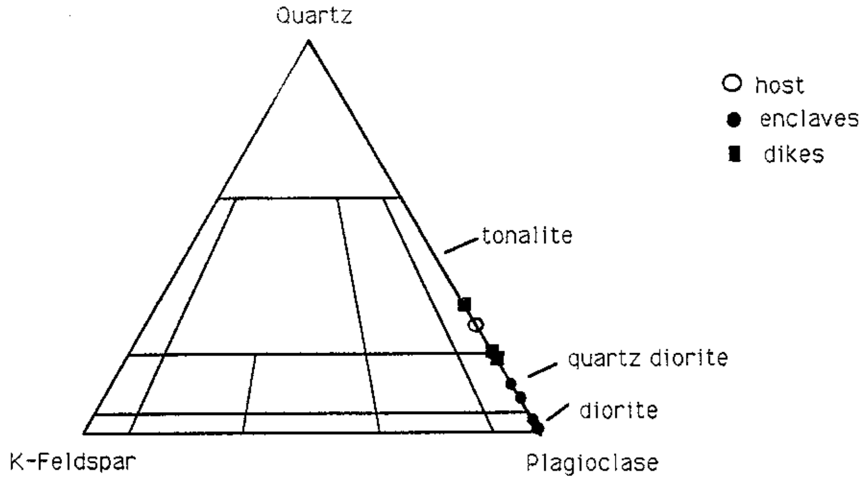



Fig. #1 Streckeisen Diagram

Fig. #2 CaO vs MgO

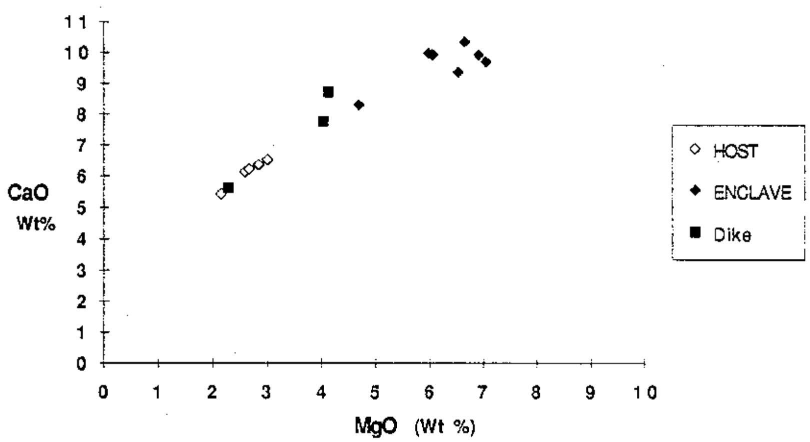



Fig. #3 FeO* vs MgO

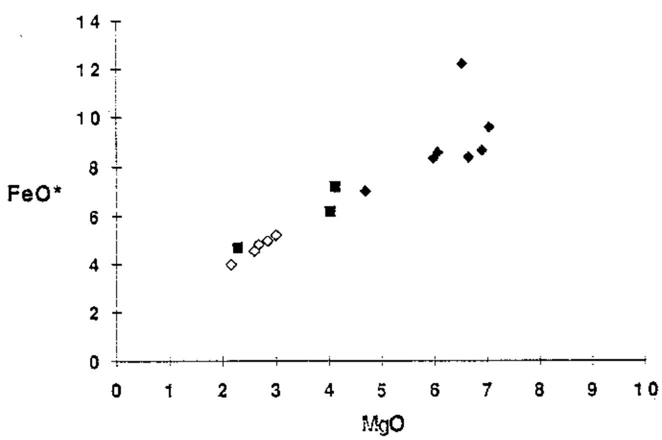


Fig. #4 Sc vs MgO

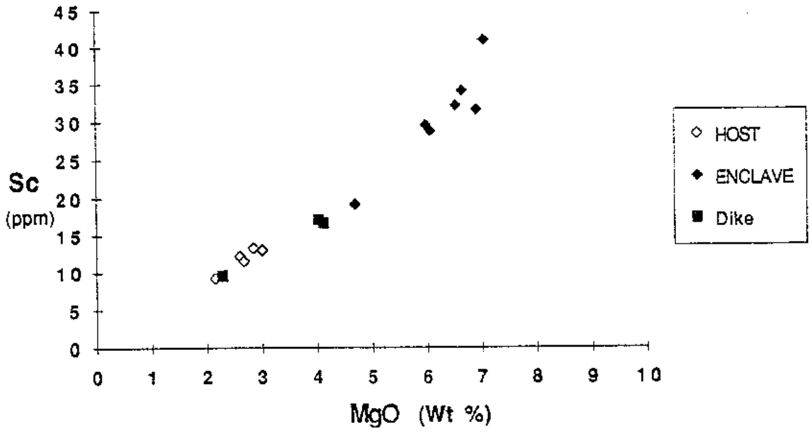



Fig. #5 Co vs MgO

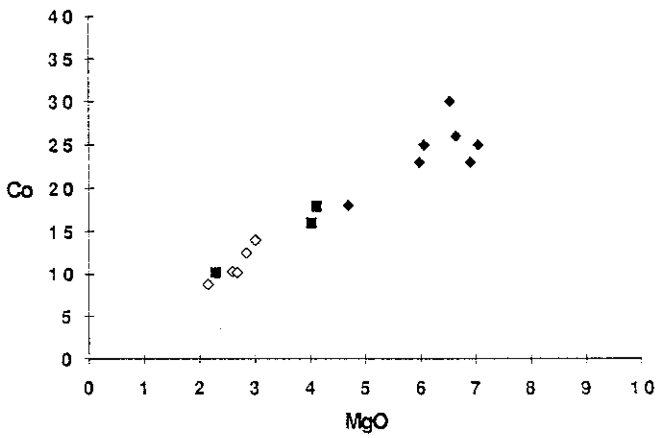
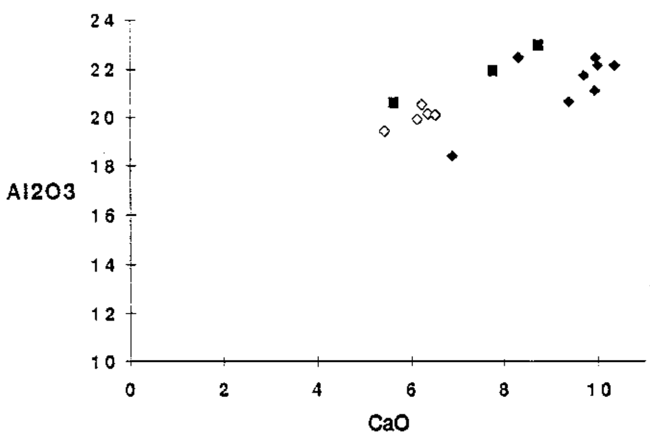



Fig. #6 Al2O3 vs CaO



## REFERENCES CITED

Dodge, F. C. W. and Kistler, R. W., 1990, Some additional observations on inclusions in the granitic rocks of the Sierra Nevada: Journal of Geophysical Research, v. 95, p. 17,841-17,848.

Krauskopf, K., 1943, The Wallowa Batholith: American Journal of Science, v. 241, p. 607-628.

Piwinskii, A. J. and Wyllie, 1970, Experimental studies of igneous rock series: Felsic body suite from the Needle Point Pluton, Wallowa Batholith, Oregon: Journal of Geology, v. 78, p. 52-76.